Andam: A Flood Early Warning Device Prototype

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Abstract

Objectives: This study focused on the development of Flood Early Warning Device that mitigated the detrimental effects of flooding which has been dubbed as one of the most destructive natural phenomena in the Philippines specifically, in the Eastern Visayas Region. Methods/Statistical Analysis: The researcher adopted the prototyping model as a guide in the development of the system prototype. Prototyping-based methodology conducts the analysis, design and implementation phases simultaneously. The researcher initiates the prototyping process through the observation of the current method of relaying early warning messages to community members. The data gathered became inputs to the design and development of an early system prototype. This process is repeated until the best version of the system is developed. Once the end-users agree with the final design of the system, the researcher proceeds with the final implementation of the prototype. The researcher utilized a questionnaire based on the IBM Computer Usability Satisfaction Scale focused on evaluating the systems' overall usability. Findings: To evaluate the overall usability of the device, end-user testing with the City Disaster Risk Reduction Management (CDRRM) Officials of Borongan City was conducted using the IBM Computer System Usability Scale. End-users evaluation resulted in a grand mean of 4.81 interpreted as Highly Usable. This implies that they find the system’s interface pleasant, organized data, found a fewer number of errors and was generally satisfied with the entire system. The various components of the device have been successfully integrated and the connection between the transmitter and receiver was successfully established. Application/Improvements: The device was developed by integrating stream flow sensors and a Global System for Mobile Communication (GSM) module into an Arduino Microcontroller that sends Short Message Service (SMS) warning once the speed of the stream reaches its threshold and sends another SMS once the stream flow is back to its normal speed. The device will ease the level of severity of flood and could provide time for an early evacuation procedure in order to save lives and properties as well.

Keywords: Flood, Global System for Mobile Communication (GSM), Sensor, Short Message Service (SMS), Warning Device

1. Introduction

As a country situated on the Pacific Ring of Fire and close to the equator, the Philippines is prone to various types of natural calamities. One of the most occurring natural calamity, especially in lowlands, is flooding. Floods are among Earth’s most common and most destructive natural hazards. This is evident from the immense amount of rainfall the country experiences every year. The Philippines had experienced countless extensive and extremely destructive natural calamities. A tremendous number of casualties, loss of properties, livelihood, destruction of infrastructure and a big downfall in the national economy were the common effects of these natural phenomena. Some of the most usual root causes of massive flooding are clog canals, overflowing rivers, coastal water surpluses, and ruptured dams.

The University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UPTCAGP) launched a research program entitled “Nationwide Hazard Mapping using LiDAR” or Phil-LiDAR, supported by the Department of Science and Technology (DOST) Grants-in-Aid (GiA) Program. It operationalized the development of flood hazard models that would produce updated and detailed flood hazard maps for the major river systems in the country particularly in
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Borongan City\textsuperscript{3}. But, if an instrument will also be developed and implemented and will forecast the water current level from its source, it would be a very great help\textsuperscript{4}.

In Eastern Samar the Loom River basin covers the City of Borongan. It has a drainage area of 67 km\textsuperscript{2} and considered as one of the biggest and longest river in the city. According to the 2015 national census of Philippine Statistics Authority (PSA), a total of 8,286 persons are residing within the immediate vicinity of the river distributed among seven barangays Alang-alang, Purok D1 (Poblacion), Purok B (Poblacion), Purok D2 (Poblacion), Purok F (Poblacion), Purok H (Poblacion), and Taboc.

In 2014, Borongan City was greatly affected by Typhoon Ruby with international name “Hagupit” it maintained an estimated rainfall amount from 7.5 - 20 mm per hour within the 600 km diameter of the typhoon triggering storm warning signals in several places in Eastern Samar. The heavy rains brought by the typhoon made loom river to overflow reaching more than 12 feet affecting thousands of residents and killed sixteen (16) people in Borongan City all caused by the intense flooding\textsuperscript{4}.

This alarming problem and the increase of natural calamities experienced by the Philippines annually has prompted the researcher to develop a prototype SMS-based flood early warning device called ANDAM. The term Andam, is a waray-waray term (a local dialect in the Philippines), which means prepared. It was developed by integrating an Arduino microcontroller, streamflow sensors, and a GSM module. The streamflow sensor was placed near the water source in Bgy. Siha, while the water level sensor was mounted near Loom river watershed. The microcontroller sends SMS warning once the speed of the stream reaches its threshold and sends another SMS once the stream flow is back to its normal speed. Hence, flood monitoring devices provide advance warning of flood events which can potentially allow minimizing life risk, evacuation of vulnerable groups, and in residents moving their assets to a safer place\textsuperscript{5}.

2. Objectives

This research aimed to develop an Arduino-based flood early warning device. In particular, this study aimed to achieve the following objectives:

1. Integrate the following functionalities to the device:
   1.1 Determine from its source the water current speed;
   1.2 Record data from the calculated water current speed, delete logs, add/update/delete contact numbers; and
   1.3 Send Short Message Service (SMS) as an early warning for an upcoming flash flood.

2. Evaluate the overall device usability using the IBM Computer System Usability Scale.

3. Significance of the Study

The successful development and implementation of this study contributed greatly to the City Disaster Risk Reduction Management (CDRRM) officials and residents of flood-prone communities in Borongan City, Eastern Samar. Once the speed of the stream reaches its threshold, the device will immediately send early warning messages containing information on the possibility of flooding based on the water current speed from the river water source. This will then provide an avenue for officials to facilitate an early evacuation or return process.

3.1 System Development Model

The researcher adopted the prototyping model as a guide in the development of the system prototype. Prototyping-based methodology conducts the analysis, design and implementation phases simultaneously. All three phases are done in a cycle until the best version of the system is completed\textsuperscript{6}.

![Figure 1. Prototyping Model\textsuperscript{7}.](image)

Figure 1 illustrates the prototyping process. The model is subdivided into three (3) major phases namely, (1) Planning, (2) Analysis-Design-Implementation and (3)
Final Implementation Phase. The researcher initiates the prototyping process through the observation of the current method of relaying early warning messages to community members. The data gathered became inputs to the design and development of an early system prototype. This process is repeated until the best version of the system is developed. Once the end-users agree with final design of the system, the researchers proceed with the final implementation of the prototype.

3.2 System Flowchart and Architecture

Figure 2 and 3 shows the flow of data from the ANDAM transceiver to the desktop application. The system starts with activation of the transmitter, once the connection has been established, the sensors will start detecting changes in the stream flow and send data to the receiver and store it in the ANDAM Database.

A system architecture is the conceptual model that defines the structure, behavior, and more views of a system. An architecture description is a formal description and representation of a system, organized in a way that supports reasoning about the structures and behaviors of the system.

Figure 3 shows the streamflow sensor placed near the water source in Bgy. Siha, while the water level sensor was mounted near Loom river watershed. The microcontroller will send Short Message Service (SMS) warning once the speed of the stream reaches its threshold and send another SMS once the stream flow is back to its normal speed.

3.3 Hardware Specification

Table 1 shows the different hardware and modules needed to develop the prototype. The primary component of the device is the Arduino microcontroller that will serve as the heart and brain of the prototype. This also serves as an intermediary between the other sensors and components to the complimentary software that will be developed. Other important components are water flow sensors that will read the water current speed and the xgbeeS2C that will aid in the transmission of data.

3.4 Respondents and Instrumentation

Respondents of the study were the City Disaster Risk Reduction and Management officials. The researcher utilized a questionnaire based on the IBM Computer Usability Satisfaction Scale. The questionnaire focused on evaluating the systems' overall usability.

4. Results and Discussions

The various components of the device have been successfully integrated and the connection between the
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transmitter and receiver was successfully established. The following figures were the result of the system integration and software development:

**Table 1. Hardware Specification**

| HARDWARE                      | SYSTEM MINIMUM REQUIREMENTS                     |
|-------------------------------|-------------------------------------------------|
| Microcontroller (Arduino)    | Atmega 328 Microcontroller                       |
|                               | Input Voltage 7-12V                             |
|                               | 14 Digital I/O Pins (6 PWM Outputs)             |
|                               | 6 Analog Inputs 32 K Flash Memory               |
|                               | 16 mHz Clock Speed                              |
| Sensor 1 & 2 (Water Flow Sensor) | Water Flow Sensor Flow Meter Hall              |
|                               | Flow Sensor Water Control 1-30L/min 2.0MPa      |
| Solar Panel                   | SV 0.2 W 40 mah DIY Sun Power Battery Solar Panel Module Cell Size: 50x |
| Xgbee S2C                     | ISM 2.4 GHz                                     |
|                               | 0.960 x 1.087 (2.438 cm x 2.761 cm)            |
|                               | Integrated Whip, Chip or U. FL Connector,       |
|                               | RPSMA Connector, RPSMA Connector                |
| Rechargeable Battery          | LG 18650 300 mah Flat Top                       |
| Charger Board                 | 5V Micro USB 1A 18650 TP4056 Lithium Battery    |
| Laptop                        | Lenovo Yoga 500                                 |
|                               | 4GB RAM                                          |
|                               | 64 Bit                                           |
| SmartBro Joystick             | Smart Prepaid                                   |
| Cellular Phone                | GSM                                              |
|                               | 103.5 x 45 x 15 mm                              |
|                               | 1.52 Inches, 7.5 cm²                            |
|                               | 128 x 128 pixels, 1:1 Ratio                     |

The Figure 4 shows how the ANDAM prototype simulates the water behaviour and replicates the water source in Brgy. Siha and Loom River. The Prototype will be situated near the water source where sensors will also be installed. The water flow sensors will determine the flow of the current and send its readings wirelessly to the ANDAM Prototype. Once, the current exceeds the normal flow, the device will send Short Message Service (SMS) warnings to the residents of the community where the prototype is installed.

The Figure 5 shows the complimentary app that was developed to receive updates from the device. The system monitors and tracks the reading of two sensors and is connected to a Short Message Service (SMS) module, ready to send once a critical reading has been captured by the water flow sensors.

**Figure 4. ANDAM Prototype.**

**Figure 5. Real-Time Monitoring Interface.**

### 4.1 System Evaluation Result

To evaluate further the overall usability of the device and the desktop application, end-user testing with the City Disaster Risk Reduction Management (CDRRM) Officials of Borongan City, was conducted using the IBM Computer System Usability Scale. A total of sixteen (16) DRR Experts evaluated the system. The testing resulted in a grand mean of 4.81 interpreted as Highly Usable. This implies that the end-users find the system's interface...
pleasant, found a fewer number of errors, found the data
grouped and was generally satisfied with the entire sys-
tem. This also implies that the users were able to complete
their assigned goals and tasks using the system.

5. Conclusion

Based on the results of the system development and end-
user testing, it was established that the prototype was able
to determine and calculate the water current speed of
the river from its source in Brgy. Siha. The system able
to record data from the calculated water current speed,
delete logs, add contact numbers, renew/update saved
contact numbers and delete contact numbers through
the aid of a desktop application and its database, and
send Short Message Service (SMS) to the saved contact
numbers as an early warning for an upcoming flood/
flash flood. It could be of great help to prevent or lessen
damages that the flood may bring. The end-user testing
resulted in an overall mean of 4.81 interpreted as highly
usable. Based on the result it signifies that the system has
passed the Software Quality Evaluation Tool based on
IBM Computer System Usability Scale.

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