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To cite this article: I Setyawati et al 2019 IOP Conf. Ser.: Earth Environ. Sci. 273 012050

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Conceptual Design of Mobile Application for Post-disaster Rapid Assessment of Damaged Houses

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Abstract. The current rapid assessment of post-earthquake damaged houses has been done manually. The determination of the damage level is also very subjective. Moreover, the available time during a rapid assessment and limited number of enumerators lead to ineffective decisions for responses and assistances. There are several application had appeared trying to answer the problems, but still they have many types of data that need to be input and even need a lot of time to process. The system design to be simple, more user-friendly and time efficient to be operated during the assessment. This study is aimed to develop a conceptual design of a system to collect data of houses damaged by earthquake using mobile application which propose to work both online and offline. The system will consists of five components: mobile device, user, data center (web server and database), internet, and data processing center (administrator and manager to verify and analyze the data). The application design to be integrated with Google Maps containing concise data entry to facilitate users (trained users and common users) and to shorten the time of data collection. Final collected data will be presented through the website and perform descriptive and spatial analysis.

1. Introduction

In the time of a disaster occurs there are two urgent things that must be done immediately. The first is emergency response which is rescue and handling of disaster victims activities. The latter is rapid assessment which aims to assess the area affected by the disaster and the needs of victims. Rapid assessment is conducted to assess the disaster-affected area and the needs of disaster victims. Activity during rapid assessment is collecting the basic data needed later in recovery phase, and also make a priority list for responses. The aspects evaluate including location, damages, and sources so that the severity of damage can be determined [1].

The current rapid assessment especially in assessing damages has been done by manually [2]. Surveyors have to fill a rapid assessment form then gathered and inputted to the database. This activity takes time and energy while the available time usually only two weeks constraints for the surveyor to work fast. This situation can be worsened by the lack of resources, neither human resources nor supporting facilities to mobilize. Due to these limitations, the data obtained becomes less accurate and affecting the decision that would be made.
Based on Pidie Jaya earthquake on last December 2016, where rapid assessment activities were disrupted by the limitation of sources that led to unoptimium data from rapid assessment process. This phenomena gave an impact related to the unavailability of the accurate data which produced the unoptimized countermeasure. Based on that circumstances, it would be very helpful if there is a system that can accommodate the building assessment which efficient and accurate through the smartphone technology. The use of smartphone utilization in the development of this system by considering the ease and practicality of the user, in this case, the surveyor.

The development of this application focused on Android-based smartphone. Android smartphones currently lead the world in terms of their users. According to Gartner, Inc. (a research and advisory company), smartphone users reach 86.1% worldwide in the first quarter of 2017 [3]. Thus, maximum number of users can utilize the application if Android smartphone is used as basic of application development [4]. There are also two applications that had been developed previously in Italy, named Earthquake Damage Assessment Manager (EDAM) [5] and Clarinspect in New Zealand. Both applications have been relatively adequate for building data collection after the earthquake. But the amount of data that must be filled to the form are time-consuming, especially when the number of enumerator is limited, while the time span during the rapid assessment period relatively short (three days to two weeks).

This study focus on data collection of damaged houses affected by earthquake. The application has two working mode; online and offline. It can help surveyor to collect damages data with or without internet connection. The form designs to be simple and brief to ease the data gathering process and shorten the time. This Android-based data collection application is expected to facilitate the surveyor in the field. In addition, the spatial analysis also can be performed with map-based due to google map API services integration.

2. Mobile Application on field assessment

Mobile apps utilization keep increasing due to the increasing of smartphone users. The application purpose has vary from simple game to scientific tools. Todays application were supported Google maps API which location based to specified location and described it visually intuitive. The Application has been utilized for navigation, tourism, etc. The availability of taking coordinates from google maps API services and geotagging photo based app would be highly useful for helping field assessment to collect location based data. There are few existing mobile apps that built for field assessment due to earthquake impacts. These apps analized and compared for collecting information in designing conceptual framework for mobile app of Building Assessment due to Earthquake impact. They collected data such as photos, videos, damaged description and location. The application that developed in China [2] are only working with the internet connection (online). On the other site, there are two more application that developed in Italy [5] and Hawaii [6] which can operate both offline and online. But the requirement for the rapid assessment in Indonesia need to adopt the system and framework requirement which is legally standared by Indonesian Government (PUPR). The application that we propose is the application that can work both offline and online with easy user-interface to be utilize with broader users. The application will focus on house damage assessment to help the process in time efficiency and data accuracy.
Tabel 1. Building assessment app in some countries.

| Mobile App. | (Xu et al) | EDAM | MERCI | Proposed App. |
|-------------|------------|------|-------|---------------|
| **Country** | China      | Italy | Hawaii | Indonesia     |
| **Type of survey** | Damaged buildings caused by earthquake | Damaged buildings caused by earthquake | Damaged buildings caused by earthquake | Damaged houses caused by earthquake |
| **Input** | Data, photo, video | Data, photo, video, and sketch | Text, photo, video | Data photo |
| **Mode** | Online | Online/ Offline | Online/ Offline | Online/ Offline |
| **Output** | - Map - Descriptive analysis | - Map - Damage evaluation | - Map - Descriptive analysis | - Map - Descriptive analysis |

3. System Requirements

The Apps that proposed is to help the process of damaged houses assessment to be performed faster than usual using mobile apps. The limitation of time after the earthquake occurred mostly disturbing the accuracy of the houses damaged assessment for calculating loss. In less than two weeks the data should be gathered and analyzed to determined the type of the damaged and the fund that government should spend to help the victims rebuild, or repair their houses. Based on experience of Pidie Jaya earthquake (December 7th, 2016) in where data collection was using the form from Ministry of Public Work and Civil Houses (Kemen PUPR). The Ministry determined the type of the building damaged into two only classifications; moderate and heavy damaged. This two categories not really represented the real condition which happened in Aceh Province.

According to guidebook released by Ministry of Public Work in 2013, the damaged categories were redetermined into three classes; light, moderate and heavy [7]. Light damaged is described as nonstructural damaged which only need minor repairment and can still be inhabited. The moderate were described as wall damaged, and also light structural damaged that can be repaired to be re-inhabited. The last, heavy damaged that translated into high volume of structural damaged that needs to be demolished and rebuild to be re-inhabited. The application needed the Google Map API service to work as location-based app. Beside the API services, the WebGIS also will be used to utilized the spatial data for more informative result visualization purpose. Mainly we have a few instruments for collecting data with the mobile application which are; Mobile device (android), Users (data collectors), data (photos, coordinate and text), internet connection, and server (offline and web).

3.1 Google Map API services

The apps that run in Android for damaged houses assessment is location based. The location-based is to the data classification by region using photo with geotagging features. The android app utilize google map API services to adopt the location-base application. The apps will help the data gathering in providing the coordinates of the location both with geotagging, or tagging manually offline in the maps that provided.
3.2 WebGIS

Since the android apps is highly utilize for the data gathering speed up, the visualization were later processed in Web page, in form of WebGIS. The data were stored and analyzed in a server-based and visualized through the GIS Web page.

4. Conceptual Design of Rapid Assessment Mobile App.

The Application built with user-friendly interface. Working both offline and online this proposed mobile application had a slightly improved advantaged over similar rapid assessment application (Xu et al., 2016). The system consists of five components (Figure 1):

1. Mobile device, such as mobile phone, tablet, other devices with Android-based, have GPS feature and can be connected to the internet.
2. User, is a data collector or surveyor which divided into trained user and common user.
3. Internet network.
4. Data center, consist of web server and database.
5. Data processing center, where the manager verified and analyze the data.

In the users side the components divided into two catageries which are trained users and common users. Both use the mobile device to collect data from the field. The input were transported to web server which are both data center and data processing center through internet. The simple flow of the apps can be describe with input from both users from the field through the internet and continued to be stored and validated via web server.

![Diagram of system](image)

**Figure 1.** Design of system.

The flow of data collection on the mobile application started with launching the application and setting up the project. Data collection will obtained with coordinate marking, geotagging photo taking, and building condition describing. The data will be saved in the mobile device in offline mode, and continue to be upload to the server when the internet is available. The data which has been gathered by the users will be verified and validated by the manager. Validated data will be analyzed by managers. The result represented in descriptive and spatial visualization through web for more useful and informative result.

In general, there are four actors which play a role in the apps, which are; trained users, general users, admin, and manager. Both trained and general users were performed as data collectors for damage houses which continue with uploading the data to the server. The manager had higher authority in data section. Manager is able to direct and manage trained users, manage the data (verification and validation), also analyze the data. the highest authority were taken by admin, where they can manage the whole projects and managers.
The system developed is on request by open and close setting. This means that the system is opened to be used if there is a request, in case of earthquake occurs. Furthermore, when the limit time for collecting data has been terminated, then this system will be closed again. This setting is aims to avoid the unwanted data, for example, the data that is submitted out of specified time. This arrangement also intend to focus data on an event in a particular place at a certain time.

4.1 Smartphone based App design

As mention before, the app is developed to be easy to used, simple and brief to fulfill the need of efficiency and effectiveness in collecting damaged houses data during rapid assessment period. Users directed to fill the simple form with brief explanation. Therefore users can gather as many houses data as possible. Users in the App was categorized into common and trained users. The app interface will contained of direct command to fill owners info (name, address and house coordinate) and continued with building types, part that damaged with photos and descriptions included (figure 2).

![Figure 2. Smartphone-based app user-interface.](image)

First user is specified to trained users while the second is common users for more general usage and term. Both common and trained users will be directed to gather the data about the house, ie; house ownership, address, type of houses, and take some pictures. Furthermore, trained users will gather more detailed and technical data for determining the level of damage on the houses. The operation were performed by answering for 3 houses categories; brick wall, structural brick wall, and wooden houses. Structural brick wall were assess three essential part; wall and top gavel, structural part, and roof. Wooden houses have less essential part to be assessed which are walls and frame, and roof. The assessment performed by answering descriptive question about the condition of the building. All the data analyzed in comprehensive resulting the level of damage which divided into 3 damage levels; heavy, moderate, and light. The three of them has their own value per each question. The level of the damages will determine based on their percentage of the total value. Here are the classification of damage by percentage value:

- a. Light damage: <25% of total value,
- b. Moderate damage: 25%> total value <50%,
- c. Heavy damage: >50% of total value.
Meanwhile, the common users are not directed to collect technical data regarding damage houses condition. Location coordinates will be automatically recorded when collecting the data, specifically photos (geotagging). However, in order to anticipate improper or shifting coordinates, columns are also provided to fill the coordinates manually.

4.2 Web-based App design

Web is used to visualize the collecting data and to analyze data. Web-based application is only for users at the level of administrator and manager. Administrator have access to manages (add, view, edit, and delete) managers and projects. Meanwhile, managers have features to manage the trained users, data (validation and verification), and analyze the data. Valid data can be analyzed and presented both descriptive and spatial analysis (Figure 3).

![Questions Details Gempa Pijay Prov. Aceh](image1)

![Gempa Pijay Prov. Aceh](image2)

**Figure 3.** Data Analysis through web.

5. Discussion

The utilization of mobile apps had became a necessity in the digital era. The needs of massive amount of data while remained accurate in a short time frame had produced the mobile apps as one of the most effective solution. The apps would be capable of handling both the efficiency and the integration of the data of damaged houses rapid assessment. The development of the mobile application conceptual design were developed using the waterfall software development method. The method capable of giving the ease to the developer in maintaining every steps clearly and well organized to help checking with the mistaken steps.

The concept of the house damaged rapid assessment mobile application will ease the beneficiary (government) in performing the rapid assessment right after the disaster, especially earthquake. The concept were adopting the 3 classification of the houses damaged class which are light, moderate and heavy which refer to former assessment in Aceh. The concept also planned the apps to work 2 time faster then manual. This achievement will be gained with merging the data collecting and data store process through the app integration with internet. The data also become easier to be re-check and analyze while being validate first.
6. Conclusion

The needs of time efficiency which coupled with data accuracy of data gathering during emergency response had force the way of rapid assessment process to be modernized through mobile era. Mobile application gave more time efficiency and controlled accuracy by two level users. Both offline and online capability also add more function and flexibility to match the blackout that usually happened after the earthquake occurred. The use of the app is very promising for future utilization with proper development.

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Acknowledgments

We would like to extend our gratitude for Tsunami and Disaster Mitigation Research Center (TDMRC) Syiah Kuala University for funding the application development.