COMMUNITY-BASED MAPPING PLATFORM FOR ATTRIBUTION AND SPATIAL SURVEY (CoMPASS)

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ABSTRACT: Central to every disaster preparation and mitigation initiative is information. Particularly, it is very essential that information on the built-up areas are data based so that it would be easier for the local government units to account infrastructure and property damage. For this purpose, the Ateneo de Zamboanga University Phil-LiDAR 1 has developed a Geographic Information System (GIS) web-based offline application for the attribution of features extracted from a Light Detection and Ranging (LiDAR) Digital Surface Model (DSM) and for flood hazard maps validation. The application practically intends to lessen the time of conducting feature attribution by combining automatic data consolidation, geo-tagging and offline navigation. The application is developed using a Palapa Web Server and then integrated into handy android smartphones. The collected data are automatically stored in database and can be downloaded in CSV (comma separated values), KML (keyhole markup language) format and in SHP (shapefile) format. A CSV file is a table structured format which can be opened in Microsoft Excel. On the other hand, a KML file shows the collected data geographically and can be viewed through Google Earth while a SHP file is essential on post-processing of data in a GIS software. This process eliminates the tedious process of paper-pen survey, and thus lessens human-induced errors. Through this application, the researchers was able to gather the data on the types of buildings present in the flood plain. Aside from this, the buildings attributed were also categorized based on the materials used (concrete, semi-concrete and wooden), classified into types (residential, commercial and etc) and number of storeys.

1. INTRODUCTION

Geographical Information Systems (GIS) is a developing tool in this generation that is rapidly growing. GIS shows considerable potential in increasing number of application domains which is useful in regional and environmental planning (Fedra, 1993). The incorporation of GIS in web platforms enables more opportunity in spatial analysis and developments in community level activities.

Philippines located along the Pacific Ocean's "Ring of Fire" is no stranger to natural hazards. Typhoon Haiyan in 2013 and Typhoon Pablo in 2012 recorded the worst in number of casualties, damage and people affected (Rappler, 2017). With this Phil-LiDAR 1 Program was created as an expansion of the Disaster Risk and Exposure Assessment for Mitigation (DREAM) Program which aims to create 3-D flood hazard maps. One product of the project is the Light Detection and Ranging (LiDAR) Digital Surface Model (DSM) which will be used in delineating features significant to flood modeling and flood impact assessment (UP DREAM Program, 2017). Ateneo de Zamboanga University (AdZU) is the partner Higher Educational Institutional (HEI) of the University of the Philippines Diliman (UP Diliman) in implementing the program along the Zamboanga Peninsula. The challenge in the AdZU Phil-LiDAR 1 project was the attribution of the features which requires tedious process on consolidating data from paper documents.

As a result, the researchers generated a Community-based Mapping Platform for Attribution and Spatial Survey (CoMPASS) which aims to develop a localized GIS integrated mobile application which will be used in the needs of the project. The significance of the study is developing a user-friendly platform for the researchers to use in feature attribution and flood map validation. The study eliminates the use of paper and pen in the conduction of field surveys. The study also aims to increase the productivity of gathering data.

2. METHODOLOGY

The study involved four (4) phases as shown in Figure 1.

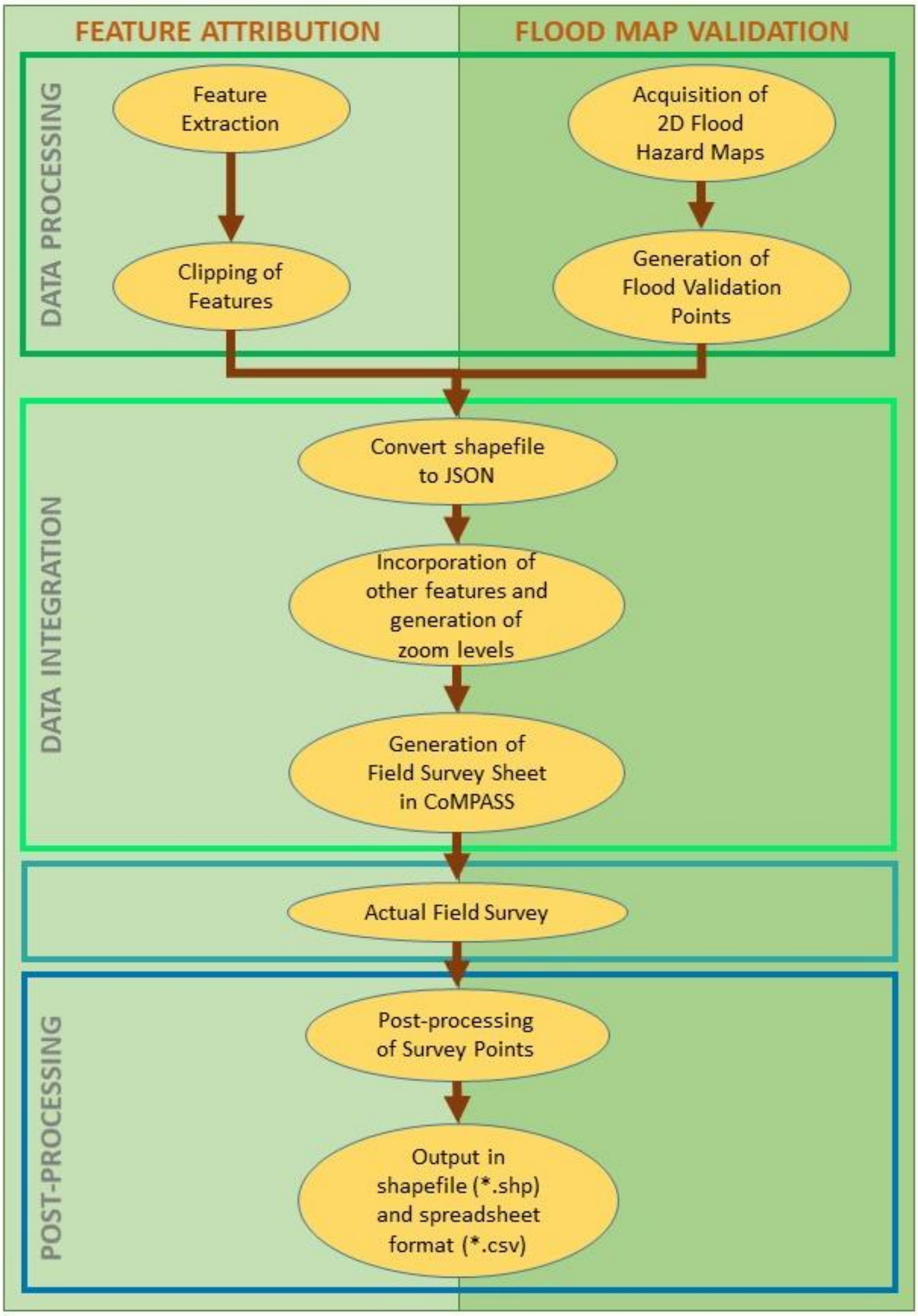

Figure 1. Research Design

2.1 Study Area

The study area composes of eighteen (18) river basins covered by ADZU Phil-LiDAR 1 as part of the nationwide Phil-LiDAR 1 Program. The river basins are located in Region IX- Zamboanga Peninsula of the Philippines. The study covers seven (7) river basins in Zamboanga City, five (5) river basins in Zamboanga Sibugay and six (6) river basins in Zamboanga del Norte. The study area were determined through the availability of LiDAR data and the flood plain boundaries provided by UP Diliman Phil-LiDAR 1.

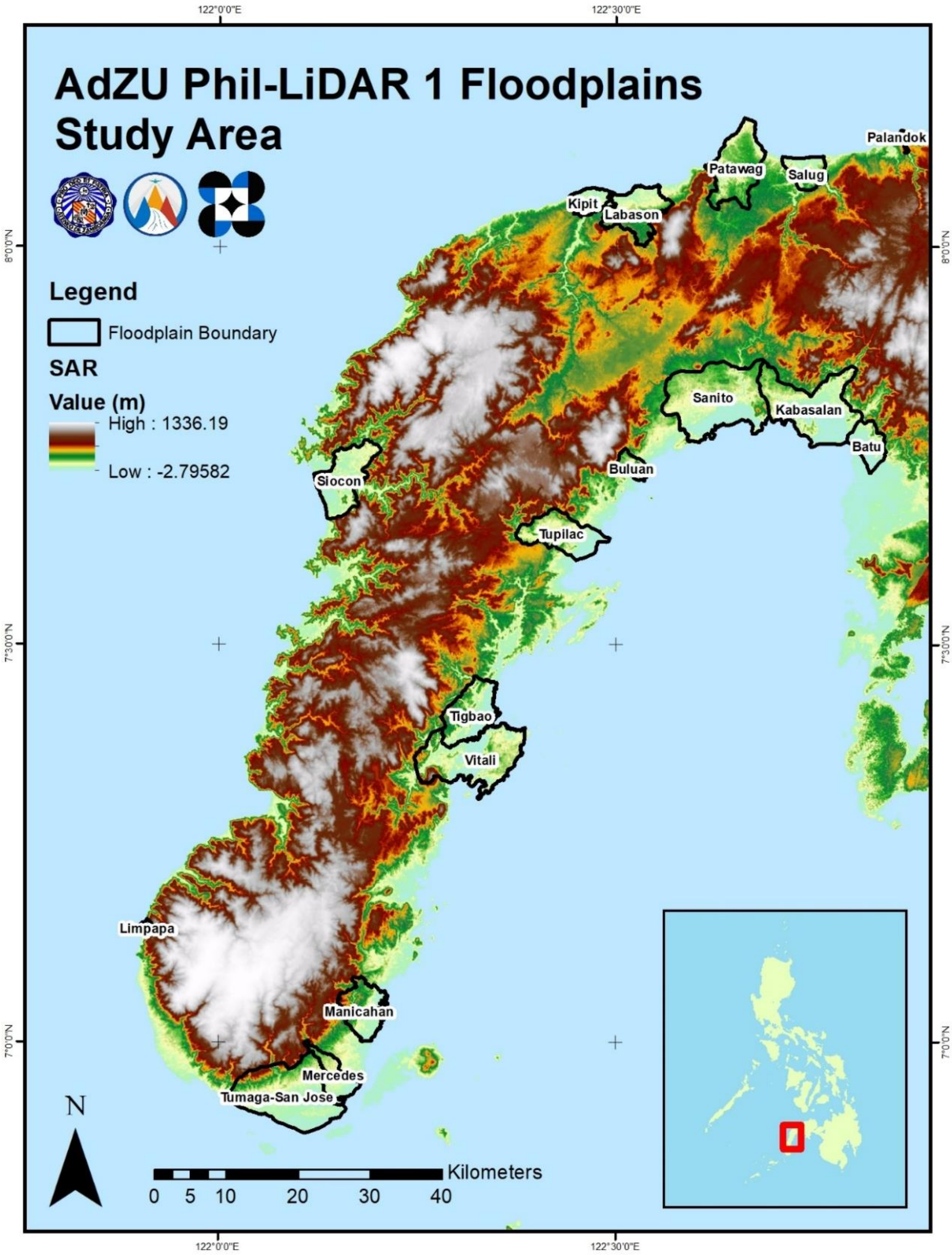

Figure 2. Study Area

2.2 System Development

The components of the system are the (a) Palapa web server, web application and mobile devices. The Palapa web server is an android application downloaded to the mobile device which serves as the server for the web application to run. The web application or web app is a client-server computer program in which the user/client run the web app in a browser. The researchers programmed the study using Hypertext Preprocessor (PHP) framework. The mobile devices to be used in the study ranges from smartphones to tablets because of its higher specification and can comply with the web application. The web application uses the built-in Global Positioning System (GPS) of the device for the location. Mobile devices used in the study have at least one (1) gigabye of Ready Access Memory (RAM) running on an Android 5.0 Lollipop or higher in order to process the data faster.

2.3 Data Processing

In the Field Attribution survey where the study will be used as a tool, features are initially processed in ArcGIS to serve as guide features in the map. The rivers and building features to be inputted in the CoMPASS were digitized by the researchers as part of the Feature Extraction of the project. The researchers used LiDAR DSM which has a 1-meter spatial resolution as basis for extracting the water bodies and building features. It is then validated using 0.50-meter orthophotos or satellite images from Google Earth. The floodplain boundary serves as the guide in delineating the features. The features were then clipped either by zone or barangay for the distribution of features to be attributed per mobile device.

The 2D Flood Hazard Maps generated per river basin by the Flood Modeling Component of UP Diliman Phil-LiDAR 1 were used as basis by the researchers in generating flood validation points. Guidelines for Flood Map Validation were prepared by UP Diliman Phil-LiDAR 1. There were six (6) ranges that the flood hazard map was classified and thirty (30) points per flood level were produced which totals to one-hundred and eighty (180) sample points. The researchers generated the sample points to flood levels where there is a near building feature for the actual survey. The researchers also integrated the flood validation questions during feature attribution survey in order to increase the number of points gathered without considering the flood hazard map's model depth.

2.4 Data Integration

The data processed were then integrated to the platform. Polygon (building), polyline (rivers and roads) and point (flood validation points) features in shapefile format were converted online to .geojson format which is a setup used for encoding geographic data features and attributes based on JavaScript Object Notation. The converted data is then incorporated into map tiles in MBTiles format which is a package file of base maps and features. Zoom levels were then generated before final coding into the PHP platform.

Using PHP framework, the survey form was coded by the researchers. The study used the established survey attributes needed by the project which was prepared by UP Diliman Phil-LiDAR 1. The attributes consisted of data needed for flood exposure assessment which is a key output of the project. The data collected on the field attribution of survey will serve as exposure data that will be statistically correlated with the flood hazard maps generated by the Flood Modeling Component of the project. The attributes needed are listed below in Table 1. Aside from the needed attributes, construction material type (concrete, semi-concrete and wood) and number of building levels where included in the survey form. For the flood validation form, historical events, date and time and actual flood depth were included in the survey form.

Attributes	Detail
Building Name	Optional for residential Buildings
Building Type	Residential
	School
	Market/Prominent Stores
	Agricultural & Agro-Industrial
	Medical Institutions
	Barangay Hall
	Military Institution
	Sports Center/Gymnasium/Covered Court
	Telecommunication facilities
	Transport terminal (Road, Rail, Air, and Marine)
	Warehouse
	Power plant/Substation
	NGO/CS) Offices
	Police Station
	Water Supply/Sewerage
	Religious Institutions
	Bank
	Factory
	Gas Station
	Fire Station
	Other government offices
	Other commercial establishments

Table 1. Phil-LiDAR 1 Field Attribution Detail

2.5 Actual Survey

Actual survey were done strategically per river basin area. Majority of the fieldwork were done considering multiple river basin that are adjacent to each other. Field attribution and flood validation survey were done simultaneously with deployment of sensors and topographic survey to be used for other parts of the Phil-LiDAR 1 project.

For field attribution survey, local personnel were hired and trained to be enumerators. The researchers prepared a simple tutorial for the usage of CoMPASS in the mobile devices that were prepared beforehand. The researchers then assigns the enumerators for the survey strategically per target location considering the number of features per enumerator. The researchers ensures the capability of the enumerators to conduct survey and were briefed beforehand of possible errors encountered.

After the survey is done, the enumerators were gathered. The researchers collected the devices used then evaluated the output of the enumerators and if necessary, resurveys were conducted.

2.6 Post-processing of Data

Post-processing of data is necessary for every attribution survey. Using a GIS software, the researchers cleans the data for unnecessary points gathered. Some points were then adjusted in order to be inside its corresponding attributed feature. This is essential in merging the attributes gathered to the building features.

3. RESULTS AND DISCUSSIONS

The study was successfully utilized by the ADZU Phil-LiDAR 1 Project during the Field Attribution and Flood Validation Survey. The eighteen (18) river basins covered by the project were finished faster with the use of the study. In field attribution, there were a total of 167,646 features attributed and a total of 7,398 flood validation points surveyed using CoMPASS. The interface of the platform is shown in Figure 3. The platform runs in an Android mobile device. The figure below shows the compass logo, base map with features, survey form, and map output.

The tedious part of the study was the Field Attribution Survey. Table 2 shows the result of the study which shows the number of features per facility type in each floodplain covered by ADZU Phil-LiDAR 1. The results shows that majority of the attributed features were residential which is the most exposed building feature in any flood events in the respected river basins.

Figure 4 on the other hand shows the average rate of features attributed per enumerator in a day. The sequence of the floodplain shown below were arranged from smallest to largest number of building features. For Limpapa and Palandok flood plains with less than one-thousand (1,000) building features performs the lowest rate. The researchers observed that this is caused by features not being close to each other which take more time for the enumerators to survey. Another cause is the accessibility of the features due to its topography. These two (2) floodplains were also the smallest in area which is not that developed compared to other river basins. This follows the lesser infrastructures like access roads in the area. Majority of the rate of enumerators exceed one hundred and seventy (170) per day which shows an average rate of attribution. The rate of enumerators in Buluan and Manicahan exceeds to three hundred (300) features per day which shows excellent rate of attribution. This was mainly because closeness of building features being surveyed. The researchers observed the varying rate of enumerators was mainly because of the proximity and accessibility of the building features.

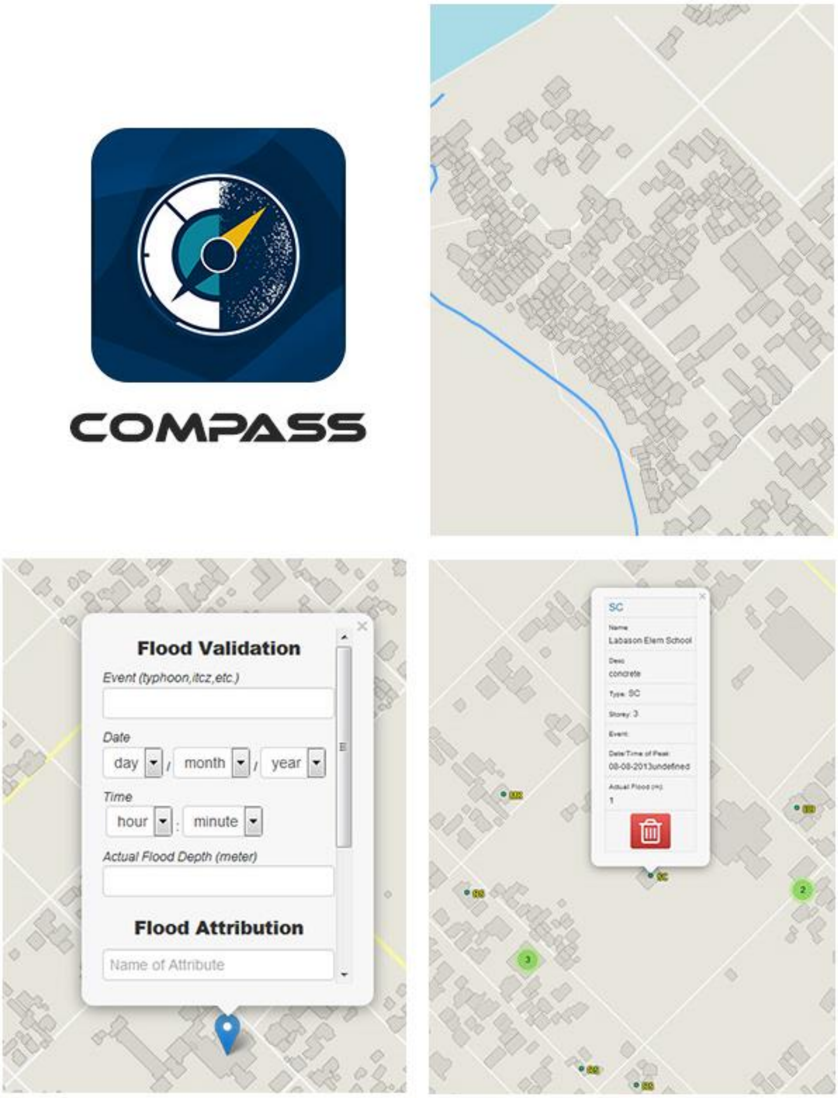

Figure 3. CoMPASS

Facility Type	Batu	Buluan	Kabasalan	Kipit	Labason	Limpapa	Manicahan	Mercedes	Palandok	Patawag	Salug	Sanito	Siocon	Tigbao	Tumaga & San Jose	Tupilac	Vitali
Residential	2,966	1,616	8,639	1,710	6,068	416	5,564	11,262	455	6,995	4,213	18,761	6,407	2,518	744,440	1,557	3,259
School	41	16	276	15	65	15	54	136	13	55	43	139	90	79	750	34	72
Market	22	11	98	11	37	14	43	383	4	103	34	107	86	35	1,949	15	70
Agricultural/Agro-Industrial Facilities	12	7	36	5	16	4	13	80	7	237	1	6	55	2	89	123	16
Medical Institutions	1	1	17	-	7	1	5	11	1	6	1	11	13	-	86	2	1
Barangay Hall	4	1	27	2	3	-	4	4	1	17	6	11	14	2	29	3	3
Military Institution	-	-	3	-	8	-	-	1	-	2	-	1	2	1	406	-	4
Sports Center/Gymnasium/Covered Court	2	1	22	3	10	-	-	9	1	6	5	8	11	3	52	8	4
Telecommunication Facilities	1	-	2	-	1	-	2	1	-	2	-	-	1	-	9	-	-
Transport Terminal	4	-	7	-	1	-	-	-	-	2	2	12	2	-	25	-	-
Warehouse	12	5	33	-	35	-	10	12	8	31	10	15	37	1	184	8	16
Power Plant/Substation	-	-	2	-	-	-	-	-	-	-	-	10	1	-	6	-	1
NGO/CSO Offices	2	-	4	1	-	-	1	-	-	1	-	8	2	-	8	3	-
Police Station	-	-	3	-	1	-	-	2	-	1	1	3	2	1	21	-	1
Water Supply/Sewerage	1	-	4	-	-	2	5	4	-	1	-	3	1	-	41	6	-
Religious Institutions	13	6	96	12	37	7	12	13	7	42	6	60	44	11	163	20	26
Bank	1	-	1	1	1	-	-	-	-	2	-	19	1	-	20	-	-
Factory	-	-	1	-	2	-	4	85	-	-	-	19	1	-	215	-	2
Gas Station	-	-	6	-	4	-	-	-	-	6	-	9	3	1	45	-	2
Fire Station	-	-	1	-	1	-	1	-	-	1	-	1	1	-	4	-	-
Other Government Offices	4	3	34	5	19	-	1	8	1	3	4	53	16	2	138	33	-
Other Commercial Establishments	28	2	80	4	73	-	10	27	3	26	23	250	32	3	1,114	3	9
N/A	-	-	204	2	-	-	149	-	-	-	-	-	29	-	234	-	-
Total	**3,114**	**1,669**	**9,595**	**1,771**	**6,389**	**459**	**5,878**	**12,038**	**501**	**7,538**	**4,349**	**19,506**	**6,851**	**2,659**	**80,028**	**1,815**	**3,486**

Table 2. Facility Type Results in Building Attribution per Floodplain

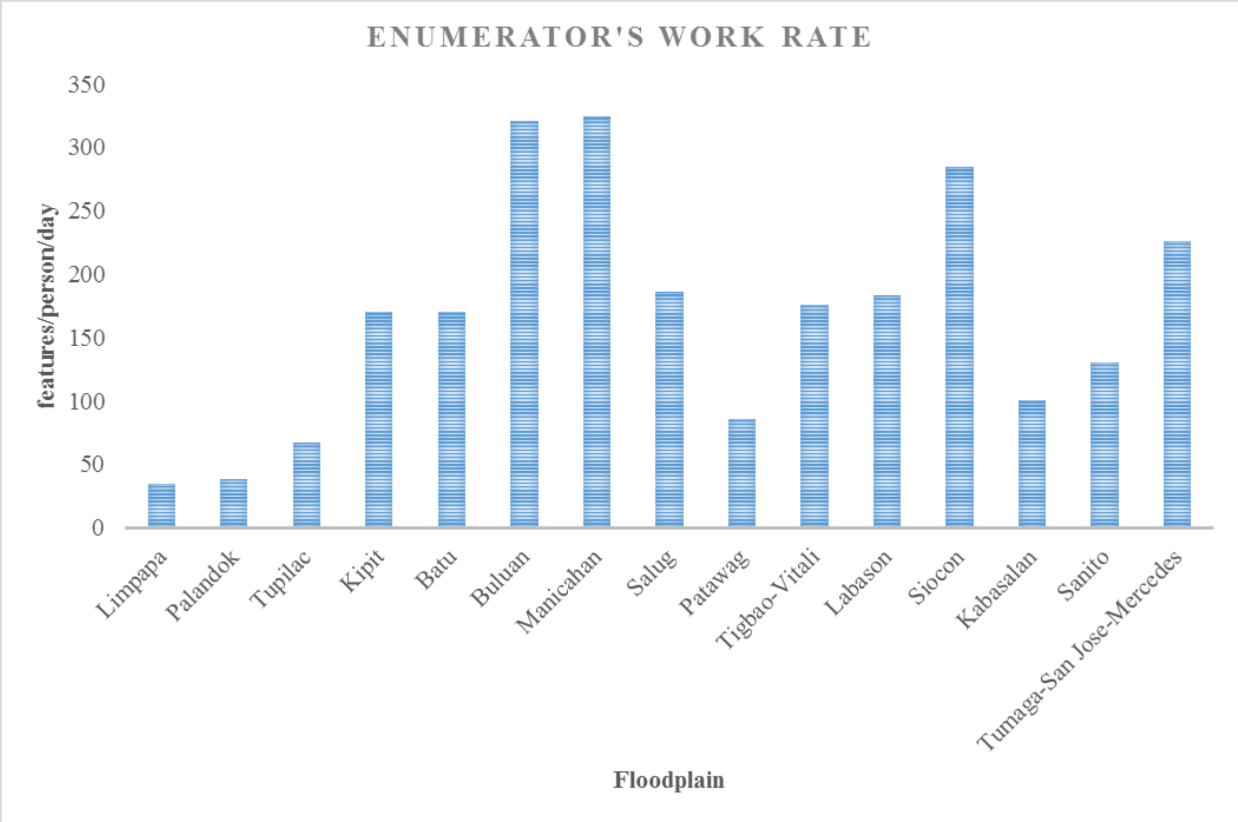

Figure 4. Enumerator's Work Rate

4. CONCLUSIONS AND RECOMMENDATIONS

The study was essential to the completion of the ADZU Phil-LiDAR 1 project. The field attribution survey and flood validation survey was successfully conducted using the CoMPASS. The study served its purpose as a venue for a paperless survey which utilizes latest development in the field of GIS and application development. The study have gained interest in the local government of the river basins where the study was conducted. The rate of enumerators in using the CoMPASS platform shows faster rate compared to manual paper survey as observed by the researchers. Interactive platform for text input and option-based questions was effective in conducting the study. Specifically the Municipality of Labason and the Province of Zamboanga del Norte have already communicated with the researchers in developing a survey form specific for their needs.

The framework used in the study was simplified that it only functions on the basic needs of the project. Because of this, the codes were vulnerable to copyright issues. The researchers recommend the licensing and security improvement of the core framework of the study. The researchers also recommend improvement of automatic synchronization of data from the device to the server once the mobile device is connected to the internet. Logging of time of feature attribution will also trace the amount of time the enumerators used in surveying and in transferring from one feature to another.

In this generation, GIS as a tool for planning, research and developmental works have been a priority for developing countries especially for hazard-prone countries like the Philippines. With this, it is a continuing challenge of improving services of this study. The researchers were only limited in using CoMPASS as a tool for project-related activities but sees the great potential especially in creating database for local communities were technology is still in its early stages. The study will improve its services for the region and for the Geoinformatics and Systematic Assessment of Flood Effects and Risk for a resilient Mindanao (Geo-SAFER Mindanao) which continues to develop flood hazard maps. The researchers have already initiated the second version of the study which aims to produce a standalone Android application that is more efficient and interactive to the needs of the region.

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