AUTOMATED WATERLEVEL MONITORING USING REAL-TIME OBSERVATION (ALeRTO)

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ABSTRACT: As the Philippines is geographically located near Pacific Ocean, episodes of natural phenomenon are undeniably present and these has brought devastation in the country. As a response to these events, the Philippine government encourages the mainstreaming of Disaster Risk Reduction and Management and Climate Change Adaptation (DRMM-CCA) initiatives to national and local programs. Several of the initiatives were the installation of Automated Rain Gauges (ARG) and Automated Water Level Sensors (AWLS) in flood prone areas. These sensors provide key information to government agencies such as the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAG-ASA) and PROJECT NOAH or the Philippines Nationwide Operational Assessment of Hazards, which are supposedly disseminated to the Local Government Units (LGUs) for them to be informed on an impending flooding in the area. However, it has been observed that these information and data are not directly accessible to local government units. As a preventive measure, the ADZU Phil LiDAR 1 has developed a system which aims to help the local authorities and communities along the flood-prone areas prepare for the adverse effects of floods by providing an early warning system which is capable of sending alert messages prior to flood events. The system retrieves data in the Water Level Monitoring Stations (WLMS) and Automated Rain Gauges (ARG) from the Advance Science and Technology Institute (ASTI). The Automated Waterlevel Monitoring Using Real-Time Observation (ALeRTO) device is programmed to monitor the ASTI website for critical water level and rain data, and interpret it into threshold categories which are: high, medium and low. As the device is programmed to identify water level threshold, it sends out alert messages via sms to registered users specifically to Local Government Units. Given this, the system will be able to expand the platform on disseminating information to two end-users, the LGUs and other government agencies (received via SMS) and at the same time to anyone who would access the website via the internet.

1. INTRODUCTION

The disaster statistics of the United Nations International Strategy for Disaster Reduction (UNISDR) revealed that from 1980 to 2010, the Philippines is ranked second in most occurrence of storm, flooding and property loss. As it is geographically located near the Pacific Ocean, episodes of these natural phenomenon is not surprising anymore. But due to the recent changes in the climate pattern, the intensity of natural phenomenon has intensified the devastation in the country. This was proved in the last few years when the typhoons Washi (2011), Bopha (2012) and Hiayan (2013), has caused hundreds of lives and property damages. For Haiyan alone, the National Disaster Risk Reduction and Management Council (NDRRMC) has estimated P36.6-billion worth of economic damages and killed over 6,000 people (Laude, 2013).

In response to these events, the Philippine government encourages the mainstreaming of Disaster Risk Reduction and Management and Climate Change Adaptation (DRRM/CCA) initiatives to national and local programs. This scheme is continually urged in order to have a paradigm shift from post-disaster response to a proactive and preventive approach.

One of the initiatives of the government in disaster prevention and mitigation is the installation of Automated Rain Gauges (ARG) and Automated Water Level Sensors (AWLS), strategically placed in the flood prone areas. These sensors feeds the data that will determine the lead time for evacuation in case of extreme rainfall and flooding in low lying areas. Thus, these provide key information to government agencies such as PAG-ASA, and PROJECT NOAH which are then disseminated to the Local Government Units (LGUs) of an impending flooding in the area.

However, although these systems are laudable as it is, there are some limitations as regards the information dissemination and accessibility of the data. Major government agencies such as PAG-ASA and OCD are the only recipient of the data, thus limiting the awareness in the local level. Several local disaster offices will have to wait for updates from PAG-ASA and NDRRMC for them to take action, thus results to poor disaster preparation, especially if the hazard is not considered as a typhoon but could still affect the water levels of their respective river systems. Moreover, some local disaster offices could not monitor the weather conditions due to limited access to the internet.

As a preventive measure, the ADZU Phil LiDAR 1 has developed a system that aims to help the local authorities and communities along the flood-prone areas prepare for the adverse effects of floods by providing an early warning system that is capable of sending alert messages prior to flood events. A standardized 3-level warning systems corresponding to three identified critical water level will be sent to registered users.
Through this system, the office aims for the local authorities and communities to be more prepared for possible effects brought by continuous rain event. As the system will send the water level and rain level updates, the local authorities will have enough time for decision making such as early evacuation, in order to prevent death casualties brought by flooding.

2. OBJECTIVES

The main objective of this study is to develop an early warning system which would aid the Local Government Units in preparing for an impending flood event of the rivers located in their respective municipalities

Specific:

The specific objectives of the study include the following:

1. To be able to determine three critical water levels as reference for the three-level warning system;
2. To be able to develop a Short Message Service (SMS) module to send flood warning messages to registered beneficiaries via Global System for Mobile Communications (GSM).
3. To create a graphical representation of each AWLS and ARG (tandem) sensor
4. To create a web-based monitoring of all sensors in Zamboanga Peninsula
5. To create an alarm system which will notify the base station in case the water level rises
6. To determine the values for the threshold of each river cross section

3. REVIEW OF RELATED LITERATURE

Flashfloods have become one of the most dangerous and destructive calamities in most parts of the world. It swept lives, infrastructures and properties even with presence of state-of-the-art forecasting equipment. Unfortunate events like dam break, levee break, are sometimes the cause of flash floods aside from the typical torrential rainfall. More countries have established Flash Flood Early Warning Systems (EWS) due to the significantly overwhelming flash flood events. Despite the technical complexity of predicting flash flood events, they are geared with enough confidence in terms accuracy of their results, and the lead time for advance cautionary action.

In Region 8, Philippines, Deutsche Gesellschaft fur Technische Zusammenarbeit (GIZ) has long established a vast knowledge and experience in the management and setting up of Local Flood Early Warning System (LFEWS) alongside with its partner local government agencies. The efficiency of LFEWS in the area promotes the reduction of human vulnerability and suffering through the strengthened capacity of local disaster risk reduction management institutions in terms of decision-making. GIZ-LFEWS was piloted in the Binahaan Watershed of Leyte Province in 2008 which later on replicated to seven other watershed in the region. Since then there have been an observable improvement in terms of saving lives and properties, increased awareness among the public, and a progressive institutional performance of local governments.

The Hyogo Framework for Action and the post 2015 framework for Disaster Risk Management Reduction prioritize early warning and put greater focus on continuing to strengthen these early warning systems. Early warning systems can only become effective if all components are operative. These components include knowledge of the risks, monitoring, analysis and forecasting of the hazards, communication or dissemination of alerts and warnings, capacity of locals to early warning data. As recognized, communication and dissemination component has received the least attention which eventually resulted to poor reaction to the flood affected communities. This case study aims to lessen the warning communication gap.

In the Indian Himalayan region, Community-Based Flood Early-Warning System was established by the collaboration of ICIMOD, Aranyak and SEE to enhance the resilience of 45 flood hazard vulnerable communities. By the use of flood sensors attached to transmitters, the information and Communications Technology (ICT) created a system to monitor the rising of water level. A signal is wirelessly transmitted to the receiver when the water reaches a critical level. And with the wide use of mobile phones, flood warning information is then disseminated to the appropriate agencies and vulnerable communities downstream. Following this system, pre-cautionary measures can be done avoiding bigger damage to properties and lives.

This study stresses the significant effects of flooding and other relevant events to the vulnerable communities across the world. It strongly promotes the utilization of science and information technology for a better understanding and much more sound decision-making processes.

4. THEORETICAL FRAMEWORK

In engineering hydrology and hydraulics, the relationship between the water level or stage and the corresponding discharge of the river is known as the rating curve. It is an empirical relationship used to estimate discharge in open channels, natural or artificial, and is established at particular sections of the river where a stream gauge is present. It is determined by fitting the actual discharge data, which is usually gathered using a flowmeter, and the stage data, which is measured by a stream gauge, to a curve. This curve is usually expressed in power or polynomial equations.

One-dimensional (1D) flood models are created to simulate the flood extent of the estimated discharge values. One-D flood models work under the assumption that the velocity across the cross-section is uniform and the water level at that section is horizontal.

5. METHODOLOGY

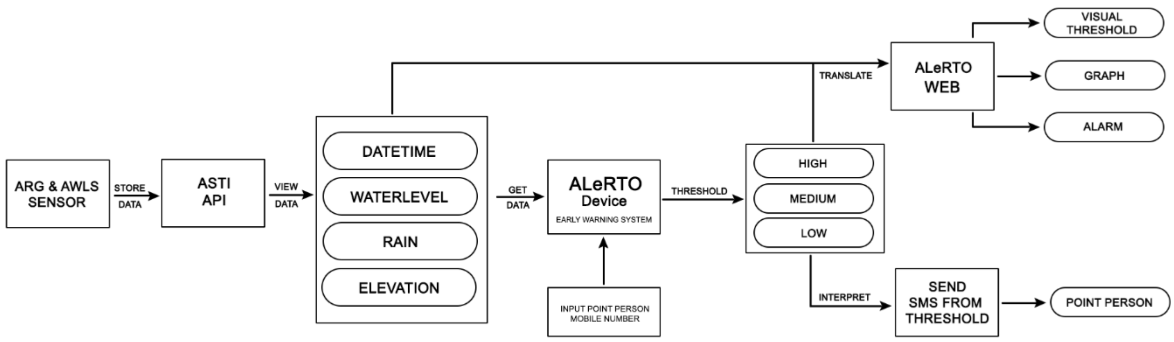

Figure 1. *Flowchart of the research methodology*

This diagram above shows how the system will disseminate the data from the sensors towards the end-users. The data, which comprises of date/time, water level and amount of rain, gathered from the Water Level Monitoring Stations (WLMS) and Automated Rain Gauges (ARG) are sent to the web, specifically to Advance Science and Technology Institute (ASTI) for data recording and storage. These ASTI data could be accessed online for free and are repository for viewing real-time water level and precipitation data.

The ALeRTO System is dependent on the repo site of ASTI where all the data of the sensors are being stored. The device (Intel Galileo Gen 2) gets the data from the ASTI repo site and interprets it using the uploaded codes. In the system, there are identified threshold values which are represented by 3 categories or conditions: Low, Medium and High. The system then compares the data it gathered from the ASTI repo site to the threshold values. This comparison process will determine the category or conditions of which the value of the data will be placed. If the value coincides with a specified condition, it will send the data via sms to the assigned point person (i.e LGU, etc.). The system will send 3 SMS for each threshold conditions: First is during the first peak; the second text is during a second significant peak; and the third sms is during the final peak before it moves to the next condition.

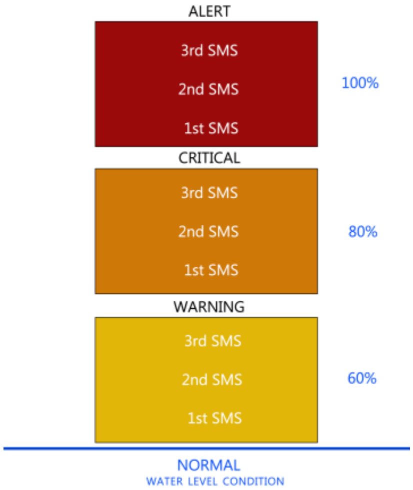

Figure 2. *Threshold Levels*

The program will also compare if there are changes in water level. If there is a change, it will send sms every 10 mins (or depending on the sensor), especially if the threshold is at the critical, going to alert level. Once the system identifies that the river already reached 60% full (warning condition), monitoring of the water level of the river is then intensified.

The system is a standalone program. Once the system identifies all the possible scenarios, it can process the data by itself. Simple maintenance works will be done like reloading of the sim card for sending SMS and checking the software and hardware for any possible problem.

Aside from this, the same critical water level data and rain data can be viewed online illustrated in three forms: Visual Threshold, Graph and Forecast. Given this, the system will be able to expand the platform on disseminating information to two end-users, the LGUs and other government agencies (received via SMS) and at the same time to anyone who would access the website via the internet.

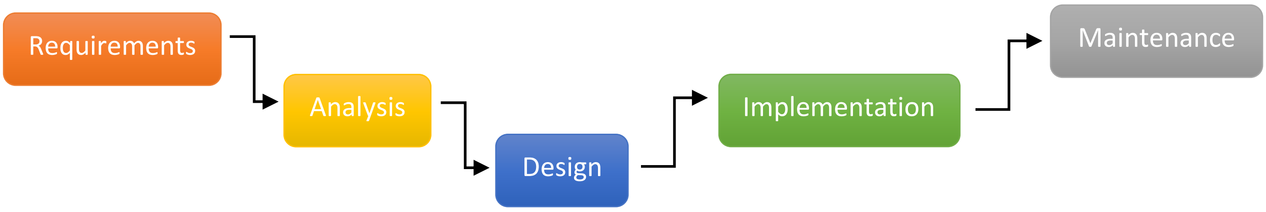

Figure 3. Methodological Framework

RESULTS AND DISCUSSION

As a result of the development of the ALeRTO system, the website for the monitoring of the available Automated Rain Gauges (ARG) and Automated Water Level Sensors (AWLS) had been uploaded to the internet and the sensors is being monitored closely. Below is a screenshot of the website

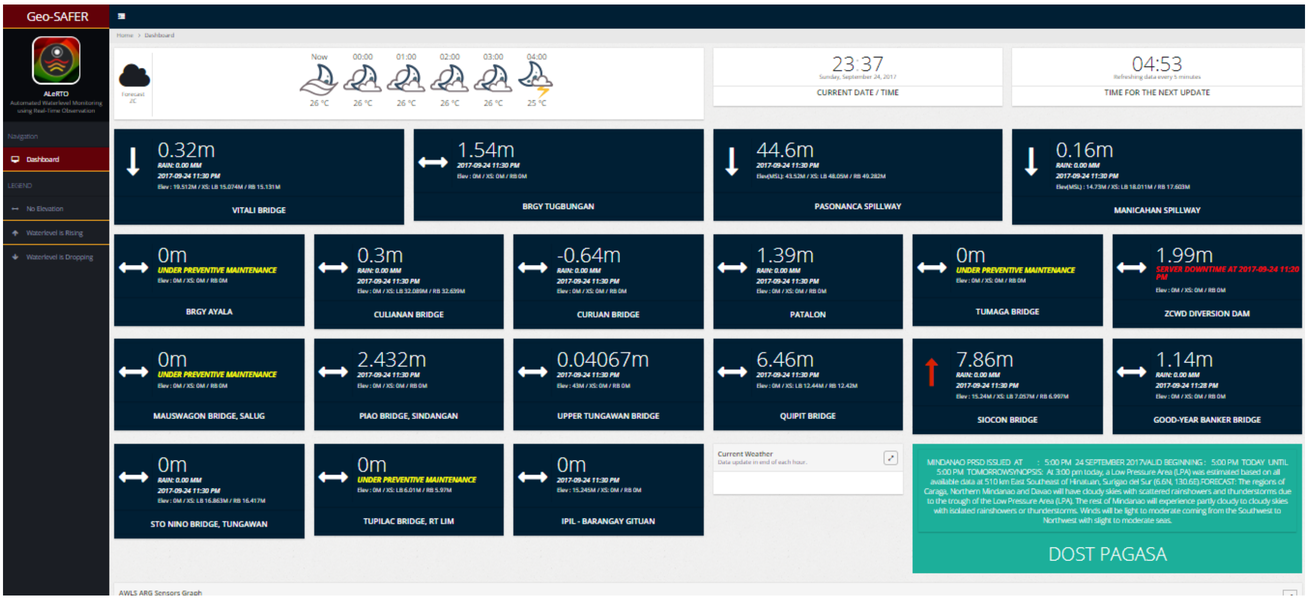

Figure 4. ALeRTO Website

The website showcases the available sensors in Zamboanga Peninsula with the ARG and AWLS data. These data are downloaded from the Advance Science and Technology Institute of the Department of Science and Technology (ASTI-DOST) website. An important detail in the website is the status of sensors, as shown in the image; there are sensors in color red texts as undergoing server downtime. This means that the server from ASTI is down for the moment, however this is only for a certain period of time. While those in yellow texts means that sensors under preventive maintenance; meaning the sensors or some of its attachments will have to be replaced. In addition, those sensors with the arrow up and arrow down shows that the status of the water level and rain gauge are either going up or down. However, the ones with the double arrow mean that no significant data can be shown. This would also mean that the details of the sensors are yet to be verified, like the elevation of the sensor and cross section of the location of the AWLS is not yet known. The cross section of the location of the AWLS is very important, especially that the height of the left and right bank will provide the necessary data for identifying the threshold which will be used for the alarm system.

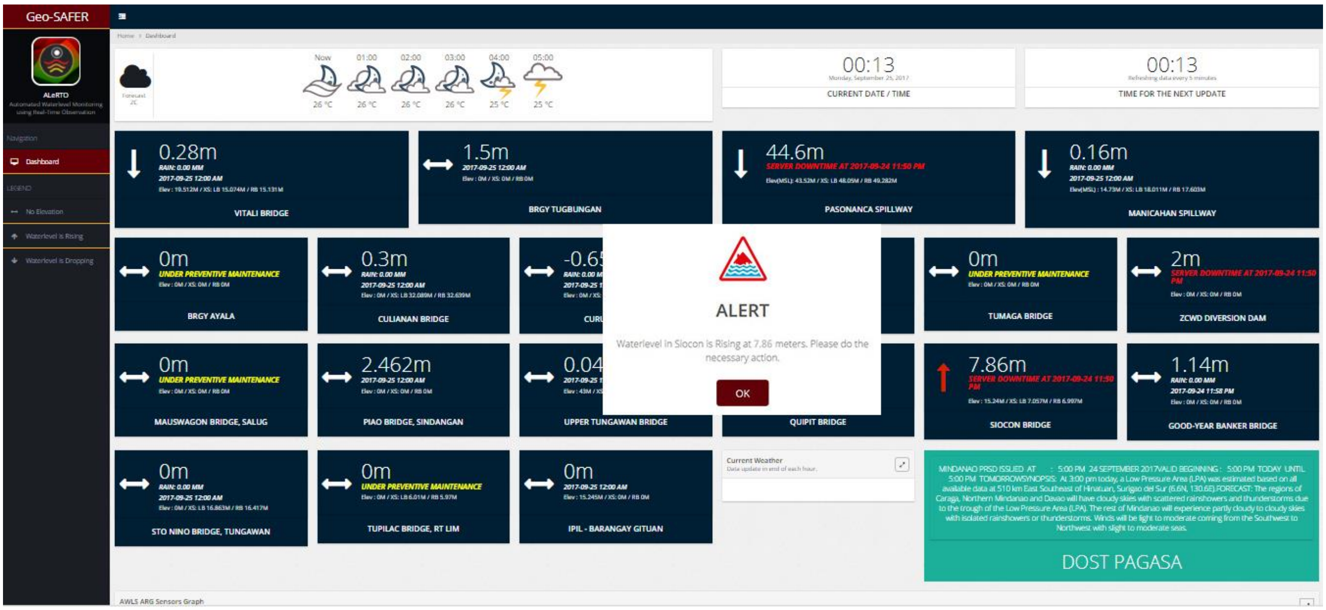

Figure 5. ALeRTO Alarm

Once the systems reaches the threshold of a given sensors, this sends out an alarm system through the website informing about the status of the water level and the subsequent increase in the waterlevel.

Figure 5. Sample SMS Message

The Figure 5 image shows a sample SMS warning systems that is sent by the ALeRTO device to the registered user, the registered user can be the Local Government Unit, specifically the Local Disaster Risk Reduction and Management Officer (LDRRMO), who is responsible for the disaster related events in the City or the Municipality. Aside from the LGUs, other stakeholder can also register in the ALeRTO system.

Both alarm systems through the website and through the SMS are simultaneously sent out to the end user. In cases, wherein the internet connection is down, an alternative alert system can still be used through the SMS.

CONCLUSION

Because of the adverse effect of Climate Change, severe weather conditions bringing about continuous and heavy rains has become more or less constantly present in the Peninsula. Thus, the need to have a localized early warning system is seen very critical in Disaster Preparation.

Through this system, a localized (river-based) monitoring of water-level is established in the region. This system particularly also gives a localized interpretation of the threshold values for the water-level, which makes it easier for the Local Government Units to understand. Moreover, as the system will send the water level and rain level updates, the local authorities will have enough time for decision making such as early evacuation, in order to prevent death casualties brought by flooding.

Aside from this, the said system also serves as an educational campaign to everyone who could access the ALeRTO website. As an end user, they will have a glimpse on how the water level monitoring sensors and rain gauges are able to help them in preparing for a forthcoming disaster. Thus, each individual, up to the household level, could already have their own household decisions for evacuation and such.

RECOMMENDATION

Though the system has already been developed, it is still considered to be in the testing phase. This would mean that further testing will have to be conducted to eliminate any possible glitches and problems in the system. This is necessary because of the perilous data showcased in the system and which is very critical to the Local Government Unit.

Further, the water-level sensors and rain gauges will have to be verified and checked in order to be assured of their functionality and its reliability. Furthermore, the elevation data of the sensors will also have to be validated. Aside from this, the cross section surveys of each river where the sensors are located should be conducted. This will improve the accuracy and reliability of the data that will be used by the end-user as this can save lives and properties.

Moreover, information campaign on the accessibility and existence of such system should also be done. This is very important for the community of have further knowledge on things as such in order for them to have and do their individual of household level decision making in preparing for an impending flood event.

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