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Predictive Data Modeling Approach on Municipal Disaster Risk Reduction Management Flood Control Decision Support Monitoring and Alarm System (Phase1)

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Abstract

The worldwide effect of climate change makes an environmental impact on the human race. Devastating storms that cause heavy flooding to different countries become imminent and recorded a billion casualties around the globe. This problem captured international attention in the formulation of policies on the preparation, mitigation, responses on and recovery from disasters during calamities. This study focused on the development of a Municipal Disaster Risk Reduction Management Flood Control Decision Support Monitoring and Alarm System. Descriptive and developmental research designs applying the SDLC prototyping model, VB.net and Arduino programming were utilized. Identification of problems and challenges encountered by MDRRMC on flood monitoring and assessment on the extent of compliance to ISO 20510:2011 Software Quality Standards were evaluated by 10 IT experts using survey questionnaires, 11 Users and 187 resident/subscribers thru 5 point Likert Scale. The research revealed that the participants' general assessment of the system's compliance to ISO 20510 Standards as Very Great Extent with respect to the usefulness, functionality and completeness of the system in support to the MDDRMC operations. The system performs real-time detection of water levels of creeks/rivers which provide sound alarm to the nearest affected residents and text message alerts to residents/subscribers. Moreover, the system also allows sending of additional alert messages to the subscribers prior to the expected typhoon landfall.

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I. INTRODUCTION

The unpredictable behavior and wrath of nature undoubtedly kills hundreds or even thousands of people, damaging many livelihood and properties across the globe due to unraveling climate change which intensifies global leaders and policy makers in the formulation of new policies and approaches in preparation, mitigation, response and recovery during disasters. Flooding problems recorded over the last twenty years is marked by 2.3 billion people across the globe covering 47% of all weather-related disasters (1995-2015) and the majority of whom (95%) live in Asia (Wahlstrom, 2015).

In Asia, Philippines and Taiwan are pointed out as the countries located at the north western pacific which are mainly steered by the pacific subtropical high pressure circulation, mostly westbound in the Pacific Ocean which become the regular typhoon path (Central Weather Bureau, 2015). Moreover, the Philippines, as the frontline of the northwest pacific region, has suffered from an inexhaustible number of deadly typhoons, earthquakes, volcano eruptions

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and other natural disasters. This is due to its location along the Pacific Ring of Fire, or typhoon belt - a large Pacific Ocean region where many of the earth's volcanic eruptions and earthquakes occur. Annually, approximately 80 typhoons develop above tropical waters, of which 19 enter the Philippine region and six to nine make landfall (US Naval Oceanographic Portal- JTWC, 2014).

The Global Climate Risk Index (CRI) developed by German reflects the countries most affected in the period 1996–2015 Honduras, Myanmar and Haiti have been identified as the most affected countries in this 20-year period. They are followed by Nicaragua, the Philippines, and Bangladesh (Sönke Kreft, 2016).

II. METHODOLOGY

Mixed methods were used in this study namely descriptive and system development. These include hardware development and configuration which covers the water level detection module while software development be centered on the MDRRMC server. The server caters the registration of text subscribers and mass sending of text alarms on the abnormal water level. Likewise, it serves as a data bank on the different water level behaviors of the different creeks and rivers of Mallig while the descriptive method was used in the interpretation of respondent's responses.

Instrumentation

Survey-Questionnaire. The principal tool used in data gathering was a structured questionnaire. The questionnaire is for the IT experts and Expert practitioners which is based on the level of effectiveness of the proposed MDRRMC Flood Control Decision Support Monitoring and Alarm System in monitoring water levels and the extent of compliance of the system to ISO /IEC 25010:2011 standards.

Interview. Interview guide questionnaire was used to get the residents' feedback on problems that they have encountered with respect to their existing MDRRMC flood monitoring and alarm system together with their current practices on flood control monitoring system. The researcher interviewed at the different lowland areas of barangay San Pedro, Centro 1, Centro 2, Casili, Victoria and Maligaya.

Focus Group Discussion. The researcher used this to gather information and feedback on validation of questionnaires from the expert practitioners in relation to system performance in identifying its strengths and weaknesses based on their experiences and observations in using the system.

Internet. Internet was used as a tool in finding related literature, related studies and other needed information as regards the system. Posting of announcement on the text subscription to the MDRRMC Server were done through Facebook.

Data Analysis

The gathered data were collected, tabulated and treated statistically using frequency count, percentage, weighted mean, and thematic analysis. Frequency and percentage was used to describe the profile of the participants.

Weighted Mean. This was used to describe the assessment of the participants as to the extent of compliance of the developed system with respect to ISO 25010:2011 system quality standards.

Problems and Challenges

1. Evaluation of problems and challenges identified by the IT experts and end-users and how the developed system addresses the identified challenges in the existing system were interpreted using the following scale.

Table 1. Likert Scale for the Problem and Challenges identified by the expert and end user

Mean	Verbal Description
4.20 – 5.00	Strongly Agree (SA)
3.40 – 4.19	Agree (A)
2.60 – 3.39	Neutral (N)
1.80 – 2.59	Disagree (D)
1.00 – 1.79	Strongly Disagree (SD)

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Table 2. Likert Scale to Describe the Extent of Compliance of the Developed System to ISO 25010 Software Quality Standards

Mean	Verbal Description
4.20 – 5.00	Very Great Extent (VGE)
3.40 – 4.19	Great Extent (GE)
2.60 – 3.39	Moderate Extent (ME)
1.80 – 2.59	Little Extent (LE)
1.00 – 1.79	Very Little Extent (VLE)

b. T-Test for Independent Groups. This tool was used to identify whether there is a significant difference between the assessment of the IT expert and MDRRMC End-users with respect to the developed system compliance to ISO 25010 standards at 0.05 level of significance.

2. Thematic Analysis. This was used to analyze the responses of the IT experts and End-users/ participants during the conduct of interview and the system test and evaluation for data commonalities.

III. RESULTS AND DISCUSSION

I. Current practices of the Municipal Disaster Risk Reduction Management Council in flood control monitoring

The Local Disaster Risk Reduction Management Council (LDRRM) practices on disaster preparedness was formulated with the theme "Operation L!STO" in October 2014, a national advocacy program for disaster preparedness that guides LGUs and DILG personnel on actions they need to take before, during and after a disaster (Academy Local Government, 2018).

Mayors, in fact, received advisories called Critical Preparedness Actions (CPAs) with alert levels Alpha, Bravo and Charlie. CPAs are issued before PAGASA declares a tropical cyclone warning signal (signal nos. 1, 2, 3, 4, or 5). The CPA alert levels indicate the typhoon strength and potential impact, with Charlie as the strongest.

Based on the advisories that the mayors receive from DILG, they are able to determine their LGU's Critical Preparedness Action: Alpha, Bravo, or Charlie. They also check the conditions and forecast for the CPA, including the amount of rainfall, wind speed, critical areas, and potential impact.

CPA checklist has four major timeframes: (1) Upon Alert; (2) Before - within 24 hours after alert; (3) During - divided into two sub-time frames: within 24 hours before landfall and within 12 hours after landfall; and (4) After.

Upon Alert. This is the time science agencies DOST-PAGASA and DENR-MGB, and DILG communicate the information or alert to LGUs.

Before. It includes recommended minimum preparedness actions that LGUs must do within 24 hours after receiving the alert from the science agencies and DILG.

During. It consists of recommended minimum critical preparedness actions that LGUs must do within 24 hours before the expected onslaught or landfall of a tropical cyclone or typhoon in the area. These actions are intended to ensure the safety of lives, assets and properties. During the onslaught or landfall of the tropical cyclone or typhoon, the response teams stay in a safe location and await deployment. LGUs must monitor alerts and coordinate via radio and satellite phones, if such communication is still possible. Recommended minimum response actions of LGUs in the affected areas 12 hours after the onslaught or landfall of the tropical cyclone or typhoon are done.

After. It includes recommended minimum actions of LGUs to prepare for transition from response to early recovery and rehabilitation, and, finally, to post-recovery and rehabilitation.

The current operational manual shows the preparedness of MDRRMC upon, before, during and after typhoon landfall operations where monitoring of flood starts upon receiving advisory from CPA for the possible category alert level of a typhoon. Continuous typhoon monitoring is done every 6 hours using satellite cellphone and radio to

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determine the actual trajectory of the typhoon. Upon CPA alert advisory, the MDRRMC disseminates the same to the residents through the barangay disaster response team before, during and after typhoon landfall where a staff member is designated to personally monitor the water levels of a creek/river to oversee the water level. In case of possible occurrence of flood, he calls over the radio to the MDRRMO for immediate action in giving alarms to the affected barangays by way of personal announcement made by the barangay officials.

II .Problems and Challenges Encountered by the MDRRMC in terms of Flood Control Monitoring System

The assessment of the End-users' and Resident/Subscribers on the Problems and Challenges encountered by MDRRMC in flood control monitoring System. The End-User general assessment reflects an overall weighted mean of 2.56 with a description of Disagree while there are three (3) sub categories marked with a description of Disagree and others are marked Strongly Disagree and Agree. This implies that MDRRMC Officers and Staff members are encountering problems on daily monitoring of water level measurement, inavailability of flood control monitoring and flood warning systems. On the other hand, they Agree on their efforts in regular information dissemination to the affected residents during heavy rain fall and typhoon and effective advisory announcement prior to the typhoon landfall. The Residents/Subscribers' general assessment also reflects a description of Disagree as indicated by most sub categories assessment with a description of Disagree which affirms the MDRRMC problems on daily monitoring of water level measurement, inavailability of flood control monitoring, flood warning systems and water level detection system is reliable. This implies that both Residents/Subscribers' and MDRRMC's encountered problems on their existing water level detection system.

III. The developed system, Municipal Disaster Risk Reduction Management Flood Decision Support Monitoring and Alarm System

The MDRRM-Flood Control Decision Support Monitoring and Alarm System is composed of water level detection sensor that measures real-time water levels. Water sensor automatically sends text alert messages to the MDRRMC Server upon water detection of above normal level, sound alarm immediately switches on to provide immediate alarm to the nearest affected resident short, long and continuous alarm is sounded based on the different alert level categories. The MDRRMC Server forwards the water level update to all residents/subscribers for mass text alerts for possible evacuation. Moreover, text messages alert interval differs from the alert level category. It starts from alert level category Charlie where water level update is updated every after 15 minutes for real-time monitoring. Barangay residents may subscribe or unsubscribe from the system to receive and stop receiving water level updates.

IV. Extent of Compliance of the Developed System to ISO25010:2011 Software Quality Standard

The overall assessment of IT experts and End users on the extent of compliance of the developed system, "Municipal Disaster Risk Reduction Management Flood Control Decision Support Monitoring and Alarm System" towards ISO 25010:2011 software quality standard. The participants rated 7 out of 8 indicators as Very Great Extent of compliance. This implies that the proposed system has met the international software standards in terms of software quality.

V. Test for significant difference of the assessment of IT Experts and End-users in terms of the developed system's extent of compliance to ISO 25010 Software Quality Standards

The assessment of IT experts and End-users on the developed system's extent of compliance to ISO 25010 Software Standards. The data reveals that

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there is no significant difference between IT Experts' an End-Users' assessments on the developed system's extent of compliance to ISO 25010 Software standards. This implies that the developed system has complied with international software quality standards as assessed by both IT experts and End-users in terms of performance efficiency, compatibility, usability, reliability, security, maintainability and portability.

VI. Suggested Enhancement that can be adopted for the Developed System Application.

Upon series of testing and deployment of the developed system in the actual environment, the water module sensor was exposed to extreme heat temperature and acid rain together with possible human contact. The following areas for improvement were identified for enhancement:

1.A Water sensor perimeter fence should be built around the water sensor to secure against human physical contact to avoid destruction and theft.

2.The Water sensor frame should be coated with Rubberized Insulation on the metal frames to avoid immediate corrosion caused by acid rains.

3. The water sensor Postpaid account should be applied for the GSM service provider to avoid monthly loading of prepaid load to the sensors and to the MDRRMC Server.

4.MDRRMC should procure a dedicated server for the MDRRMC server to cater 24 hours service registration and water level update for the barangay residents/text subscriber.

5.MDRRMC should provide a Web Hosting server for International update on water levels and posting of evacuation center map.

SUMMARY OF FINDINGS

I. Current practices of the Municipal Disaster Risk Reduction Management Council in flood control monitoring

Evidence gathered from series of interviews, document reviews and actual observations show that the following practices of MDRRMC are conducted before, during and after typhoon landfall in terms of flood control monitoring:

1. There is direct coordination between LGU to the following agencies DOST, PAGASA, DENR and DILG. These agencies are the prime sources of typhoon advisories called Critical Preparedness Actions (CPA).

2. There is continuous typhoon monitoring every 6 hours using satellite cellphone and radio to determine the actual trajectory of an upcoming typhoon.

3. Dissemination of information to the residents through the barangay disaster response team is conducted prior to the typhoon land fall.

4. MDRRMC officer designate a staff member during and after typhoon landfall to personally monitor the water levels of Casili creek and Mallig river to oversee the water levels. In case of possible flood occurrence, he calls over the radio to the MDRRMO for immediate action in giving alarms to the affected barangays by way of personal announcement made by the barangay officials.

II. Problems and Challenges Encountered by the MDRRMC in terms of Flood Control Monitoring System

Data obtained from survey questionnaires and interviews based on the Expert Users' and Residents/Subscribers assessments on the existing flood control monitoring system of MDRRMC show the following problems:

1. There is no technology used in monitoring water level measurement and no constant monitoring of water levels is conducted;

2. There is in availability of flood warning systems which provide warning alarm and

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unreliability of water level detection especially during and after typhoon landfall.

III. The developed system, Municipal Disaster Risk Reduction Management Flood Decision Support Monitoring and Alarm System

The developed system MDRRMC Flood Control Decision Support Monitoring and Alarm System generally performs round the clock real-time measurement of water levels which provide sound alarm upon detection of above the normal water level starting from category level charlie; the sound alarm alerts the nearest affected residents for their immediate action and possible evacuation. Text alert messages is also provided about the water level of the creek/river is also provided for the residents/subscribers. Prior to the typhoon land fall the system can also be used to disseminate important announcements and PDRRMC circulars to all the residents/subscribers thru text messages.

IV. Extent of Compliance of the Developed System to ISO25010:2011 Software Quality Standard

The developed system "MDRRMC Flood Control Decision Support Monitoring and Alarm System" was generally found to be compliant with an assessment description of Very Great Extent. This only tends the usefulness, functionality and completeness of the system in support to the MDDRMC operations.

V. Test for significant difference of the assessment of the IT Experts and End-users in terms of the developed system's extent of compliance to ISO 25010 Software Quality Standards

Independent sample T-test shows that there is no significant difference on the assessment of the developed system between IT experts and End-user participants in compliance to ISO 25010:2011 software quality standards at 0.05 level of significance.

VI. Suggested Enhancement That Can Be Adopted For The Developed System Application

Additional future enhancement considerations on both water sensor module and MDRRMC server include:

1. Water sensor perimeter fence should be built around the water sensor to secure against human physical contact to avoid destruction and theft.

2. Water sensor frame should be coated with Rubberized Insulation on the metal frames to avoid immediate corrosion caused by acid rain

3. The water sensor postpaid account should be applied for the GSM service provider to avoid monthly loading of prepaid load to the sensors and to the MDRRMC Server.

4. MDRRMC should procure a dedicated server for the MDRRMC server to cater 24 hours service registration and water level update for the barangay residents/text subscribers.

5. MDRRMC should provide a Web Hosting server for International update on water levels and posting of evacuation center map.

CONCLUSION

Based on the findings, the developed system has met its intended functional operations to provide real-time detection of water levels, giving sound alarm, upon flood detection, to the nearest affected residents; provide text alert messages to residents/subscribers; and, spread circular orders/additional alert messages prior to an expected typhoon landfall.

The developed system has met all the required technical and user requirements set by MDRRMC and it is fully compliant to ISO 25010:2011 Software Quality Standards. The system is a great help to the Municipal Mayor, MDRRMC and DILG before, during and after the onslaught of typhoon in ensuring prevention and mitigation of the loss of lives and properties. The affected residents are

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warned with real-time sound alarm and text alert messages during typhoon and heavy rainfall.

RECOMMENDATIONS

Based on the findings and conclusions, the researcher recommends the following:

1. For the researcher to conduct demonstration and training to the MDRRMO and MDRRMC staff on the use, installation and maintenance of the developed system for their familiarization and mastery.

2. For the MDRRMC to conduct mass information dissemination to residents/subscribers on the registration and water level updates of the developed system and their familiarization on the different sound alarm warning of the water sensor module.

3. The developed system may be tried out with more End-Users to ensure its functionality and subject the system to a regular continued improvement and monitoring scheme.

4. To enhance the developed system which may include other functionalities such as mapping and data predictive analysis.

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