# A Mobile and Android-Based Application for Local Disaster Risk Reduction and Monitoring

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**Abstract:- The occurrence of natural calamities and disasters becomes prevalent due to climate change. In Philippines, natural disaster incident increases annually and high vulnerability risk index (World Risk Report, 2016). In order to address these challenges, this study had been undertaken to mitigate the risk associated to natural disaster both life and property. Specifically, the study aims to develop real time mobile monitoring system with drone technology that will provide accurate information that currently occurring on the ground. The assessment of the system used under ISO 9126/ISO/IEC 25010. standard system evaluation and Kano's Model in evaluating the developed system. Results show that the system Q-score is 2.06, 2.02 and 1.8 respectively. for Usability, Functionality and Reliability of the system. Likewise, its general grade rating is DQ. This result indicates positive users' perspective about the system on its reliability, functionality, and usability.**

***Keywords:*** *Mobile Application, Android, Drone, Kano's Model.*

## I. INTRODUCTION

It is undeniable that natural disaster occurrence worldwide is continually increasing due to climate change. In fact, in recent years devastating disasters occurred – the 2011 Japan earthquake, the 2010 Haiti Earthquake, the 2008 Cyclone Nargis, the 2004 Indian ocean tsunami, and the 2013 typhoon Haiyan in the Philippines are only some of the few examples.

In the Philippines, a significant numbers of natural disaster usually occurs – typhoons, volcanic eruption, floods, landslide, and earthquakes becomes the usually scenario reported in all news media. With this, the country has been identified as one of the most disaster prone countries in the world. Based on the World Bank Report, 50.3 percent of it. total land area, and 81.3 percent of its population are vulnerable to natural hazards (World Bank, 2008). This information has been further affirmed by the World Risk Report where it revealed that the country's risk index is at 26.70 making it as the third in the most disaster-prone countries globally (World Risk Report, 2016).

Furthermore, according to the Joint Typhoon Warning Center (JTWC), out of an average of 80 typhoons the developed annually in the Pacific east coast, 19 of which enters in the Philippine region, and between six to nine make a landfall (Bushnell et al., 2018). Thus, the country has been considered as the most exposed country to tropical storms worldwide. In fact, the occurrence of typhoon Haiyan greatly devastated the eastern part of the country in 2013. And it has been said that the said storm can generate 10 times as much energy as the Hiroshima atomic bomb. Likewise, Philippine usually suffered also from an inexhaustible occurrence of deadly volcanic eruptions and earthquakes. This is also due to its location as part of the so called Ring of Fire (Bankoff, 2016).

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Indeed, disasters are becoming more complex and climate change poses a greater potential for adverse impacts. Recent events such as the super typhoon "Yolanda" that strikes down Samar and Leyte, in the Philippines four years ago left a huge impact to the lives and properties of the people. It is because people don't have enough information and understanding of what the typhoon may bring. Also, it is because people have lack knowledge of what the typhoon is and preparation to undertake. Thus, the need to have a system that provides real-time information provides precautionary measures, safety provisions on real-time basis is very essential to undertake.

In particular, this study intends to develop a real-time and mobile based application system that provides information on the current dynamics of certain calamity, provide notification and warning systems to resident of local communities, and give necessary directions and precautionary measures.

## II. LITERATURE REVIEW

Natural Disaster is the consequence of natural hazards such as cyclone, storm, earthquake, tsunami, flood, etc. This earth has already observed the vicious mode of nature which has taken millions of lives. The 2011 Japan earthquake and tsunami, the 2010 Haiti earthquake, the 2008 cyclone Nargis, the 2004 Indian Ocean Tsunami, the 1991 Bangladesh cyclone are some current examples of deadliest natural disasters. As such, since the occurrence of natural disaster is inevitable, therefore it is necessary to device a prevention mechanism to shield the lives and properties (Sonwane, 2014).

In the Philippines, the National Disaster Risk Reduction and Management Council (NDRRMC), is the government agency that undertakes programs and intervention that will ensure the protection and welfare of the people during disaster and emergencies. In fact, one of the agency's initiative is the utilization of the Geographic Information System in order to characterize the social vulnerability to climate related hazards of the different areas of the country using the modified Social Vulnerability Index (SoVI). The end goal of the said initiative is to identify the different hazards prone areas of the country so that an appropriate hazard and disaster mitigation measure and intervention be established (Disaster Risk Reduction in the Philippines, 2019).

The project Nationwide Operational Assessment of Hazard (NOAH), is another government disaster prevention and mitigation program. The program uses a science and technology based approach in generating an accurate hazard data, and utilized the said generated data to make an advanced and informed decision capability mechanism geared towards hazard risk reduction. The end goal of the program is to attain disaster-free and empowered communities by providing open access to accurate, reliable, and timely hazard, and risk information. The program also undertakes research projects to develop technologies and tools that further build the capacity of the government and the public in disaster preparedness and response (Cadiz, 2018).

In the same line, a research-based project dubbed as "project yolo" was undertaken whose main function is to coordinate and assist Municipal Disaster Risk Reduction and Management Office of the Philippine Municipal Government Units. The outcome of the said research is the developed mobile-based application system that provides safety tips and things to do in the event that there is an occurrence of natural disaster (Pineda., 2014).

Today, crowdsourcing has become an innovative ICT-based approach to solve problems. Crowdsourcing is a mechanism in which information is obtained through an active participation of people in a network – networked people usually responds or provide information to an open calls posted in a network (Cabanillas, 2016; Fienen, et al., 201; Machado, et al., 2016; Pederson, et al., 2013). This method is usually adopted when information is directly sought by affected individual, and in most cases responses are made in a real-time.

Moreover, a research-based mobile application dubbed as Mobile Application for Emergency Response and Support (MAppERS) was developed whose main function is to provide communication between citizens and civil-protection agents in times of crisis. The project exploit geospatial data gathered by citizens and volunteers with their own devices such as mobile phones to provide authorities with relevant information in case of flood emergencies (Frigerio, et.al., 2018).

## III. MATERIALS AND METHODS

The system was developed based on Dynamic System Development Model (DSDM) approach. DSDM is a project development concept that describes the stages of system development shown in figure 1. In general, the development model for the system is divided into 5 stages as (1) system design and analysis based on users' demand and existing technologies, (2) Design Selection and Material Selection and (3) Design Presentation and Validation, (4) Design implementation and construction, and (5) Pilot-testing and evaluation (Labrador, et al., 2014).

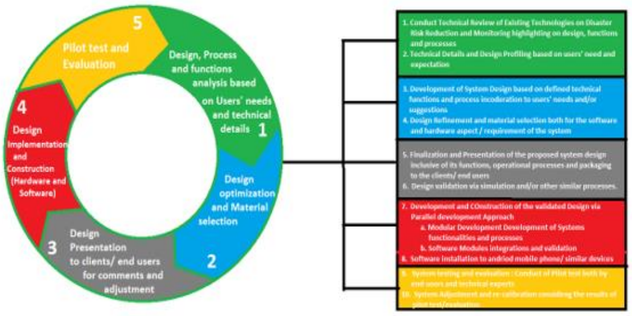


**Fig 1.** The System Development Model

The different software development stages laid-down the different specific activities. At the initial stage, technical review of existing technologies that are similar to the proposed system was undertaken. The focus of the technical review is to find out the different mechanisms – functions and processes of the existing system which could be adopted and integrated into the proposed system subject to customization integrating the users' needs and demands. Note however, that design consideration are only restricted to Disaster Monitoring and Updates generation and notification.

In general context, the technical design of and development of the system was primarily based on the expected system functionalities. With this, the development of the different system functions is simultaneous but separately developed at once. Program coding and debugging are conducted in parallel to the different modules of the entire system processes and functions. The different system module includes SMS notification processes, auto-status updates of disaster such as news feeds, evacuation plan and risk management, and disaster image capture based on GIS system.

Consequently, the system pilot-test are undertaken for purposes of determining the extent of system functionalities based on defined technical standards and users expected outcomes. Also, the result of pilot testing was used in the design calibration and adjustment. Furthermore, aside from technical system evaluation, a questionnaire-based evaluation method was also utilized. The questionnaire-based evaluation was used to further validate the technical details of the system design and its acceptability as evaluated by both the technical experts and end-users. In particular, the ISO 9126 evaluation method and instrument is being adopted.

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Furthermore, system evaluation made use of the standard ISO 9126 software system evaluation framework and the Kano Model. The 1SO 9126 standard was used in evaluating the system functionality, reliability and usability. While the Kano Model was used in evaluating the systems quality based on user satisfaction feedbacks. Detailed procedures describe in the study of Chapagain (2005) are adopted on this study. In particular, the following evaluation quality feedback for each criterion item is used as reference: Must-be Quality (MQ), One Dimensional Quality (DQ), Attractive Quality (AQ), Reverse Quality (RQ), Questionable Quality (QQ), and Indifferent Quality (IQ). Interpretation of the said quality criteria is as follows:

1. MQ – Certain system attributes or characteristics is missing as such user is not satisfied, however user satisfaction level will not change even if the said feature is made available.
2. DQ – Availability or non-availability of certain system attributes is in linearity with users' satisfaction level. It means that when the attribute is missing, user is dissatisfied, and when it is present user is satisfied.
3. AQ – The availability or presence of certain attributes results to users' high satisfaction level, but do not cause dissatisfaction when present
4. RQ – Users' satisfaction level is reversed with that of the availability of attributes
5. QQ – Users' satisfaction level cannot be determined.
6. IQ – Users' satisfaction level is not influenced by the presence or absence of certain attributes

However, the indicated quality users' feedbacks are further categorized into two groups – the Positive Response Category (PRC) group and the Negative Response Category (NRC) group. Users responses point for each category is calculated as follows:

$$PRC = \sum (MQ, DQ, AQ) \quad - \quad (1)$$
$$NRC = \sum (RQ, QQ, IQ) \quad - \quad (2)$$

Results of Category responses is used as basis in the determination of evaluation criterion item grade which is as follows: (1) if the value of the sum of point responses of AQ, MQ and DQ is greater than the sum of that of RQ, QQ and IQ, then the grade value is equal or the same with that of the highest value between AQ, MQ and DQ. Otherwise the grade value is determined based on the highest value between RQ, QQ and IQ. (2) If the sum value of AQ, MQ and DQ equals with that of the sum of RQ, QQ, and IQ, then the grade value would be the same with that of the highest value between all categories. Furthermore, Category Strength (CS) and Total Strength (ST) of each criterion is determined through the use of the formula indicated below in percent equivalent.

$$TS = (PRC \div \text{Total User Response Value}) \times 100 \quad (4)$$

$$CS = [(\text{Highest response value} - 2^{nd}\ \text{Highest Response value}) \div \text{Total Response Value}] \times 100 \quad (5)$$

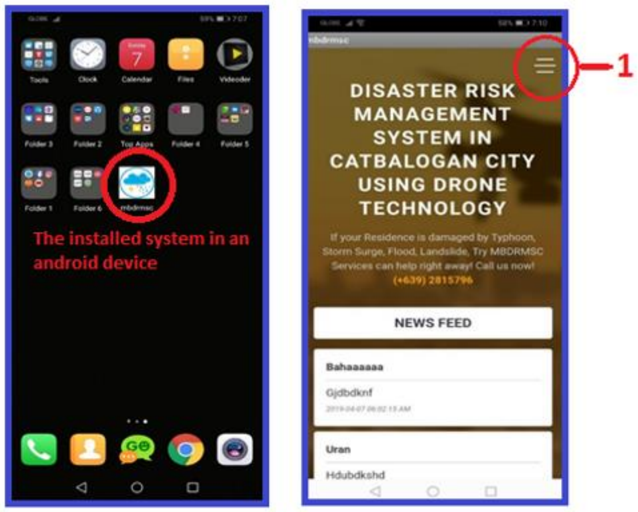
Furthermore, Quality Score (Q-Score) is determined utilizing the score weight MQ = 1, DQ = 2 and AQ = 3. Computation of the Q-Score is based on the formula Q-Score = (Score_MQ x 1 + Score_DQ x 2 + Score_AQ x 3) divided by PRC (Zhang, 2002).

## IV. RESULTS AND DISCUSSION

Anchored to the objectives of this study, an android and mobile monitoring system was developed. The system provides a mechanism for an effective disaster risk reduction and management.

### *A. The System*

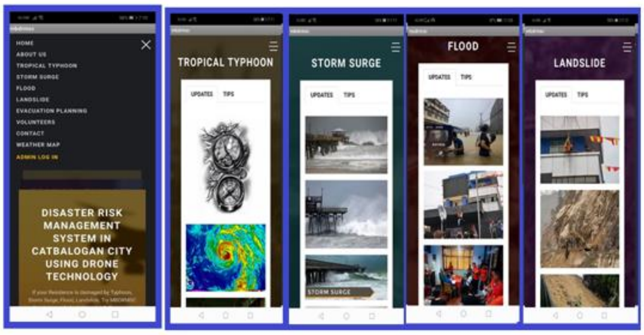
The android and mobile based disaster updates and monitoring system is software based application system was specifically designed to be used as an effective tool for disaster risk reduction and management. The system was packed into an apk file which can be installed to any type of android-based devices. Figure 2 shows the application file icon and main page of the system in a particular android device.




(a) (b)

**Fig 2.** The System Software
*(a) The Software as Installed in an Android Device*
*(b) The Software Main Page*

Figure 2(a) shows the image icon of the develop system when it is being installed in an android device and figure 1(b) is the main default page of the system. The icon image of figure 1(a) is generated upon successful installation of the software. The system installation software is a compressed android package file (APK) – a file that works and compatible only for android-based devices. When the image icon is launched the system default page as shown in figure 1(b) appears. The default page contains the latest news information of the current occurring disaster or calamities which the user can browse. Also the default page contains a link to the different sub-menus and functionalities of the system located in the upper-right section labelled with 1 as shown in figure 2(b). When the link is accessed a new window will appear as shown in figure 3(a) showing the different sub-modules or functions of the system.




(a) (b) (c) (d) (e)

**Figure 3.** The Different User Interface and Functionalities of the System

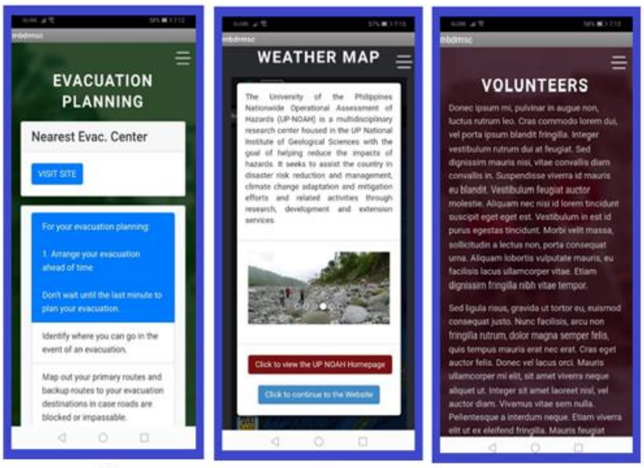
*(a) System different sub-functions*

*(b) Sample android-based information window of tropical typhoon*

*(c) Sample android-based information window of storm surge*

*(d) Sample android-based information window of a landslide*

Figure 3(a) shows the different sub-functionalities of the system. Each functionality refers to specific disaster information such as typhoons, floods, storm surge, and landslide. Detailed information such as news updates, current situation on specific areas, precautionary measures, etc for each classification of disaster can be accessed when it is being specifically selected by the user as shown on figure 3(b) to figure 3(e).




(a) (b) (c)

**Figure 4.** The Evacuation Planning, the Weather Map Module of the System

Additional functionalities of the system as indicated in figure 3(a) include evacuation plans, weather maps and volunteer. The evaluation plan module of the system as shown in figure 4(a) provides information on evacuation center locations where the nearest evacuation center is automatically suggested by the system including the safe directions. Also the evacuation planning module provides information like safety guides and evacuation plan which will guide the user on what decision or action to take in the event of emergencies.

On the other-hand, the volunteer menu – a sub-functional component of the system indicated in figure 3(a) provides the listing of volunteers - their current location and contact information which can be called or contacted by the users for help and other assistance. While the Weather Map menu, provides an updated weather bulletin. Specific information and page window- lay-out for volunteers and weather maps menus are shown in figure 4(a) and 4(b).

Furthermore, for security purposes and in order ensure that the information provided by the system to the users are accurate and reliable, an Administrative Users account are included as part of the system design. The Administrative user Accounts are the only authorized person to change and made updates to all the information in the system such as evacuation plan, list of volunteers and updates on the status of the calamity or disaster. Figure 4(a) shows the log-in window for Administrative Login and figure 5(b), (c) and (d) are sample pages in updating the information.

Aside from the functionalities of the system as describe above, the system also auto-generates SMS messages that are sent automatically to the users. This mechanism is an alternative way of providing updates of the disaster in the event that internet connectivity is not available. Note that for every information updates in the system, an automated SMS messages are likewise automatically generated and sent to the users.

### *B. System Evaluations*

The system has been evaluated by 30 respondents comprising technical experts and end-users. Test and evaluation has been made where users are given a privilege to use and explore the functionalities of the system. In reference to the system evaluation procedures indicated in the precious section of this paper, the different evaluation criteria items have been classified into the three major evaluation parameters as indicated in table 1. The total score points for each criterion is 200.

**Table 1** Evaluation Parameters and its specific evaluation criteria items

| Evaluation Parameter Classification | Specific Evaluation Criteria items | Total Numbers of Criteria items |
|---|---|---|
| Functionality | Criteria 1 (c1) to criteria 11 (c11) | 11 |
| Reliability | Criteria 12 (c12) to criteria (15) | 4 |
| Usability | Criteria 16 (c16) to Criteria 30 (c32) | 17 |
| Total Evaluation Criteria Items | | 32 |

Table 2 shows the different user response computed value for each criteria. Criteria that has a computed TS value of 50% and above are the only criterion to be considered in further evaluation. For this case, table 2 shows that of 32 criteria items 18 for further evaluation. From the said 18 criteria considered for further evaluation, five (5) are falls under functionality, two (2) under the reliability, and twelve (12) under the usability. Furthermore, the CS value of the 18 identified criteria has been computed. Only those CS value that is 15 and above are considered. With this, only twelve (12) criteria has a computed value of 15% and above. These 12 criteria are the final evaluation criteria considered for the system.

Table 3 shows that has the lowest computed average Q-score at 1.8 which is the system reliability. The result indicate that system reliability still needs to be improved. Also. since the grade results for this quality indicator is DQ, therefore, users believe that improving such quality indicator will further improve the system.

It is clear also in the table 3 that all evaluation parameters have a received a DQ grades which means that further enhancing such quality indicator will improve the system based on the out-look of the users. On the contrary, the Usability quality indicator has the highest Q-score value of 2.06. This indicates that a user believes the relevance and usefulness of the system especially during the event of disaster. Likewise, the users also believe that the system is functioning properly based on its operational processes and features. Though in general users still believes that enhancing such key system characteristics will further have improved the system.

**Table 2** Criterion Total Strength (TS), Category Strength (CS) and Classification

| Evaluation Parameters | Criterion Item | PRC | NRC | TS | CS | Classification |
|---|---|---|---|---|---|---|
| Functionality | c1 | 87 | 113 | 43.5 | 12 | IQ |
| | c2 | 117 | 83 | 58.5 | 32 | DQ |
| | c3 | 97 | 103 | 48.5 | 42 | IQ |
| | c4 | 112 | 88 | 56.0 | 32 | DQ |
| | c5 | 87 | 113 | 43.5 | 25 | IQ |
| | c6 | 91 | 109 | 45.5 | 36 | IQ |
| | c7 | 96 | 104 | 48.0 | 10 | IQ |
| | c8 | 112 | 88 | 56.0 | 14 | DQ |
| | c9 | 118 | 82 | 59.0 | 36 | DQ |
| | c10 | 116 | 84 | 58.0 | 45 | DQ |
| | c11 | 97 | 103 | 48.5 | 63 | IQ |
| Reliability | c12 | 93 | 107 | 46.5 | 41 | IQ |
| | c13 | 68 | 132 | 34.0 | 32 | IQ |
| | c14 | 100 | 100 | 50.0 | 20 | DQ |
| | c15 | 112 | 88 | 56.0 | 16 | DQ |
| Usability | c16 | 147 | 53 | 73.5 | 14 | DQ |
| | c17 | 104 | 96 | 52.0 | 35 | DQ |
| | c18 | 114 | 86 | 57.0 | 26 | DQ |
| | c19 | 90 | 110 | 45.0 | 13 | IQ |
| | c20 | 110 | 90 | 55.0 | 8 | DQ |
| | c21 | 113 | 87 | 56.5 | 45 | DQ |
| | c22 | 112 | 88 | 56.0 | 36 | DQ |
| | c23 | 98 | 102 | 49.0 | 24 | IQ |
| | c24 | 97 | 103 | 48.5 | 32 | IQ |
| | c25 | 109 | 91 | 54.5 | 38 | DQ |
| | c26 | 108 | 92 | 54.0 | 14 | DQ |
| | c27 | 113 | 87 | 56.5 | 16 | DQ |
| | c28 | 114 | 86 | 57.0 | 12 | DQ |
| | c29 | 97 | 103 | 48.5 | 14 | IQ |
| | c30 | 112 | 88 | 56.0 | 10 | DQ |
| | c31 | 94 | 106 | 47.0 | 9 | IQ |
| | c32 | 95 | 105 | 47.5 | 10 | IQ |

**Table 3** Evaluation Criteria Q-Score

| Evaluation Parameters | Criteria item | Criteria Description | Q-score | Ave | Grade |
|---|---|---|---|---|---|
| Functionality | c2 | Task/Process Performance | 1.8 | 2.02 | DQ |
| | c4 | Information and Content Organization/ Clarity | 2.3 | | DQ |
| | c8 | Security: Access and Authorization | 2.0 | | DQ |
| | c9 | Accuracy | 1.9 | | DQ |
| | c10 | Interoperability | 2.1 | | DQ |
| Reliability | c14 | Error handling | 1.9 | 1.8 | DQ |
| | c15 | System Operation Recovery | 1.7 | | DQ |
| Usability | c25 | User friendly/ Ease of use | 1.8 | 2.06 | DQ |
| | c26 | UI Design attractiveness | 2.3 | | DQ |
| | c27 | Applicability of Information | 2.1 | | DQ |
| | c28 | Relevance of Information (up to date information) | 2.0 | | DQ |
| | c30 | Design Structure | 2.1 | | DQ |

## V. CONCLUSION

Anchored to the general intentions of the study, a localized disaster risk reduction and monitoring system particularly to be used in the Province of Samar, Philippines has been developed. It offers several functions which include but not limited to advance notification and warning system, real-time updates and monitoring of the calamity and disaster and Evacuation Plan among others. The Quality score (Q-score) of the different evaluation parameters of the system is 2.02, 1.8 and 2.06 respectively for system functionality, reliability and usability with all having a grade value of DQ. The results indicate that the system is indeed functional, reliable and usable based on the general perspective of the users.

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