WEB AND MOBILE-BASED DATA COLLECTION USING VGI FOR BUILDING FEATURE MAPPING/ATTRIBUTION IN THE FLOOD-PRONE ZONES OF WESTERN VISAYAS, PHILIPPINES

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Abstract

The rapid increase of the Philippine population and its economy has spurred an urban sprawl in various cities and towns across the country. The rise of building structures used for residential, commercial, medical, and industrial purposes has entailed land use conversion which presents a challenge in regards to government monitoring. Due to the limited manpower and financial resources of the national and local governments, comprehensive mapping and building structure inventories for urban planning, disaster risk management, and other applications have been insufficient and inadequate. A platform for Volunteered Geographic Information (VGI) data collection is thus useful when the government machinery cannot keep up with the expanse of the urban sprawl. Furthermore, geospatial databases populated by VGI would aid decision-makers in the formulation of government socio-economic policies, urban planning, and disaster management plans including loss estimation in the event of disasters.

This study incorporates both web-based tools and an android mobile application in creating a framework that can be used in geospatial mapping of building structures. Using available Digital Surface Model (DSM) which is derived from LiDAR data and orthographic photos, building outlines are manually extracted to create a geospatial database of the building structures in the flood-prone areas of Western Visayas, Philippines. Through digitization, each building outline is represented by a polygon. The geographic coordinates of the vertices of the digitized buildings are extracted and subsequently uploaded to the database server to be readily available for download in the web-based and mobile applications. When downloaded, these geographic coordinates are linked to create a digitized building which is overlaid to a *Google* Map layer. The database framework includes building attributes such as building materials, building height, and number of floors which are essential information in disaster management. The framework uses unified structures across web and mobile which incorporates the application of VGI. Building structures are mapped and attributed by mobile device users who act as efficient local contributors.

Keywords: mobile GIS, building attribution, volunteered geographic information, data collection, database development, disaster management

1. INTRODUCTION

1.1 Background

The Philippines, a developing nation with a population of about 100.98 million (POPCEN, 2015) and ranked as the world's second fastest-growing economy as reported in Bloomberg, is subject to numerous disasters per year which significantly affects countless of people, buildings and infrastructures across the country due to its geographical location and its physical environment. According to World Bank, the country is the third most vulnerable country to weather-related extreme events, earthquakes, and sea level rise. In a study conducted by World Bank in 2008, the country was identified as a natural disaster hot spot with approximately 50.3 percent of its total area and 81.3 percent of its population vulnerable to natural disasters and the Centre for Research on the Epidemiology of Disasters (CRED) recorded 207 significant damaging natural disasters in the Philippines from 2000-2012 as mentioned in Natural Disasters at a Glance (SEPO, 2013).

The rapid increase of the Philippine population and its economy has spurred an urban sprawl in various cities and towns across the country. Furthermore, building structures perform a crucial role in the protection to human life and the occupants' possessions in the event of disasters**.** The rise of building structures used for residential, commercial, medical, and industrial purposes have entailed land use conversion which presents a challenge for government monitoring. The rapid growth of cities presents a formidable challenge for urban managers, including how to monitor growth and change across the city and to forecast areas of risk (Song et al, 2010).

Geographic data and tools are essential in all aspects of emergency management: preparedness, response, recovery, and mitigation (Goodchild et al, 2010). In addition, the US National Research Council (NCR, 2007) reported that it is widely acknowledged that maps and all forms of geospatial data are essential in the earliest stages of search and rescue, that evacuation planning is important, and that overhead images provide the best early source of information on damage; yet the necessary investments in resources, training, and coordination are rarely given sufficient priority either by the public or by society's leaders. However, despite of government officials' initiatives to carry out the comprehensive mapping and inventory of building structures, the efforts seem to be insufficient due to the limited manpower and financial resources of the national and local governments.

The study recognizes the important role of building structures in times of disaster. This paper aims to provide another mechanism of geospatial data gathering of building structures with the aid of mobile devices and Personal Computers (PC) by creating an application called 'Buildings Wikimap'. In the Philippines, ongoing trends of using mobile devices and Internet have recently spiked the interest of the citizens. According to Ericsson's latest report on global mobile usage, the smartphone penetration in the Philippines is expected to reach up to 40% by the end of 2015, rising from 2014's 30%, and about 57.3 million of Internet users. The application, features geographic information system (GIS) technology, presenting the ability to integrate, store, process, and output geographic information in order to assist the decision maker in making correct decisions in an emergency situation (Rossetti, 2008). The authors takes advantage of this ongoing trend in the Philippines in mapping of building structures using the built-in Global Positioning System (GPS) tracking features of smartphones and PC devices with internet connection.

With the use of remote sensing data and geographical information system (GIS), the authors will create a web and mobile-based application that will aid in geospatial data collection of building structures. Furthermore, the study will incorporate the use of Volunteered Geographic Information (VGI) in the process of data collection. VGI is closely related to the concept of crowdsourcing (Howe, 2008), which has acquired two somewhat distinct meanings. Users participate in VGI communities and share their data with other community members at no charge. The authors recognize the important role of the citizen volunteers in the success of the building inventory and mapping. As stated by Marcus et al (2012), VGI is the collaborative and voluntary collection of any kind of spatial data, and has evolved to become an important source for geo-information.

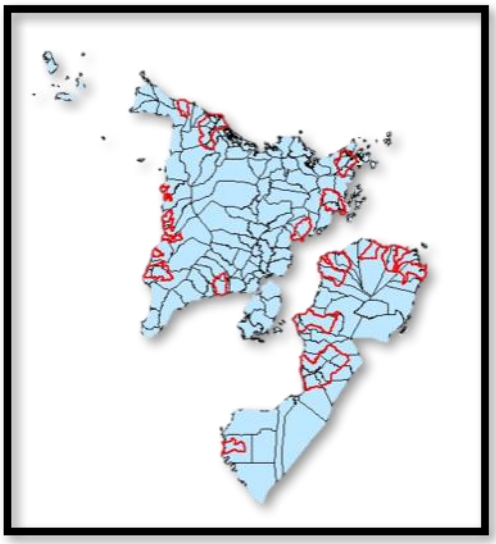
Furthermore, the authors recognize the importance of up-to-date and timely mapping of building structures for monitoring, nationwide land-use planning and assessment for disaster management. Through this proposed web and mobile-based application as well as the incorporation of the concept of VGI, the researchers hope to provide an alternative way to map building structures in the Philippines.

1.2 Study Area

The study covers the provinces of Western Visayas, Philippines; namely Aklan, Antique, Capiz, Guimaras, Iloilo, and Negros Occidental. Based on the 2010 census by the Philippine Statistics Authority, Western Visayas has a population of 7,089,739.

The region has an extensive history of flooding problems, encountering about 100 out of 133 cities and municipalities of the region cited as a high risk for landslides and floods by the regional office of Mines and Geosciences Bureau (MGB) as reported in The Manila Times (Pendon, 2016).

Figure 1: Floodplains of the 22 Rivers in Western Visayas



The scopes of this study are the floodplains of the 22 major river basins in Western Visayas (Figure 1), which covers a land area of 2580.433 square kilometers. This comprises: 2 rivers in the province of Aklan (Aklan and Ibajay river), 7 rivers in the province of Antique (Cairawan, Cangaranan, Dalanas, Paliwan, Sibalom 2, Tibiao, and Ipayo river), 4 rivers in the province of Iloilo

(Balantian, Barotac, Pinantan and Sibalom river) and 9 rivers in the province of Negros Occidental (Bago, Binalbagan, Danao, Grande, Himoga-an, Imbang, Malogo, Sipalay and Tanao river).

2. METHODOLOGY

2.1. Data

Data used in this study includes Digital Surface Models (DSM), orthographic photos, and flood extent shapefiles of the flood prone areas in Western Visayas. These data were obtained from the Philippine national hazard-mapping project, Phil-LiDAR 1, which is a government funded collaborative work between UP Diliman and UP Cebu for the Western Visayas region. The LiDAR data has a resolution of 1 meter and a point density of 2-4 points per square meter while the ortho-photo has a resolution of 0.5 meter. Both datasets have Universal Transverse Mercator (UTM) Zone 51N projection.

DSM, which is derived from LiDAR data, is a 3D representation of terrains surface; Orthophoto is an aerial photo of ground features geometrically corrected; and Flood extent shapefile identifies the flood-prone zones in Western Visayas.

2.2. Building Extraction

With the aid of DSM, orthophoto and flood extent shapefile, building outlines within the flood extent are manually extracted through the digitization of building structures. Each building outline is represented by a polygon, referred heretofore referred to as a digitized building, and assigned with a unique building identifier. The output of this process is a digitized building shapefile of all building structures within the flood extent of the 22 river basins.

2. 3. Buildings Wikimap Framework

The framework of the *buildings wikimap* is designed to incorporate the application of Volunteered Geographic Information (VGI) in building feature mapping and attribution. It comprises three layers, namely the presentation layer, business layer and data layer (Figure 2). The presentation layer provides interactive components that execute and display the user interface and manage user interaction. This layer is implemented in both the web and mobile platforms. The business layer provides the logical components and functionality of the application. Google Maps Server is also included in the business layer, serving as a tool that provides satellite or roadmap orthophoto on the presentation layer. In the data layer, central geodatabase server has been configured to store the geospatial and other necessary data.

Figure 2: Buildings Wikimap Framework

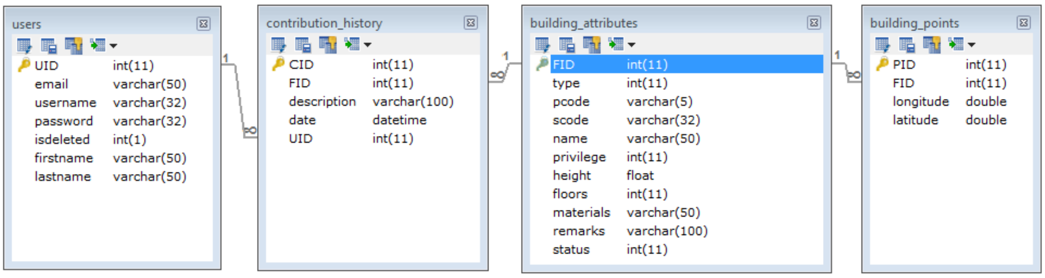
PRESENTATION LAYER	Mobile Application	Web Application
BUSINESS LAYER	Webservices	Google Maps Server
DATA LAYER	Geodatabase	

2.4. Geodatabase Architecture

In the data layer, centralized geodatabase is defined using a Relational Database Management System (RDBMS) on the server. MySQL, an RDBMS, is used to create the geodatabase for building structures and other necessary data.

The geodatabase of building structures is named *bsm.* The *bsm* geodatabase contains 4 table objects, namely *users*, *contribution_history*, *building_attributes*, and *building_points*. The geodatabase schema is organized so that it can easily be accessed, managed, and updated. It has been standardized across the framework. Moreover, the schema is designed to maximize the storage capacity without compromising the performance the geodatabase. Figure 3 shows the entity relationship diagram and the structure of the geodatabase.

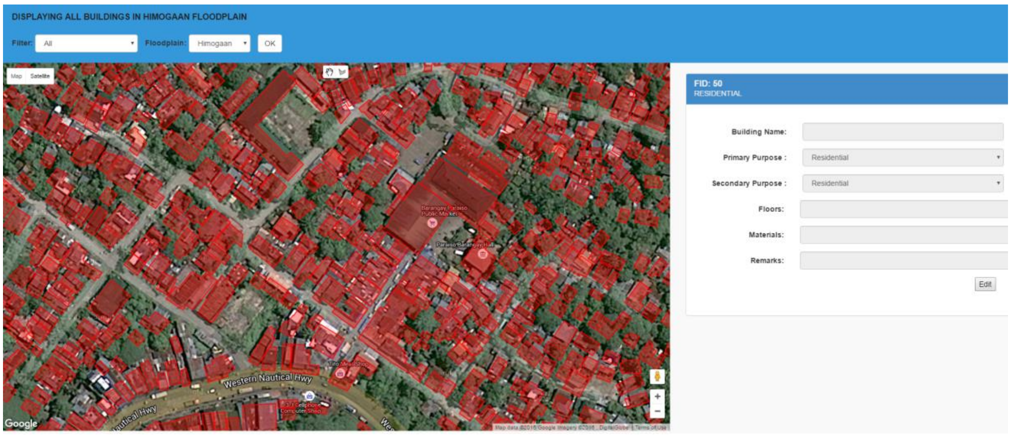
Figure 3: Geodatabase Entity Relation Diagram



2.5. Web-based Application

In the presentation layer, a web-based application has been developed using PHP, Google Map Library V3 API, JavaScript, HyperText Markup Language (HTML) and Cascading Sheet Style (CSS). The user interface of the web-based app consists of login, user registration and building maps and attributes (Figure 4). The web-based application is designed to allow users to login and register an account, view, and map and attribute geospatial data to the building features.

Figure 4: Web-based application



In the web-based application, the digitized buildings are embedded to Google Maps using the geospatial data of points from the geodatabase. Furthermore, only users with an account can add, delete and update a digitized building, this is to minimize the inaccuracy in building mapping and attribution and to protect the final geospatial data of building features in the centralized geodatabase server. Users without a registered account are only limited to view the compilation of geospatial data of the building structures. The users are also allowed to filter the view using the building type attribute as keyword.

Finally, internet connection is a primary requirement to use the web-based application because all data requests will go directly to the centralized geodatabase hosted online.

2.6. Mobile-based Application

Using an android platform and Google Map Library V3 API, a mobile-based application has been developed along with the web-based application in the presentation layer. The android platform has been selected for mobile development due to the current popularity of the operating system (OS) and to the high availability of affordable android OS mobile devices in the market. The android application will operate as a mobile geographic information system (mobile GIS), and will be used to collect geospatial data of building features. The user interface of the android app consists of user registration and login, configurations, digitized building map (Figure 6), and building attributes (Figure 7) and interface.

Figure 5: Building Wikimap Icon

Source: https://logomakr.com/15rpoY

Figure 6: Digitized Buildings Map Interface

Figure 7: Building Attributes Interface

The mobile application is implemented with a local geodatabase. The local geodatabase is designed with the same structure of the centralized geodatabase.

It will serve as a local storage of the downloaded and updated geospatial data of building structures, user information of logged-in users in the device, and contribution history in the mobile device. The local geodatabase in the mobile device will allow users to login to an account, map and attribute building structures without the need of an internet connection and can be combined to the centralized geodatabase upon uploading the local dataset in the mobile device to the centralized geodatabase with the use of an internet connection. The 500 digitized buildings is the maximum view per screen.

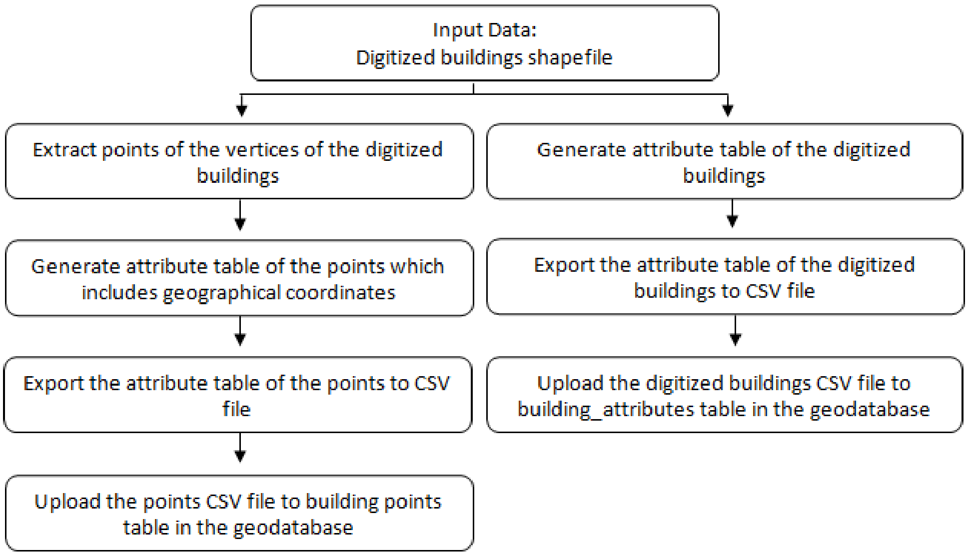
Furthermore, it is designed that only users with registered accounts can utilize the main functionality of the app. During the first login, the user must be connected to the internet for authentication. However, the succeeding log-ins of same the account does not require internet connection. So, users who wish to access the main functionality must have an internet connection to register an account to the centralized database.

Moreover, components are implemented in the mobile app to send user requests in the server and these requests are received and processed using the implemented PHP web-services. The PHP web-services queries the requested data in the centralized database and provides the data to the presentation layer.

2.7. Conversion of Digitized Buildings Shapefile to Geodatabase

Figure 8 shows the workflow of the conversion of digitized buildings shapefile to geodatabase data. The vertices of the digitized buildings are extracted using the

Figure 8: Procedure of Converting Digitized Buildings Shapefile to Geodatabase



Feature Vertices to Points Tool in Data Management. Then, using calculate geometry, the geographical coordinates of the points are calculated. These points will serve as a guide in creating a digitized building in the web-and mobile-based application. Furthermore, the points also contain an attribute which is an identifier to which digitized building it belongs.

2.8. Building Attribution

The mobile-based application in figure 7 and web-based Application shown in figure 4 shows the user interface for updating the building attributes. These attributes are vital information in disaster management and city planning.

The *FID* is the identifier of the building structures, and is automatically assigned by the app. The *no. of floors* is the attribute for the figure of floors the building has. The *est. height* is the height estimation of the building. The *building name* is the name of the building structures. The *primary purpose* and *secondary purpose* are for the building type, which is defined through the purpose of the building, see (Table 1) the list of identified building types. The *primary type* is the primary purpose of the building which *secondary type* is for the secondary purpose of the building, and it the data is optional. The *materials* are the resources used in the construction of the building. Lastly, the *remarks* is for the information which the VGI thinks it is vital, however, no column is assigned.

Table 1: List of Building Types

Building Type	Description
Residential	A building designed for people to live in. *ex. Home, Apartment, Condo*
School	A Building used for education. *ex. High School, Elementary, University*
Market/Prominent Stores	An important and well-known building. *ex. Public Market, Malls*
Agricultural & Agro-industrial	Building used in farming operations. *ex. Pigpen, Chicken pen*
Medical Institutions	A building where sick or injured people are given medical care *ex. Clinic, Birthing Center, Hospital*
Barangay Hall	the seat of local government for the *barangay*
Military Institution	A building used by military officers *ex. military barracks*
Sports Center/ Gymnasium/ Covered Court	A building equipped for games, and other big activities.
Telecommunication Facilities	structures and equipment which make up a *telecommunications* network *ex. cell tower, radio station tower*
Transport Terminal (Road, Rail, Air, and Marine)	a structure where city or intercity stop to pick up and drop off passengers. *ex. Bus Terminal, Airport, Port*

Warehouse	building where raw materials or manufactured goods may be stored before their export or distribution for sale
Power Plant/Substation	an installation where electrical power is generated for distribution.
NGO/CSO Offices	A facility used by a not-for-profit organization that is independent from states and international governmental organizations.
Police Station	A building used by police officers.
Water Supply/Sewerage	A facility where water supply are controlled
Religious Institutions	A building used for religious activities, and worship services. *ex. Chapel, Church*
Bank	A building used by financial institution. *ex. BPI, Landbank*
Factory	A facility where manufacturing takes place
Gas Station	An establishment beside a road selling gasoline and oil.
Fire Station	A facility where fire engines and other equipment of a fire department are housed.
Other government offices	Government buildings which are not on list; buildings which are owned by the government. *ex. DRRMC office, Municipal hall, DePED office*
Other commercial establishments	Building primarily use for commercial purposes but cannot be considered as prominent store or market. ex. *Sari-sari Store, Autoshop Restaurant, Bakeshop*

4. CONCLUSION AND FUTURE WORK

The authors observed a geospatial shift in the digitized buildings using DSM of LiDAR data and orthophoto when overlaid on the Google Map orthophoto.

This paper presented aims for the creation a web and mobile-based application which incorporates the concept of VGI in data collection and aims to help the government in the mapping of building structures within the flood extent of the 22 river basins in Western Visayas. The study intends to maximize the manpower of the Philippines without compromising the financial budget of government and its citizens and to motivate the citizens to contribute in nation building.

In the near future, we intend to use the collected geospatial dataset for disaster management and city planning. We also intend to have a further study of the accuracy of the collected geospatial data.

To end, the Buildings Wikimap application has already been developed and is still on the testing phase, the authors plan to release the application before the start of year 2017.

5. ACKNOWLEDGEMENTS

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