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AUTOMATED RAINFALL MONITORING SYSTEM

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Abstract. The Barangay LGUs in Sorsogon City has a traditional way of monitoring flash floods during tropical storms. It strongly relies in the daily weather forecast issued by PAGASA, which somehow helps them to prepare earlier before a storm makes its landfall. With the rapid development of technology in electronics and ICT, the development of a system that monitors rainfall intensity was made possible. Included in the system developed is the capacity to monitor water level of bodies of water such as rivers with a move accurate data and more specific to the location of flash floods in the nearby Barangays. The researcher developed a more reliable, accurate, detailed and specific Automated Rainfall Monitoring System (ARMS). The proposed system is a great aid for Barangay residents to prepare and alert them in times of calamities where flash floods are imminent. The system also aids the LGUs and DRRM to increase their accuracy for rescue in the community in times of disasters such as typhoons and tropical depressions, informing them of locations possible for flash floods to occur. The proposed system is innovative in terms of reliability, user-friendliness, accuracy and maintainability.

The findings of the study depict that the system is applicable to Barangay Piot Sorsogon City and any Barangay in the Philippines suffering from flash floods caused by overflowing bodies of water such as rivers or lakes, having an overall mean of 3.7555. The components of the system are fully functional and are deemed to be essential to the entire operation of the system. The system was evaluated against its functionality, reliability, usability, efficiency, maintainability and portability.

Along with the positive findings of the study, the developer deems it necessary to implement the developed system to help the flood prone Barangays monitor flash floods, prepare, alert Barangay residents and inform DRRM accurately of specific locations where flash floods might occur. The Researcher believed that a reliable, user friendly and maintainable flood and rainfall monitoring system may minimize casualties in times of calamities whereby enhancing preparedness and alertness of Barangay residents and concerned citizens.

Key Words. Automated Rainfall Gauge, Automated Rainfall Monitoring System, Flood Monitoring, Monitoring System, Rainfall Monitoring System, System with Arduino, System with SMS, Ultrasonic Sensor, Weather System

INTRODUCTION

In this world, it sometimes seems like change is the only constant. Every day brings news of smaller computers, faster microprocessors, larger networks and smarter software. And as we think of new ways to put computer technology to work, our world becomes ever more computerized. In less than a human lifetime, the computer has transformed virtually every facet of our society – and the transformation is just beginning. The pace of the computer revolution has become so explosive that farfetched predictions routinely come true (Beekman, 1994)

Depending on the nature of the information that flows within an organization, a system may be closed or open. Closed systems do not have connections with other systems, thus, they stand alone. Open systems, on the other hand, interact with other systems as they exchange information. In a closed system, information does not flow in or out of the system; it stays within for use of the particular system only. As an element of a bigger system, a subsystem is always open, for it needs to give and receive information to and from other subsystems.

There are various definitions of an information system, but the most appropriate definition is that of Steven Alter which speaks that information system is a particular type of work system that uses information technology to capture, transmit, store, retrieve, manipulate or display information, thereby supporting one or more other work systems." A work system refers to any unit or system itself that produces output for internal or external customers through a process performed by human participants with the help of information technology. Although they have been synonymous to computerized systems, information systems are not necessarily electronically aided or computerized. Nevertheless, most systems nowadays interface with one another through a medium of information transmission. In the information system, this medium of system elements include the equipment, software, accurate date, personnel (that of the system or the users) and the documented procedures of the system (Albano, 2003).

Flooding is usually brought about by an increased quantity of water in a water system, like a lake, river overflowing. On occasion a dam fractures, abruptly releasing a massive quantity of water. The outcome is that a number of the water travels into soil, that 'flooding' the region.

Aside from lack of products and house and office property, streets infrastructure flood water consists of bacteria and sewage flow of waste sites and chemical spillage which leads to a variety of diseases afterwards. Flood predictions need information like: The speed of change in river stage on a real-time basis, which may help indicate the seriousness and immediacy of this threat. Understanding the form of storm generating the moisture, such as length, intensity and areal extent, which is valuable for discovering potential seriousness of the flood?

Flood disaster is one of the most common national disasters in the Philippines. The occurrence of floods has taken many victims. Flood disasters occur due to environmental imbalances carried out by humans such as forest destruction with forest exploitation irrespective of boundaries. The information system of the flood in the middle of society is still done by the conventional way that is by verbal delivery of related parties such as Disaster

Risk Reduction Management (DRRM), military and the police. A delivery system that has been applied by the community by using communication methods of communities is considered to still have weaknesses in terms of time and information.(Satria, et al, 2019)

Based on the information and communication system that has been applied by the society today, the government has implemented the development of monitoring system and early detection of natural disasters in general in the form of encouragement to the government and private research institution to be able to develop disaster early warning system. It aims to be able to mitigate and reduce disaster victims in general.(Natividad and Mendez, 2019)

Upon the entry of the 21st century, the Philippines was vulnerable to the effect of climate change or global warming, as typhoons became stronger than ever before such as Typhoon Yolanda hit the country in the year 2014 in which thousands of lives perished specifically in Tacloban City in the Province of Leyte due to storm surged. Millions of Peso worth of structures was damaged especially to agricultural and personal properties. The weather condition changed due to global warming. A longer period of draught and heavy rainfall was experienced in most of the months in a year.

Currently, the Philippine government funded a project known as NOAH of the Department of Science and Technology (NOAH). They installed Automated Rain Gauges (ARG) and Water Level Monitoring Stations (WLMS) along the country's major river basins (RBs). However, project NOAH is still under development in which some essential information are not yet available to view in their website. (Natividad and Mendez, 2019)

Most of these technologies being developed commonly apply in weather forecasting, flood detection and monitoring system using sensing devices, modeling software, Internet and mobile technology. However, these systems are usually for one-way communication only. In order to get an update or latest information, local communities need to access the website. And in accessing this website, it requires computer or smart phone that has an Internet feature, and most individual could hardly afford to purchase one. In addition to that, individuals are busy for their daily routine, and monitoring activity cannot be their priority. These are the reasons why communities are blinded with the current status of the nearby river watershed. The unawareness led to the overflow of the watercourses of the river waterway and the subsequent inundation of various localities causing extensive damages to properties and human life. The City of Sorsogon is located at the central portion in the province of Sorsogon. It has several Barangays that are prone to flooding due to overflowing of rivers such as Brgy. Piot, Brgy. Salog & Brgy. Sulucan. It has also several lowland Barangays that causes floods due to heavy rains such as Brgy. Rizal West District Sorsogon City.(Natividad and Mendez, 2019)

Some of the most affected Barangays in Sorsogon City during typhoon and heavy rains were Barangay Piot, Barangay Salog and Barangay Sulucan were residents near the river and low lands need to evacuate to avoid the overwhelming flood. Most of the residents, especially those houses with no 2nd floor flee to evacuation centers when the local authorities tell them to do so. Some of the residents stay in their houses where they have 2nd or 3rd floors. During floods, many personal properties were damaged such as motorcycles, cars, home appliances and many more because they could hardly predict the sudden rise of water level of the river especially during night time. Although, river control or river wall was built alongside the river, still the water overflows if there's too much rain coming from the highlands and springs. The after effect of the flood is miserable to the residents of Barangay Salog because lots of muds and sands must be cleaned up, both in their houses and streets.

Rain and Evacuation Monitoring System was conceptualized because it is a timetable response to the needs of Flood prone Barangays. This research aimed to save lives, personal properties and to enhance residents' alertness during calamities like typhoons and heavy rains caused by tropical cyclones. It is also a great aid to civil defense authorities, residents of Barangay and DRRMM to provide them accurate and timetabled information on possible severe flooding caused by heavy rains that may result to overflowing of waters near the river.

The system required desktop computer as the central computer or server, Wireless router, Arduino microcontroller, GSM modems and automated rain gauge (ARG) as its hardware requirements. The preferred software used in the system was Windows OS (Windows 10 or Windows server 2008) and application software using Visual Basic.Net.

General Objectives

The main objective of this project is to design and develop a Rain and Evacuation Monitoring System.

Specific Objectives

Specifically, the study aimed to:

1. design and develop a rain and evacuation monitoring system that:
    - 1.1. monitors the rain level in the river banks using open-source electronics platform called Arduino, with Automatic rain gauge (ARG), Ultrasonic Sensor and Hygrometer;
    - 1.2. sends alerts via short message service (SMS) to the server that indicates the real-time situation of the rain level to flooded areas;
    - 1.3. evaluates and send alarm to the community.
2. evaluate/validate the proposed system using industry accepted quality standards in terms of:
    - 2.1. functionality
    - 2.2. reliability
    - 2.3. usability
    - 2.4. efficiency
    - 2.4. maintainability
    - 2.5. portability

Table 3.8 – Project Development Time Frame

Task	August				September				October				November				December			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Requirements Planning																				
Researching the current problem																				
Defining the requirement for the project																				
Finalizing the requirements with each stakeholder's approval																				
User Design																				
Prototype Iteration Test Refine																				
Rapid Construction																				
Preparation for Rapid Construction																				
Program and application development																				
Coding																				
Unit, integration, and system testing																				
Cutover																				
Final debugging																				
Ready for launching																				

Table 3.8 – Project Development Time Frame is displayed. The researcher planned this in order to finish the system on the desired time.

Analysis and Quick Design

Analysis and quick design were the first phase in the methodology of this study. It was a process of collecting and interpreting facts, identifying the problems, and decomposition of a system into its components. It is also the part wherein existing system was being analyzed. Analysis was made for the purpose of studying a system or its parts in order to identify its objectives. It was a problem-solving technique that improved the system and ensured that all the components of the system work efficiently to accomplish their purpose.

First activity made by the developer was to visit the Barangay Local Government Unit (LGU) office to conduct a casual interview regarding the flood prone areas in Barangay Piot, Sorsogon City. The researcher confirmed that there is a chance that waits for enhancing the awareness and preparedness of Barangay residents, severely affected by flood. The usual way of becoming aware from incoming typhoon, tropical depression or low-pressure area (LPA) relies on the daily weather forecast issued by PAGASA. With the development of internet, barangay residents was able to track the location, direction, gustiness, speed and rain intensity of a storm, several days before a storm would be able to hit a certain region from all over the country. The Disaster Risk Reduction Management (DRRM) also send early warning messages, storm signal of every province affected by upcoming storm and the possible effect of the storm in the affected region to all Telco subscribers in the area affected by the storm through SMS.

Prototype Cycles

Prototype Cycles were important to the developer. This was the phase where the developer thought about the solutions in a different way (tangible product rather than abstract ideas), as well as to fail quickly and cheaply, so that less time and money is invested in an idea that turns out to be a bad one. There were three main activities in prototype cycles: build, refine, and demonstrate. After the casual interview the researcher prepared the necessary things needed in the development of the project – that included the preparation of the software and hardware requirements, likewise the diagrams of the planned system for easy development. There were several researches made and documentation while prototyping. The researcher went to IT experts thrice to secure their feedback on the developed system. Until the project study was ready for testing and evaluation of the stakeholders and IT experts.

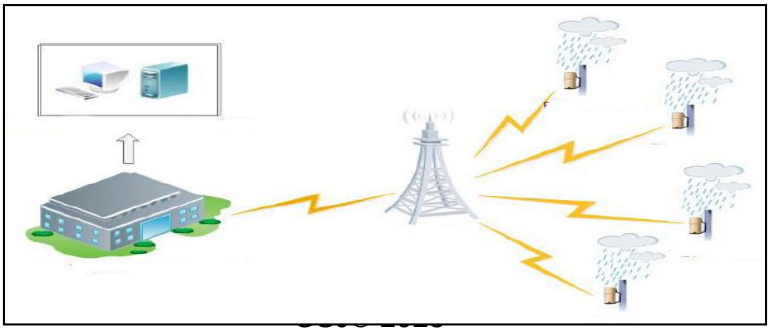

Figure 4.2 - System Architecture of the Developed System

Figure 4.2 reflects the system architecture of the developed Automated Rain Monitoring System for Barangay residents specifically Barangay Piot, Sorsogon City. The communication between the data acquisition system going to the data storage, while processing and alerting system is done thru SMS. The decision if the central computer will send alert message to the Barangay residents, LGU and DRRM, is based on the threshold value from the parameters sent by the data acquisition system.

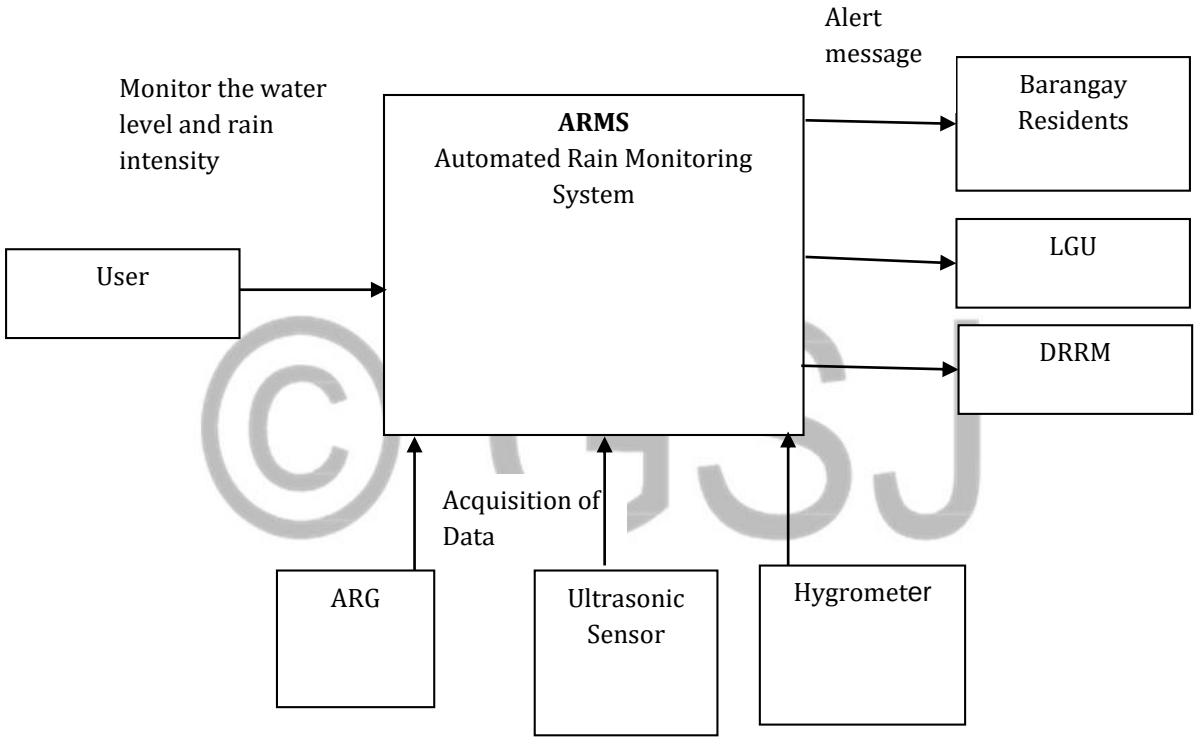

Figure 4.3 - Context Flow Diagram of the Developed System

Figure 4.3 the context flow diagram depicts of the Automated Rainfall Monitoring System. The user monitors the intensity of the rainfall, water level, temperature and humidity of a specific location by using the developed system. The data acquisition system will send updates of data regarding the water level and rainfall intensity in every 5 minutes thru SMS to the central computer. The data processing and alerting system will also send SMS to the Barangay residents, LGU and DRRM with the use of a USB to serial GPRS modem.

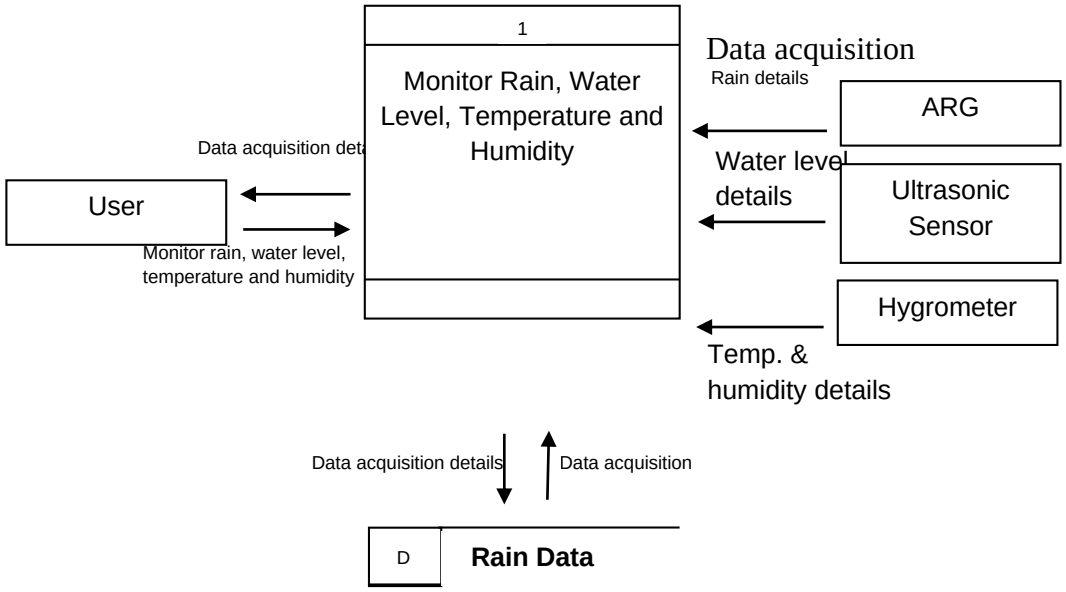

Figure 4.4 - Data Flow Diagram (Rainfall Monitoring)

In Figure 4.4 displays the data flow diagram of the developed system. The user monitors the rain, water level, humidity and temperature with the aid of the system. The system provides the user with data acquisition details. The data acquisition equipment (ARG, Ultrasonic and hygrometer), gives details on the status either it's time to send alert messages or just monitoring the rain, water level, humidity and temperature details.

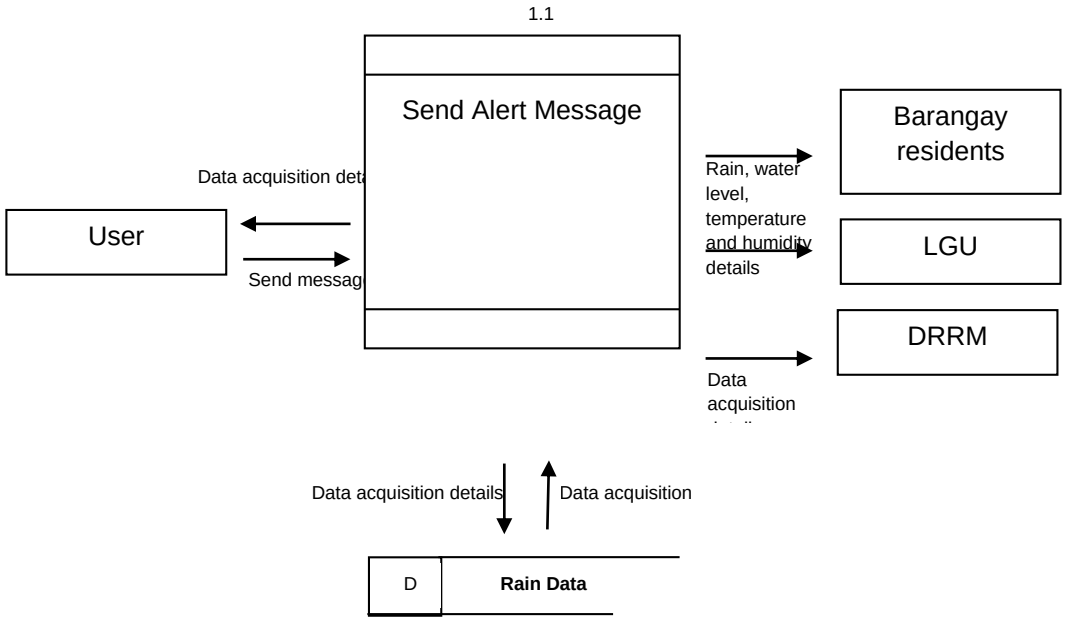

Figure 4.5 - Sending Alert Message DFD

Figure 4.5 shows the data flow diagram of the Sending Alert Message from the developed system to the recipients.

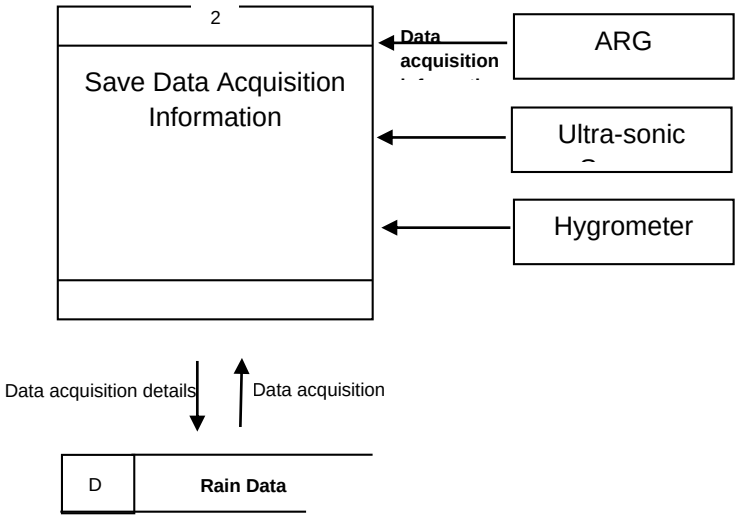

Figure 4.6 - Save Data Acquisition Information

Figure 4.6 displayed the data flow diagram of the save data acquisition information from the sensors to the developed system.

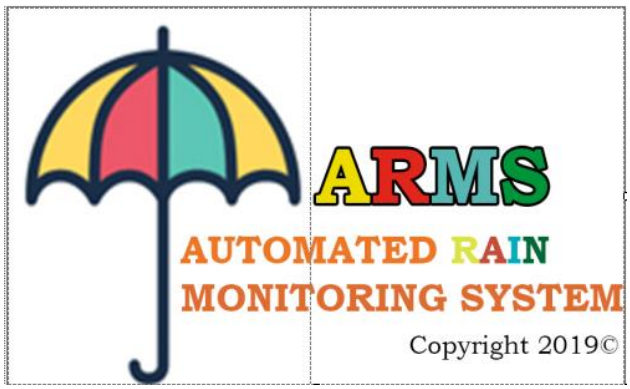

Figure 4.7 Splash Screen of ARMS

Figure 4.7 depicts the Splash Screen or the graphical control element consisting of a window containing an image, a logo of the developed system, the Automated Rain Monitoring System.

Figure 4.8 - The Data Acquisition System (Prototype)

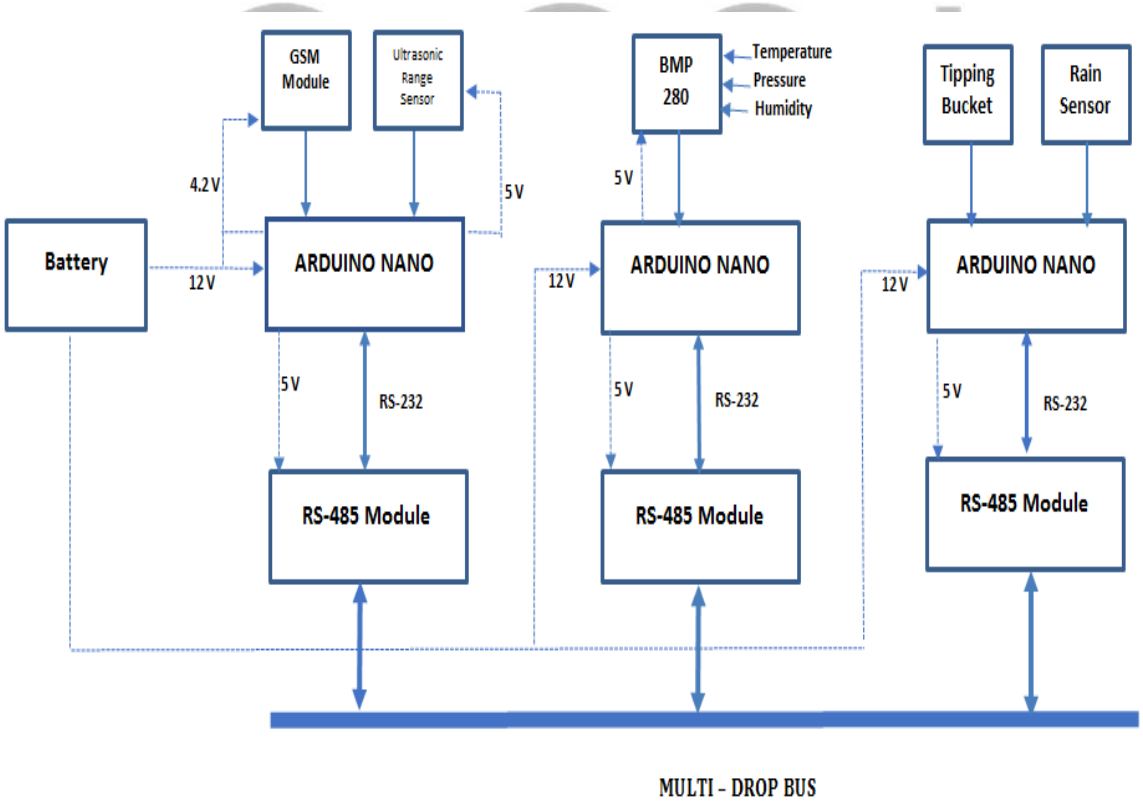

Figure 4.9 -Block Diagram of Data Acquisition System

Testing

System Testing is a level where a complete and integrated software or hardware is tested. The purpose of this test was to evaluate the system's compliance with the specified requirements. It was tested against the requirements to make sure the system is meeting customer needs. The researcher made sure that unit testing, integration testing, system testing, and acceptance testing where done and had a complementing feedback. The proponent used statistical tools to get the information organized and had a general view of the whole scenario of the study.

This included Frequency, used in order to determine the most dominant variable/s in the data, such as the current methods used, problems encountered and possible solutions. Ranking was used in order to determine the order of priority of the variables, the scaling system and weighted mean which was used by the proponent as a technique to monitor the respondent's interpretation of facts.

The formula used to determine the weighted mean was:

$$\text{Weighted mean} = \frac{\mathrm{F}_1(1)+\mathrm{F}_2(2)+\mathrm{F}_3(3)+\mathrm{F}_4(4)+\mathrm{F5}(5)}{\mathrm{F}_1+\mathrm{F}_2+\mathrm{F}_3+F_4+F_5}$$

Table 4. 1. - The Evaluation Rubrics

Interval Scale	Description	Interpretation
4.1 – 5.0	Highly Applicable	The system efficiently and effectively satisfied all quality model characteristics in terms of functionality, reliability, usability, speed and maintainability
3.1 – 4.0	Very Applicable	The system efficiently and effectively satisfied some of the quality model characteristics in terms of functionality, reliability, usability, speed and maintainability
2.1 – 3.0	Applicable	The system minimally satisfied all quality model characteristics in terms of functionality, reliability, usability, speed and maintainability
1.1 – 2.0	Slightly Applicable	The system hardly satisfied the quality model characteristics in terms of functionality, reliability, usability, speed and maintainability
1.0 or less	Not Applicable	The system did not meet quality model characteristics in terms of functionality, reliability, usability, speed and maintainability

The system evaluation was anchored on the ISO 9126. The areas that were evaluated in the developed system were the functionality, reliability, usability, efficiency, maintainability, and portability. Thus, the results were presented in series of tables below.

The two (2) sets of respondents provided insights on the overall quality of the system. These respondents were ten (10) IT Experts, three (3) Barangay officials from Barangay Piot Sorsogon City. The respondents evaluated the system using the five-point scale system reflecting One (1) as the lowest and Five (5) as the highest.

Table 4.2. - Table of Verbal Interpretation

Mean	Verbal Interpretation
0 – 1.0	Absence of the Expectation
1.1 - 2.0	Less than what is expected
2.1 – 3.0	Presence of the expectation
3.1 – 4.0	More than what is expected
4.1 – 5.0	Far more than what is expected

Table 4.9 - Overall Evaluation of the Automated Rainfall Monitoring System

Quality Characteristics		Section Mean	Interpretation
1.0	Functionality	3.33	More than what is expected
2.0	Reliability	3.5315	More than what is expected
3.0	Usability	4.00	More than what is expected
4.0	Efficiency	3.6965	More than what is expected
5.0	Maintainability	3.975	More than what is expected
6.0	Portability	4.00	More than what is expected
	Overall Mean	**3.7555**	**More than what is expected**

Table 4.9 displayed the rating of the ten (10) IT professionals who were consulted and requested to test and evaluate the system. Each one had its own opinion in giving points. The lowest rate is 3.33 in the section of the system's functionality because on the time it was evaluated by some of them, the system is not yet in its hundred percent conditions. The highest rate was the Usability and the Portability; both received 4.00 rates which mean that the developed system is "Far more that what is expected" of it. With an overall mean of 3.7555, the developed system can be used where it is intended for.

Implementation

After all the evaluation and testing conducted by the three (3) barangay officials from Piot, Sorsogon City, and ten (10) IT experts in the three provinces of Albay, Sorsogon, and Camarines Sur, the Automated Rainfall Monitoring System (ARMS) may be implemented in the place where it can be of help. But since this is a capstone project for the MIT degree, any individual or community who is interested to implement this will communicate first to the developer and the Aemilianum College Inc. before the implementation.

Summary of Findings

During the development and after testing and evaluation of the developed system the following findings have been established:

1. The barangay Piot, Sorsogon City was using a traditional method of preparing, alerting and informing Barangay residents in upcoming flood or disaster which has a heavy reliance on PAGASA daily weather forecast and DRRM advisory. The development of the Automated Rainfall Monitoring System was applicable to the monitoring of flash floods in flood prone Barangays in the city after having a 3.7555 overall mean in the evaluation result among the respondents. With such results in evaluation, the developed project is appropriate to the needs of the flood prone barangays.
2. The component parts are fully functioning and essential to the entire operation of the system. The Short Message Service (SMS) and the Graphical User Interface (GUI) aid the monitoring activity of the system.
3. Barangay Piot LGU of Sorsogon City considered their preparation and alerting activities as normal but needs improvement because they really needed an accurate and exact monitoring of rain intensity and water level specific to a certain location.

Conclusions

Based on the findings of this study the following conclusions are formulated:

1. The developed system is considered to be “Very Applicable” as perceived by the different respondents. The developed system is serviceable to the Barangay Local Government Unit (LGU) of Sorsogon City. The Barangay residents whom are vulnerable to flash floods during tropical storms were the immediate beneficiaries. The system has functions and features that can be easily learned by the user.
2. The developed Automated Rainfall Monitoring System passed the International Organization for Standardization (ISO) 9126 – (which is concerned primarily with the definition of quality characteristics to be used in the evaluation of software products). Having been evaluated with an overall mean of 3.7555, the system is therefore deemed to be very applicable to be installed.

Recommendations

Based on the conclusions the following recommendations are hereby offered.

1. The current alerting system in Barangay LGUs in Sorsogon City may be improved through the implementation of the project study entitled: Automated Rainfall Monitoring System for Barangay residents specifically Barangay Piot, Sorsogon City.

2. Additional functionalities may be studied and integrated in the new Automated Rainfall Monitoring System to greatly improve the services offered.
3. Additional Automated Rain Gauge can be integrated in the system for the purpose of a broader coverage of monitoring the rain fall.

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