Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 7, July 2021: 3291-3303

Evaluating the technical and social viability of Water Level Monitoring of San Jose, Camarines Sur

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Abstract

This paper describes the technical and social viability of water level monitoring system of San Jose, Camarines Sur. A flood monitoring device was also developed as new proposed system for better water level monitoring management. The proposed device was also evaluated in its functionality, usability and accuracy aspects.

The results show that the average percentage error of the water level device was 6.483% comparing the actual measurement and the measurement of the proposed device using centimeter as unit of measurement. The functionality and usability aspects also yielded highly acceptable results having a means of 4.7 and 4.9 respectively in its IT experts' evaluation ratings.

This means that the proposed system will be of great help to the community and to the Local Government Unit for effective and efficient monitoring and management of water level measurement and information.

Keywords: MDRRMO, Arduino, social viability, rain gauge monitoring, water level marker.

INTRODUCTION

The Municipality of San Jose. Camarines Sur is located at southern part of the province and composed of 29 barangays. The municipality belongs to Type II Climate characterized by the absence of a dry season and very pronounced maximum rainfall from November to December. It is during these months that the Northeast monsoon season occurs and the tropical cyclones contribute to the increased rainfall in the area. In January and February, the effect of these air masses on rainfall is considerably radical. In addition to the north-east monsoon during the months of February and March, the trail winds traveling from East to West do not give significant increase of rainfall. Likely, the month of May is the transition period between the monsoon that is prevalent from June to September. During the south-west monsoon season, the linear system called the Intertropical Convergence Zone (ITZ), brings the largest amount of rainfall to the area. In October, which is the transitive period between the south-west and north-east monsoons, the tropical cyclone brings considerable amount of rain.

The rainfall distribution in the municipality is greatly influenced by the air streams, tropical cyclones, the Intertropical Convergence Zone, shorelines, easterly waves and other rainfall-causing weather patterns. The rainfall season occurs from June to December with high rainfall intensity of 285.06mm to 474.22m and less rainfall intensity of 245.30mm to 224.06m from January to the month of May which at the same time is the onset of effective rainfall with 75% probability and it would terminate in February of the following year which consequently during this period the mountainous areas receive higher intensity of rainfall. But the trend of monthly rainfall is unimodal (having one peak) and the maximum rain period is from October to December. On the other hand, the monthly average rainfall varies from 125.86mm to 594.56mm with a mean annual rainfall of 298.54mm.

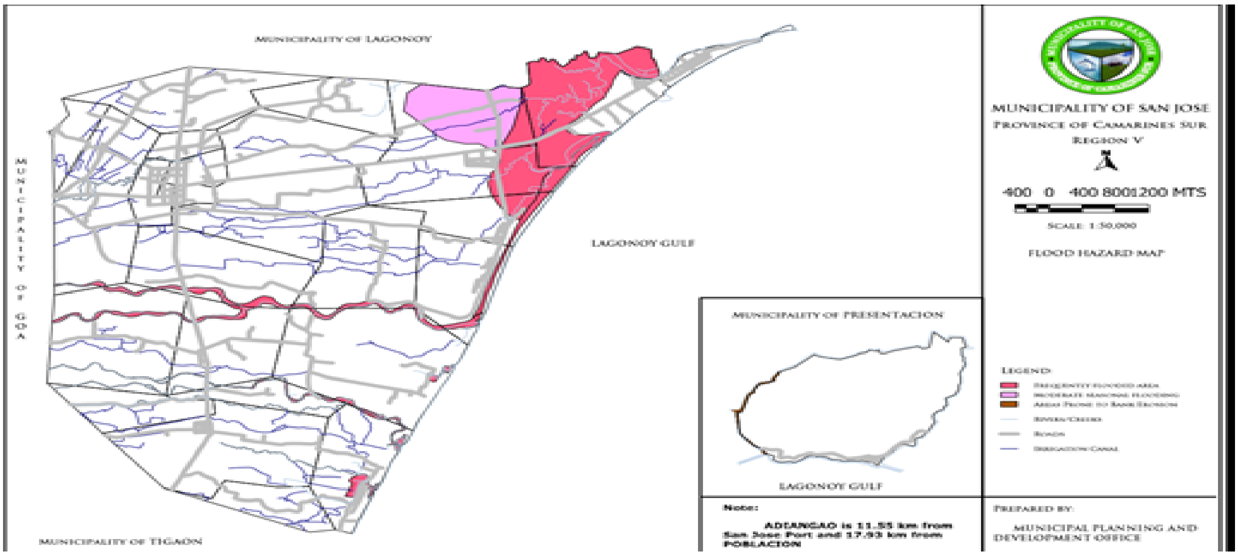

Figure 1. Flood Hazard map of San Jose

The winds are influenced by the monsoon and the Pacific Trade System with Northeast direction that occurs in November to February; Easterly winds during the months of March, April, May and October; Southwest winds in June to August; and Westerly winds in September.

It has been noted that most of the municipal area or 92.14% is free from the hazards of flooding. However, there is a slight seasonal flooding or about 1.67% that usually occur in barangay Minoro and in the northern part of Dolo which covers about 78.54 hectares. The flood reaches a depth of less than 0.5 to 1.0 meter after heavy downpour. It would usually recedes within 12 hours to a maximum of one day. Likewise, seasonal flooding is moderately experienced in some portions of barangays Dolo, Manzana, Kinalansan, Telegrafo and Calalahan with a depth of about 0.75 to 1.50 meters which would usually recedes within a few days only.

Mapping Symbol	Descriptions	Area (in Has.)	% to Total
F0	No flooding	4,333.1734	92.14
F1	Slight Seasonal Flooding	78.5370	1.67
F2	Moderate Seasonal Flooding	291.1042	6.19
	Total	4,702.8146	100.00

Source: *Municipal Comprehensive Landuse Plan & Zoning Ordinance (2000-2010)*

Table1. Area Distribution by Flooding Hazard

Several floods happened in these areas during the typhoon that resulted to loss of life and property. Monitoring the level of the water in these areas is done by actual looking at the sea water level and personally observing the constructed concrete water level monitor which is located near the sea shore or at the area where floods occurred, it has been observed that the municipality of San Jose utilized the Department of Science and Technology rain gauge monitoring located at barangay Catalotoan, San Jose, Camarines Sur. This water rain gauge monitors the volume of rain occur in the area and sent the data to the central Station of DOST in the south Luzon area and from DOST Central Station sent it to Municipal Disaster Risk Reduction Management Council of San Jose and this data relay to the Punong Barangay of the affected area.

Figure 2. Water Rain Gauge Monitoring device located at Catalotoan, San Jose, Camarines Sur

This study attempted to evaluate the technical and social viability of water level monitoring of San Jose, Camarines Sur. It is also included the development of a water level monitoring device that can help people of the flooded prone areas in the municipality of San Jose be warned and informed by sending alert through messaging of the water level update.

There are three levels of warning; these are the minor level, moderate level, and the major level. When the water level reaches the minor level, the device will send SMS which has this message. "Water level reached its minor level please stay at home". When the water level reaches the moderate level, the device will send SMS which has this message "Warning! The water level reached the moderate level, please prepare, evacuation is possible at any time!" And when the water level reaches the major level, the device will send SMS which has this message "Alert! The water level reaches the critical level, please evacuate immediately". The device will be supplied by solar power.

ALSglobal.com. (2017), in the their literature entitled, "Monitoring and Technical Services Systems for Water Level, Flow and Quality" stated that, it has become increasingly important to be able to accurately measure and report the volume and quality of the world's water resources. This is so we can adequately plan for future growth, either for potable consumption or to determine sustainable water supplies for production in industry and agriculture[1]. The cited literature above is relevant to the present study because the researcher aims also to have an accurate measure and report of volume of water in the Municipality of San Jose, Camarines Sur.

Omar Munyaneza, et al (2016), in their literature - "Water Level Monitoring Using Radar Remote Sensing Data: Application To Lake Kivu, Central Africa" narrates that Satellite radar altimetry measures the time required for a pulse to travel from the satellite antenna to the earth's surface and back to the satellite receiver. Altimetry on inland lakes generally shows some deviation from in situ level measurements. The deviation is attributed to the geographically varying corrections applied to account for atmospheric effects on radar waves. This study was focused on verification of altimetry data for Lake Kivu (2400 km^2), a large inland lake between Rwanda and the Democratic Republic of Congo (DRC) and estimating the lake water levels using bathymetric data combined with satellite images[2]. This literature is significant to the present study because the present study needs also calculation of the travel of the data from the monitoring system to the recipients. There is a need to study the speed of the proposed system to have an efficient output.

Adam Fendelman (2017) in his article entitled: “An Explanation of SMS and Its Limitations” that SMS stands for short message service and is used pervasively around the globe. In 2010, over 6 trillion SMS texts were sent, which was equivalent to around 193,000 SMS messages every second. (This number was tripled from 2007, which saw just 1.8 trillion.) By 2017, millennials alone were sending and receiving nearly 4,000 texts every month. The service allows for short text messages to be sent from one cell phone to another or from the internet to a cell phone.[3] The aforementioned cited article is significant to this study because this monitoring system needs the short message service the information dissemination. There is a need to study the efficiency of the SMS in terms of information dissemination.

MenuInc (2017), in their article: “Management Information System”, narrates that A management information system (MIS) is a computerized database of financial information organized and programmed in such a way that it produces regular reports on operations for every level of management in a company. It is usually also possible to obtain special reports from the system easily. The main purpose of the MIS is to give managers feedback about their own performance; top management can monitor the company as a whole. Information displayed by the MIS typically shows "actual" data over against "planned" results and results from a year before; thus it measures progress against goals.[4] As a computer-based system, it makes information available to users, who, in some ways or another, have similar needs. Typically, users of information are the organizations or a subsidiary subunit. The information that may be obtained from a computer-based system describes the organization or any one of its major systems. The description may be in terms of what has happened in the past, what is currently happening, and what is to happen in the near future[5]. The aforementioned articles is vital to the study. The project is also about information management that is significant to the recipients of the project. Regular monitoring and efficient service are vital, thus, the researcher needs to carefully study the components pertaining to information management.

Tarra Quismundo (2012) in her article – “DOST Undertakes Flood Prevention and Mitigation Project”, states that the National Flood Monitoring Program has been initiated on a directive from President Benigno Aquino III "to step up national efforts toward greater and more intensive disaster risk reduction and management procedures in the wake of Storm Sendong." [6] The relevance of the aforementioned article to the study is the aim of good service to the stakeholders – precautions and safety. The researcher must give an output which will give benefit to the stakeholders.

According to ABS-CBN Corporation (2009), in their article – “UP Scientists Inventing Flood Warning Systems”, narrates that Manila - Scientists at the University of the Philippines (UP) - Diliman are pitching in on efforts to improve the country's landslide and flood-warning systems. Dr. Sandra Geronimo-Catane, a respected geo-hazards expert, has clinched funding from the Department of Science and Technology for a 3-year project that seeks to create cheap but effective gadgets for flood and landslide monitoring.[7]

Recognizing the need for operational flood forecasting and warning system to help mitigate losses of life and property brought about by annual occurrences of flooding, the Government piloted a Flood Forecasting and Warning System (FFWS) for the Pampanga River Basin in 1973. The project was established with the financial assistance from the Government of Japan, the warning system proved effective than it led to the establishment of a similar system covering Agno, Bicol and Cagayan River Basins.[8] The need to create a solution to the flood problem in Manila is vital. That is how this article motivates the researcher in pursuing the project. The flooded area in the Municipality of San Jose needs to have a better solution to avoid flooding that will caused waste of life in the affected area.

Materials and Methods

This study used the descriptive method of research in the context of system development. Descriptive was used in discussing the results of the testing phase while developmental will be use during the system development. The data will be analyzed using the percentage technique and arithmetic mean after conducted the testing of the water level monitoring and Text Messaging.

Sources of Data

This research aims to evaluate the technical and social viability of the water level of the Municipality of San Jose, Camarines Sur and develop water level monitoring device and an applications support that will provide monitoring and alarm to the flooded prone areas of the municipality. The proponents shall conduct interviews one-on-one or with a small group. The interviewees would be coming from the Municipal Disaster Risk Reduction Management Office and the Local Government Unit (Barangay level).

Data Gathering Instrument

The proponents formulated survey questionnaires and interview questions for data gathering. These tools helped the researches to acquired data that was used in the study. Survey questionnaires were used in the data gathering. These are carefully formulated, set, and arranged by the researchers. The questionnaires were given to the respondents which will also be collected back to systematically evaluated and tabulated the respondent's answer. The researchers were also visited the office of the Municipal Disaster Risk Reduction Management Office to conduct interview and also visited the rain gauge monitoring device at barangay Catalotoan, San Jose, Camarines Sur and have an interview with the officer in-charge during the visit (Hon. Kagawad Noel Contigno). The conducted interviews, authorized by the respondents, will serve as legal references for the researchers. All these data collecting paraphernalia were solely used for the purpose of the study.

Data Gathering Procedures

The researchers seek approval from the concerned government agencies (MDRRMO) to make this study possible. Random people were also asked to answer the survey questionnaires. Survey questionnaires were given to random people to check the significance of the study to be conducted. Researchers were also conducted interviews to different local government unit officials who are in the flooded prone areas of this municipality. The data that were collected during the said process helped the researcher to evaluate the technical and social viability of the water level to make appropriate generalizations.

Statistical Treatment of Data

The following statistical treatments were used to treat the data:

Weighted Mean. Unbiased treatment and different observation were given conforming to their varying relative performance.

Formula:

$$\boldsymbol{WM} = \sum \boldsymbol{f x}\ \boldsymbol{N}$$

Where:

WM = weighted mean

f = frequency of score

x = raw score

N = total number of respondents

This formula was used to determine the accuracy of the developed device for water level monitoring

$$\text{Average Percentage Error} = \frac{\textit{Average True Value} - \textit{Average Experimental Value}}{\textit{Average True Value}} \times 100$$

System Development Methodology

Inception. This is the planning cycle of the system development wherein the researcher developed a water level monitoring device with SMS capability.

Elaboration. In this cycle, the researcher designed the requirements needed in system development. Included were the system components, system architecture, contextual diagram.

Construction. The researcher l utilized open-source programming language. Additional tools for the software development kit (SDK) were used such as water level sensor, Arduino board, and GSM modem. Debugging and testing of the program for fixing bugs or errors of the design was done in this cycle. Finally, the system will be release and test as beta version thru conducting a pilot test for several days.

Transition. After the beta testing, minor refinement was done to integrate corrections of bugs and the users' feedbacks which were focused mainly on fine-tuning of system, configuring, installing, and usability issues. In this cycle, the researcher assured of the usability of the system to its target clienteles.

System Design

A. System Architecture

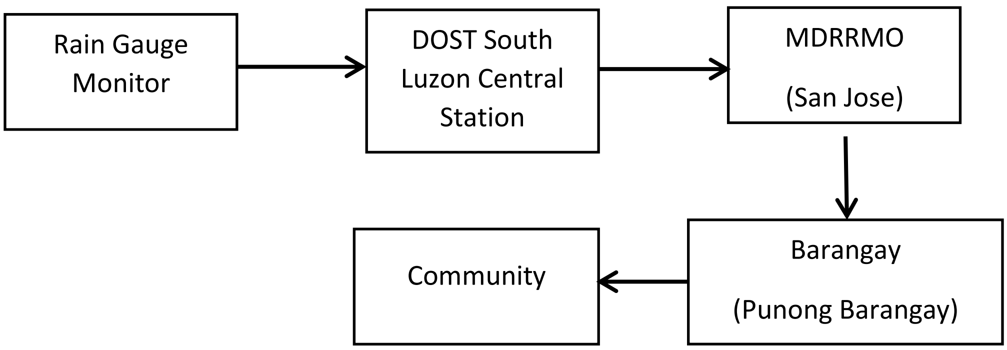

Figure3. Current Water Level Monitoring System Architecture

This current water level monitoring system of San Jose is located at barangay Catalotoan is a project of the Department of Science and Technology and the local government unit of San Jose through its Municipal Disaster Risk Reduction Office (MDRRMO). The function of this system is to measure the volume of rain water in the area. And when the certain limit is reached, this system is automatically send the data (water level) through an sms to the DOST South Luzon Central Station for validation and sent it to MDRRMO of this municipality for them to relay this message to the Punong Barangay or person in-charge of the monitoring of water level of the flooded prone area of San Jose. Then, the punong barangay will execute the proper evacuation process if it is needed.

Another water level monitoring used by the municipality is the traditional water level monitor which is the concrete marker painted with the meter level of different colors that served as the basis for monitoring.

Figure4. Water Level Monitoring located at Barangay Tagas, San Jose, Camarines Sur

Figure 5. Water Level Monitoring located at Barangay Dolo, San Jose, Camarines Sur

Figure 6. Water Level Monitoring located at Manzana, San Jose, Camarines Sur

Figure 7 shows the proposed water level monitoring that capture the need of the community in which this technology can monitor the water level directly from the affected area and send a warning through an sms to the MDRRMO and to the Punong Barangay directly.

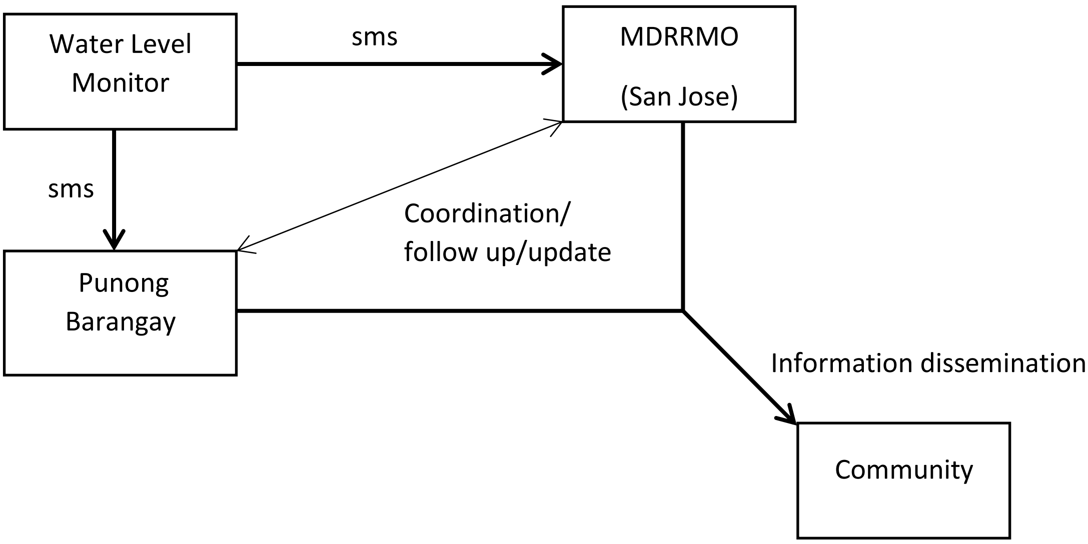

Figure 7. System Architecture of the proposed water level monitoring device

B. Hardware Level Architecture

The hardware design of the proposed water level monitor was shown in figure 8. This is composed of the different electronic devices that communicate to each other through program code embedded to the microcontroller. The following are the different parts that comprises the water level monitor: 1. Arduino Microcontroller, this is a small computer that capable of performing actions based on the program code embedded and able to handle and control different electronic device connected to it. In short, this is a programmable device used in robotic technology; 2. GSM/GPRS Module or modem, this part is used to send sms and this is directly connected to Arduino microcontroller; 3. Ultrasonic Sensor is used to monitor the distance of any object including water from it; 4. Satellite/antenna used as the access point of the system to send information to the server or recipient; 5. Broadband modem is used to receive the messages sent by the water level monitor and 6. Computer or Cellular phone that serve as the monitor and capable of sending the messages sent by the water level monitor to the desired recipient.

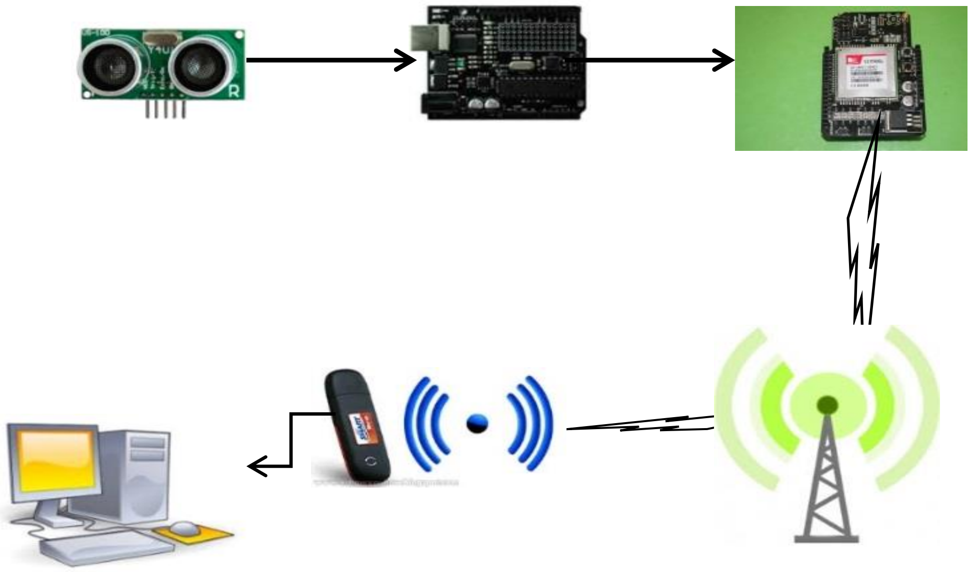

Figure 8. Hardware Architecture of the proposed water level monitoring.

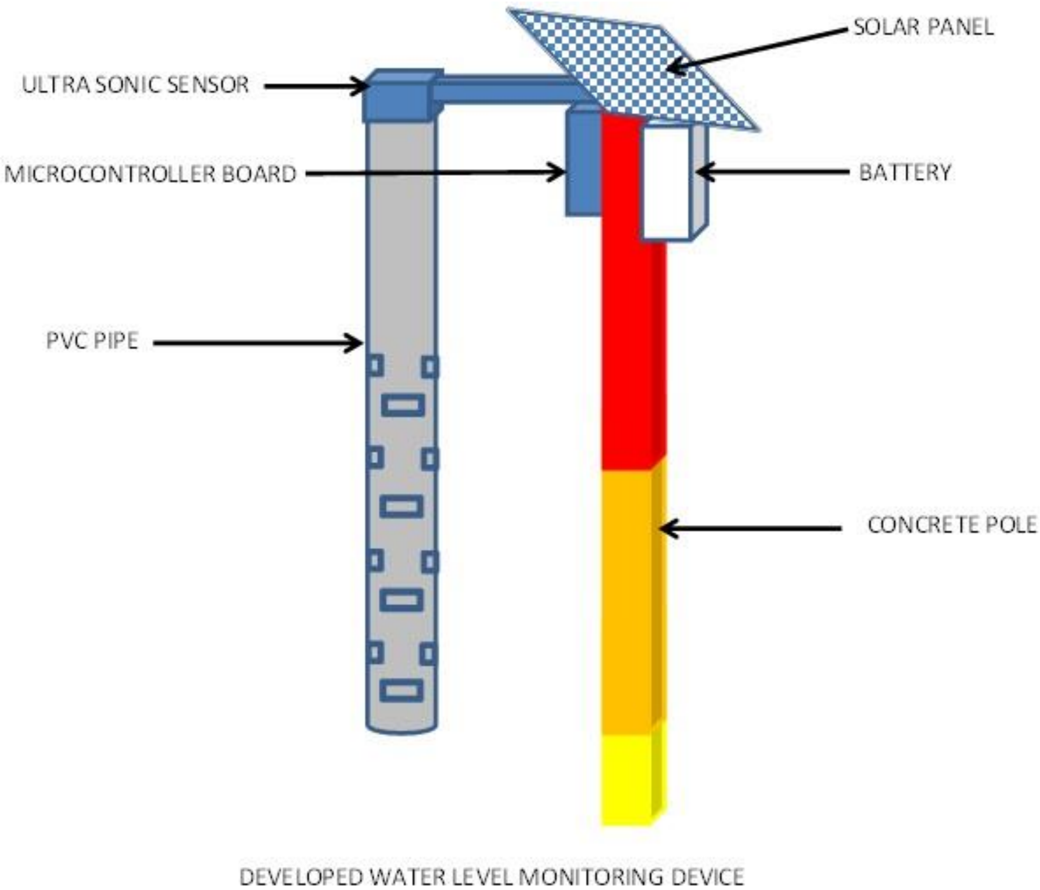

Figure 9. Design of the developed water level monitoring device

Results and Discussions

The present water level monitoring of San Jose, Camarines Sur was based on the manual monitoring of the Municipal Disaster Risk Reduction Management Office by personally looking at the flooded prone areas during rainy days through personal observation at concrete marker installed at the area or by the local government official informing them about the water level situation. They also used the DOST Rain Gauge Monitoring system located at Barangay Catalotoan, San Jose, Camarines Sur, this system monitor the rainfall capacity by measuring the volume of rainfall in that area and send the data to the DOST South Luzon central station for verification and authentication then send through sms to the MDRRMO San Jose as alarm or early warning regarding the possibility of having a flood. This Rain gauge monitoring system can only monitor rain water volume in a particular area but not all the areas with flood concerns. Municipality of San Jose, Camarines Sur is always experiencing scattered rainfall. So this kind of device may not give exact water level monitoring to the flooded prone areas of this municipality.

This study confirm the works of the UP Scientists as they invented the Flood Warning Systems wherein this study focused on flood-warning device as to the same to the present work that initiates the early warning for the flooded prone areas of the municipality of San Jose, Camarines Sur. The work of the UP Scientist was piloted Pampanga River Basin which is called as Flood Forecasting and Warning System (FFWS).

The paper published by ALSGlobal.com (2017) confirm the present study wherein this research paper aims to measure the water level and volume that can be make as the basis for an early warning for the flooded prone area.

Table 2. Reading comparison between the Actual Measurement and the Water Level Sensor

Actual Measurement (cm)	Using Sensor (cm)
50	57.15
50	57.15
100	104.14
130	133.35
150	159.33

Table 2 showed the reading comparison between the sensor and the actual testing. Testing distance is from 0 to 450 centimeters. The testing was conducted in a controlled setup that contains a water drum then the researcher varies the amount of water to correspond different level height.

The average of percentage error of the water level sensor is 6.483%.

Computation:

$$\text{Average Percentage Error} = \frac{\textit{Average True Value-Average Experimental Value}}{\textit{Average True Value}} \; X\ 100$$

$$AVP = \frac{(50+50+100+130+150)-(57.15+57.15+104.14+133.35+159.33)}{(50+50+100+130+150)} \; X\ 100$$

$$AVP = \frac{96 - 102.224}{96} \; X\ 100$$

AVP = 6.483%

Table 3. Summary of Result

Parameters	**IT Experts**	**MDRRMO/LGU Staff**	**Mean**
Functionality	4.7	4.7	4.7
Usability	4.8	4.9	4.9

Table 3, shows the result of the evaluation conducted by ten (10) IT Experts and five (5) MDRRMO/LGU Staff. The proposed system was rated in terms of its functionality with a mean of 4.7 which means highly acceptable and usability have a mean of 4.9 which is also means highly acceptable.

Conclusion and Recommendation

The study is about evaluating the technical and social viability of water level monitoring of San Jose, Camarines Sur. It sought answers to the following objectives:

1. Evaluate the present flood monitoring system
2. To design and develop a water level monitoring device
3. To evaluate/validate the developed system in terms of :

3.1 functionality;

3.2 usability;

3.3 accuracy

The Proponent did researching through different government agencies and through comparisons of different water level monitoring devices and applications. Researcher reviewed how the government distributes water level especially flood related information specifically through the project NOAH. Project NOAH was focused on the flood warning devices. Another comparison was made through the rain gauge monitoring that is located at Barangay Catalotoan of the municipality of San Jose. The Rain Gauge monitoring device is designed to monitor the rain water by measuring the volume of water of the specific rain that occurs in the area was this device is installed. After capturing the level of rain water the device will send the water level data to the Department of Science and Technology South Luzon command center which is located at Quezon province for authentication and it will send to the MDRRMO of the Municipality of San Jose. Upon receiving the data through sms, the MDRRMO will now sent the data to the Punong Baragay of the affected areas. The comparisons were done to give the proponent basis in making the prototype. Next, proponent search information on the accuracy of ultrasonic sensors that shall determine the water level reading. Upon completion, the researcher executed accuracy testing of the water level sensor and the responsiveness of the application software.

The proponent of this project follows the descriptive research methodology to evaluate the present water level monitoring of San Jose, Camarines Sur that includes Data Gathering Procedures and Statistical treatment and analysis. The proponent also adopts the phases of System Development Life Cycle in the development of a prototype of the *Water Level Monitoring System.* This included Initiation, Analysis, Design, Development and Implementation.

Water Level Monitoring System the Flooded prone areas of the Municipality of San Jose, Camarines Sur is a prototype system that has the capability to monitor water level from the river, sea or even in the flooded road and enables to send data readings of water to the remote sensor and stored as a database though SMS aided by the Arduino microcontroller.

During the testing phase, IT experts and staff of the Municipal Disaster Risk Reduction Management Office and selected Local Government Official evaluated the system performance as to accuracy and usability. Data gathered during testing time exhibits negative 6.483 percent (-6.483%) as a computer Average Percentage of Error.

Findings

To answer the foregoing problems the researcher used the descriptive developmental method of research in the context of system development. Descriptive was used in discussing the results of the evaluation of the technical and social viability of the present water level monitoring of the Municipality of San Jose, Camarines Sur and the testing phase while developmental was used during the system development. The data analyze using the percentage technique and arithmetic mean after conducting the testing of the water level monitoring. The Software Development Life Cycle (SDLC) was also utilized in designing the proposed system. Specifically, the following are the findings:

1. The Municipality of San Jose, Camarines Sur MDRRMO currently used the water level concrete gauge constructed near the river as their monitoring in determining the level of the water of the flooded prone areas and the DOST Rain Gauge Monitoring located at Barangay Catalotoan of this municipality . As to the traditional way, they record the water level from the concrete water level gauge manually. During rainy season, the MDRRMO staff in-charge had personally observed the water level by going to the flooded prone areas were the warning device located to check the water level. Generally, it takes some time to monitor the water level of the flooded prone areas of the municipality of San Jose, Camarines Sur.

2. The feasibility of implementing the developed water level monitoring device is seen important and timely in technological aspect for the Municipality of San Jose, Camarines Sur through its Municipal Disaster Risk Reduction Management Office as they are facing the new trend of information technology. It was shown from the results that the respondents approved and highly recommended the adaption and used of the proposed system.

3. Upon review of the gathered data and the result of the evaluation of the study, the researcher proposed for the development of Water Level Monitoring Device exclusively for the Municipality of San Jose, Camarines Sur.

4. The developed Water Level Monitoring System was found by the experts to have strongly usability as shown by 95% of them, and found 90% in terms of its accuracy.

5. It can also be observed from the results that the respondents highly believed that the developed water level monitoring system was easy to used and operate. The developed system shows a sense of competency and the design was also conform to the type of system. Most of the respondents had believed that the system would provide reliable information in terms of water level monitoring. Similarly, information found in this system would have shown relevant information.

Conclusion

Based on the findings of this study the following conclusions are formulated: Based on the existing means of monitoring the water level of the flooded prone areas of the Municipality of San Jose, Camarines Sur, the proponent have concluded that the developed Water Level Monitoring Device could measure the height of the water level flooded prone areas and the data can be interpreted by the application software that can be used by the agency for their decision making in monitoring and preparation for evacuation of the community in the affected areas. Instead of existing ways of measuring and monitoring the water level which are through personally checking at the concrete post with printed meter line located at the river or in the flooded prone areas, using this device will save time and effort and has real – time update. The Water Level Monitoring Device could be portable and installed not only in one area but as well as to the other flooded areas. It is therefore also concluded that the system exhibits accuracy and usability.

Recommendations

Based on the conclusions the following recommendations are hereby offered:

1. It is recommended to use the device as flood warning system.
2. The data gathered by the sensor is recommended to be sent to LGU's nearby the river as flood warning system.
3. The developed device can also be used by other researcher having related projects for their references and comparison.

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