Map-Based or Location-Based Census Operation Using Modern GIS Platform

by

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Paper Abstract

This paper aims to introduce map-based or location-based conduct of census operations using modern GIS Platform. This modern approach will facilitate integration of statistical or census information and geospatial information to make spatial analysis of census results possible through the use of dynamic maps and intelligent data visualization.

This paper attempts to present methods and procedures in conducting the map-based census operation intended specifically for the future conduct of 2020 Census of Population and Housing (CPH) and the 2023 Census of Agriculture and Fisheries (CAF). With the availability of digitized census maps and the on-going conduct of geo-tagging of buildings nationwide to develop digital building footprints, the possibility of using this vector information as point in the digitized map that represent building can be used to develop procedures that would subtantially link thegeo-tagged buildings to the census enumeration units (*i.e housing unit, household, and individual*). Generally, the process generates geodatabase that contains both geospatial information (*i.e., x, y, and z coordinates*) and census data. To illustrate the methods and procedures of map-based census taking, this paper will use results and findings from the series of pretesting conducted for the 2020 Census of Population and Housing (CPH). While the map-based census taking is done to collect person level data, no individual information but only statistical summaries and aggregation will be released to ensure compliance with the data privacy act.

The map-based census operation using the modern GIS technology will considerably improve the statistical business processes of the Philippine Statistics Authority (PSA). The improvement will be in terms of accuracy by addressing non-sampling error such as non-coverage and over-coverage. This can be done using real time GIS-based progress monitoring dashboard for supervisors for the early detection of coverage gaps and subsequently early field intervention to mitigate coverage problems. The timely release of census results can be assured using the technology since data processing is already integrated in the technology-aided data collection using tablet device.

Map-Based Census Operation Using Modern GIS Platform

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1. Introduction

The Philippine Statistics Authority (PSA) is mandated by law to carry out nationwide conduct of periodic surveys and censuses. The censuses that are regularly conducted by the PSA are the following: (1) Census of Population and Housing (CPH); (2) Census of Agriculture and Fisheries (CAF); and Census of Philippine Business and Industry (CPBI). The Census of Population and Housing (CPH) aims to gather basic information on demographic and socio-economic characteristics of the population selected important housing characteristics. The last Census of Population (POPCEN) was conducted in 2015 while the last Census of Population and Housing (CPH) was conducted in 2010. The next census of population and housing (CPH) will be conducted in 2020. The Census of Agriculture and Fisheries (CAF) aims towards the collection and compilation of basic information on the agriculture and fishery sector of the country. The last agricultural census was in 2013, that is, the 2012 CAF. The next agricultural census, the 2022 CAF will be conducted in 2023. The Census of Philippine Business and Industry (CPBI) aims to collect and generate information on the levels, structure, and trends of economic activities of the Philippines. The last industry-based census, 2012 CPBI, was conducted in 2013. The next industry-based census, 2018 CPBI, will be conducted in 2019.

The previous censuses in the Philippines were still conducted using the paper and pencil personal interviewing (PAPI). This type of interview (PAPI) method, unlike computer-assisted personal interviewing (CAPI), does not require expertise in Information Technology (IT) to implement survey/census operations. Recently, the PSA's survey data collection methods have substantially shifted to CAPI. The 2015 Global Adult Tobacco Survey used tablet-device in collecting data. The quarterly Labor Force Survey (LFS) had started to use CAPI since January 2017 survey round. The 2017 National Demographic and Health Surveys (NDHS) and the 2017 Listing of Farm Households (LFH) likewise implemented CAPI during data collection.

While the Philippine Statistics Authority (PSA) had made some progress in modernizing data collection method through the use of CAPI, the value of location or the application of "science of where" had only just started recently. Not long ago, in 2016, the Environmental Systems Research Institute (ESRI) introduced the potential applications of modern Geographic Information System (GIS) platform in the statistical business

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processes of the PSA including that of sample surveys, censuses, and administrative-based data collection. The modern application of GIS allows integration of statistical and geospatial information maximizing the usefulness of collected data in communicating statistical results with dynamic geographic details.

This paper aims to introduce map-based or location-based conduct of census operations and to explore the possibility of integrating statistical and geospatial information. The study focuses mainly on the application of GIS-based platform in the conduct of 2020 Census of Population and Housing (CPH). The integration of statistical or census information from tablet-aided data collection and the geospatial information containing vector data and raster images from the digitized census maps aims to create geodatabase that can be used to render spatial analysis from the census results and to facilitate intelligent data visualization and geospatial analytics.

This paper also attempts to present methods and procedures in implementing the conduct of map-based census operation intended specifically for the future conduct of PSA censuses, that is, the 2018 Census of Philippine Business and Industry (CPBI) to be conducted in 2019, 2020 Census of Population and Housing (CPH) and the 2022 Census of Agriculture and Fisheries (CAF) to be conducted in 2023.

2. The GIS-Based Census Operations

With the availability of digitized census maps and the on-going conduct of geo-tagging of building structures nationwide to develop digital building footprints, the possibility of using this vector information as point in the digitized map that represent building can be used to develop procedures that would substantially link the geo-tagged buildings to the census enumeration units (*i.e., housing unit, household, and individual*). Generally, the process generates geodatabase that contains both geospatial information (*i.e., x, y coordinates*) and census data.

2.1 The 5-year Rolling Program to Enhance the Digitized Census Maps

In order to fully utilize the application of GIS technology in preparation for the modernization of 2020 Census workflow, the PSA initiated a 5-year rolling program from 2016 to 2020 to update and enhance the digitized census maps for the entire country. The 5-year rolling program to enhance the GIS-based census maps includes the following activities:

1. Conduct of field validation of master sample frame (MSF) for Household-Based Surveys in 2016 through:

    a. Verification of selected primary sampling unit (PSU), barangay/ enumeration area (EA) boundaries
    b. Determination of the actual location of the Secondary sampling units (SSU) using the Global Positioning System (GPS) waypoints or coordinates.

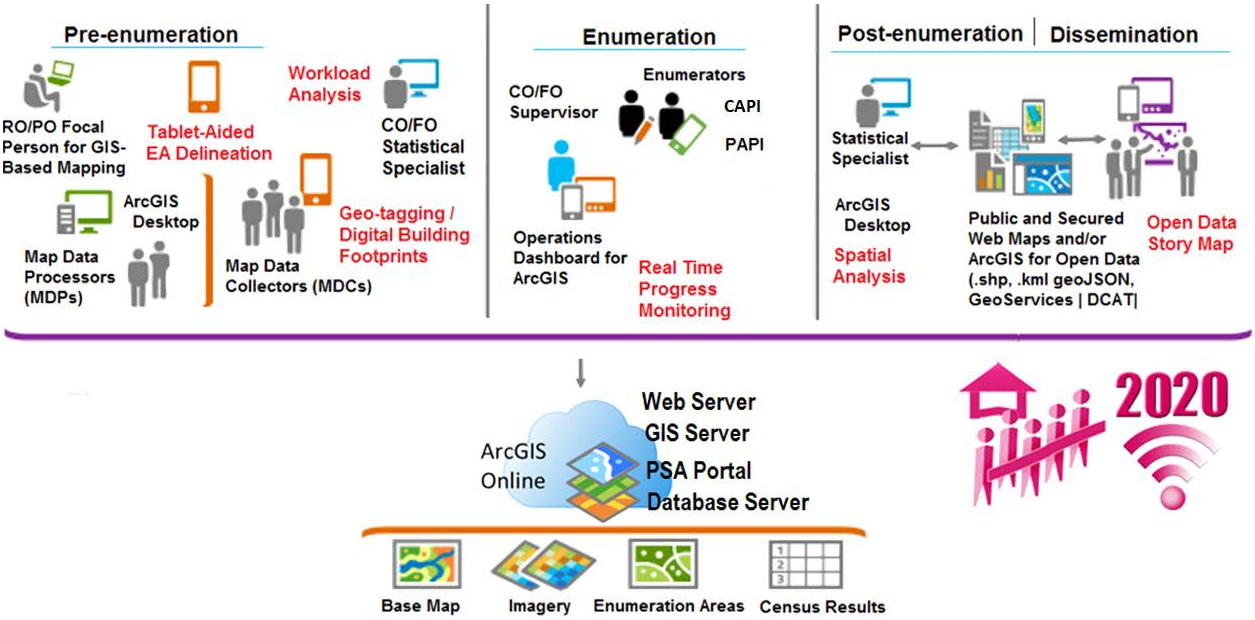
2. Conduct of tablet-aided geo-tagging of buildings to develop digitized building footprints from 2017 to 2019.

3. Conduct of Technology-aided EA delineation from digitized census maps in 2019 in preparation for the development of enumeration area (EA) reference file for the 2020 CPH

4. Conduct of 2020 Census of Population and Housing (CPH) using tablet device incorporating digitized building footprints to link geo-referenced spatial information with census statistical information

2.2 The 2020 CPH Workflow using GIS Technology

Figure 1. The GIS-Based Platform for the 2020 Census of Population and Housing



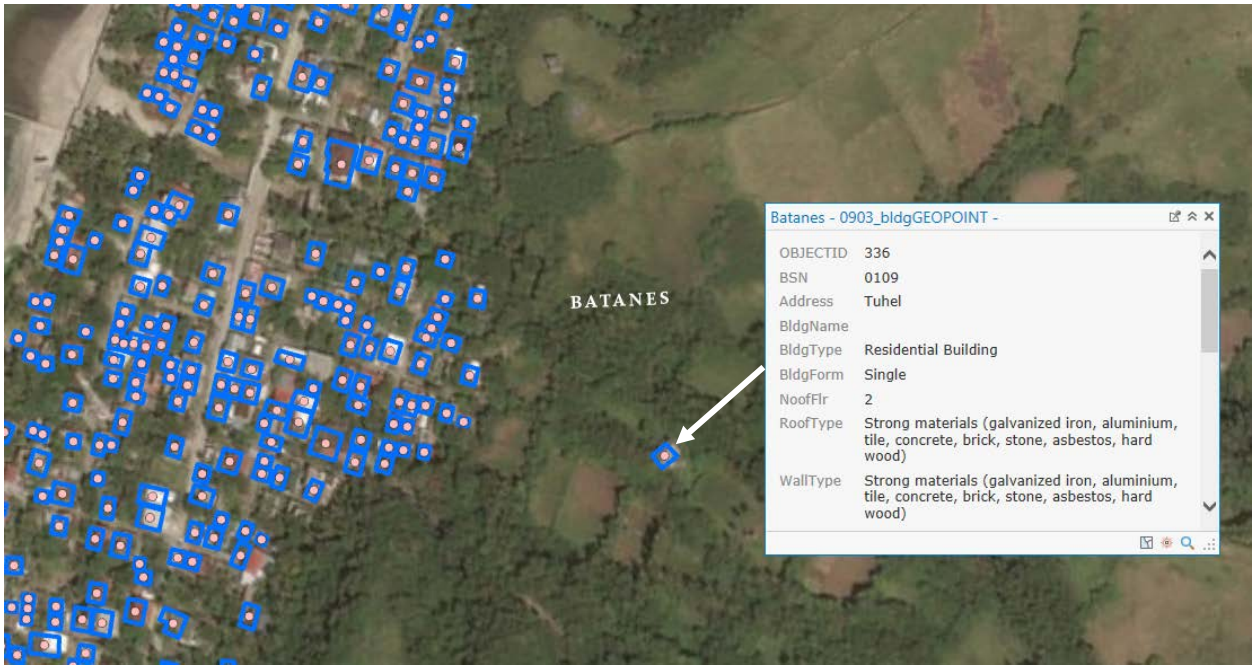
The GIS-based platform for the 2020 census workflow introduced for the first time a map-based or location-based census operation with real-time progress monitoring using GIS-based operations dashboard. The platform as illustrated in *Figure 1* presented an end-to-end GIS solution from pre-enumeration, actual conduct of census operation and up to the dissemination of results.

The integration of GIS technology in the conduct of census can facilitate the application of spatial analysis and intelligent data visualization using dynamic maps. This integration of geospatial and census statistical information can lead to the full modernization of statistical business processes for the PSA.

2.2.1 Pre-enumeration

The geo-tagging of buildings is one of the major requirements to be attained in order to execute the map-based census. In 2017, in preparation for the conduct of the 2020 Census of Population and Housing (CPH), the geo-tagging of buildings was initiated, hiring a total of 608 map data collectors (MDC) and 151 map data screeners (MDS) to cover 23,064 primary sampling units (PSUs) or area segments. In 2018, more areas are added extending to about 31 thousand EAs more. The 2018 geo-tagging of buildings hired 606 map data collectors (MDC) and 146 map data screeners (MDS) nationwide. For 2019, the geo-tagging activity targets to completely cover all areas consisting of more than 93 thousand enumeration areas across the country.

Figure 2. Geo-tagged buildings in Barangay Tuhel (Poblacion), Ivana, Batanes



The geo-tagging process as illustrated in *Figure 2* involves the creation of vector data by marking or tagging building structures as points in the digitized census map as feature map layer and simultaneously integrating attributes such as address of building, building type, number of floors, among others. The attached statistical information to the vector point can be further expanded by integrating census information as added attributes during the actual conduct of the census operation.

The results of geo-tagging will be used as inputs for EA delineation. The tablet-aided EA delineation aims to split large area segment to about two (2) or more manageable smaller area segments. This can be done by rendering modern geoprocessing tools to group points (buildings) into optimal clusters to form enumeration area as shown in *Figure 3*. The formation of enumeration area can be based on set parameters such as: (1) measure of size of about 300 households; (2) accessibility within

the area segment; and (3) conform with known administrative boundary, for example, barangay, city/municipality and, province boundaries.

Figure 3. Density-Based Clustering of geo-tagged buildings in Basco, Batanes

2.2.2 Enumeration

The ArcGIS platform developed by Environmental Systems Research Institute (ESRI) is a GIS-based integrated system that aims to satisfy specific statistical business process needs. During the conduct of map-based census enumeration using Computer-Assisted Personal Interviewing (CAPI), a GIS-based application can be used to collect data from the tablet-device as shown in *Figure 4*. The data has to be synchronized to the portal server of which progress can be monitored using operations dashboard.

Figure 4. Map-based Census Workflow

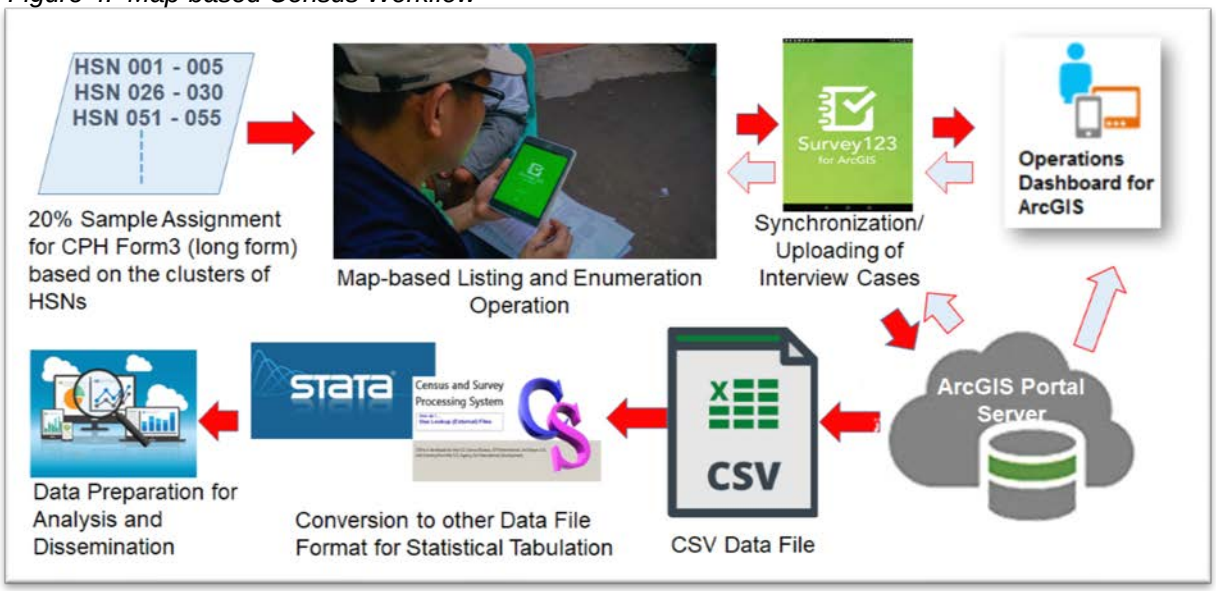
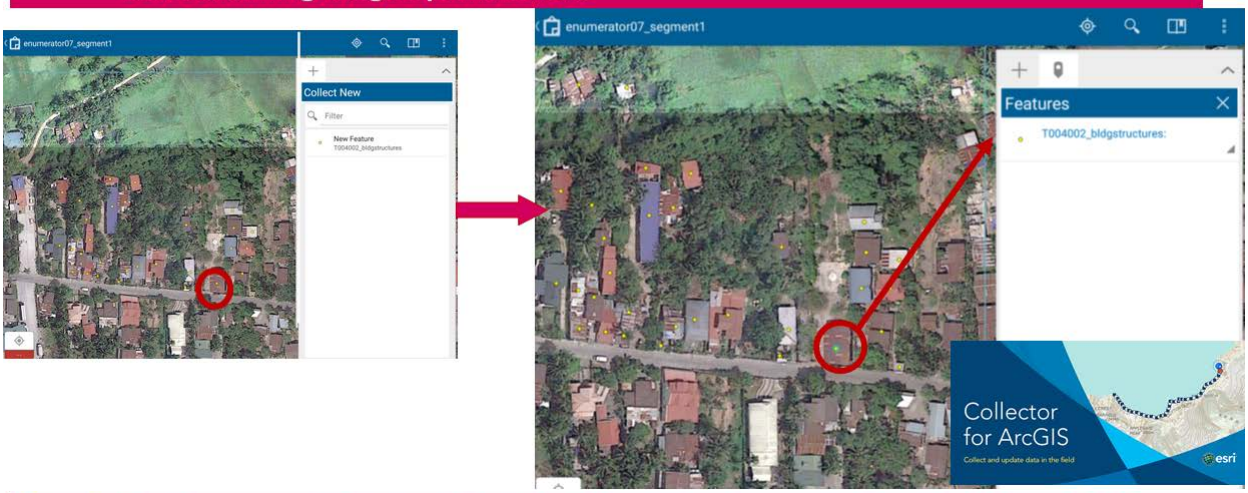


Figure 5 demonstrates the major steps in conducting map-based or location-based census operation as applied during the series of pretests in selected barangays:

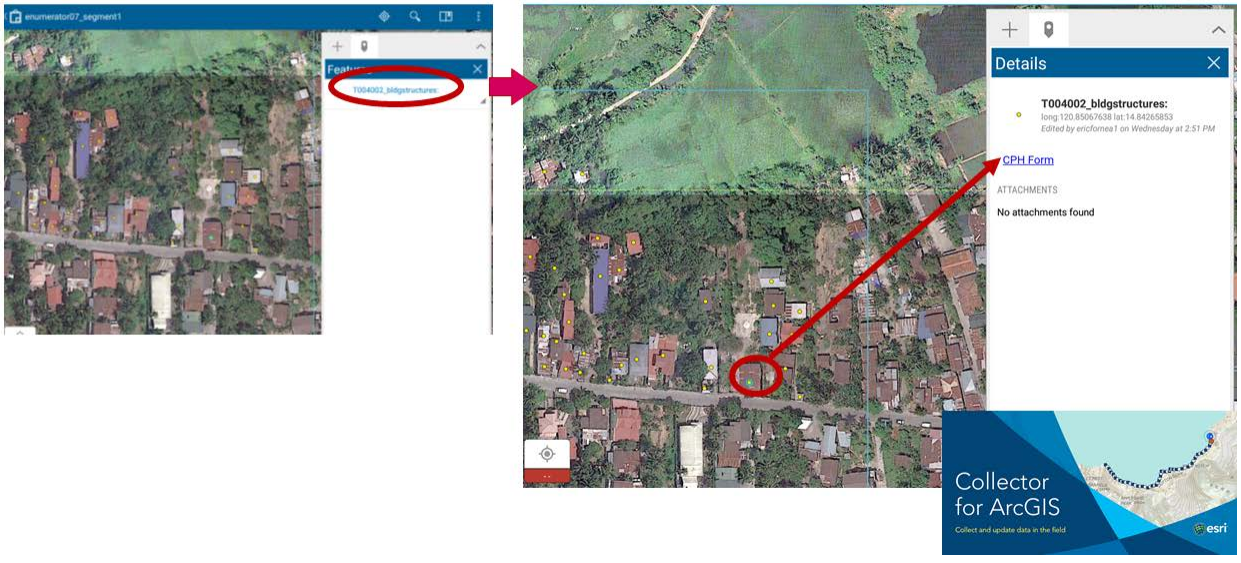
Figure 5. Map-based Census Workflow

Step 4: Examine the assigned EA features relative to the actual position and proper map orientation to determine the starting point (*first building to be listed*)

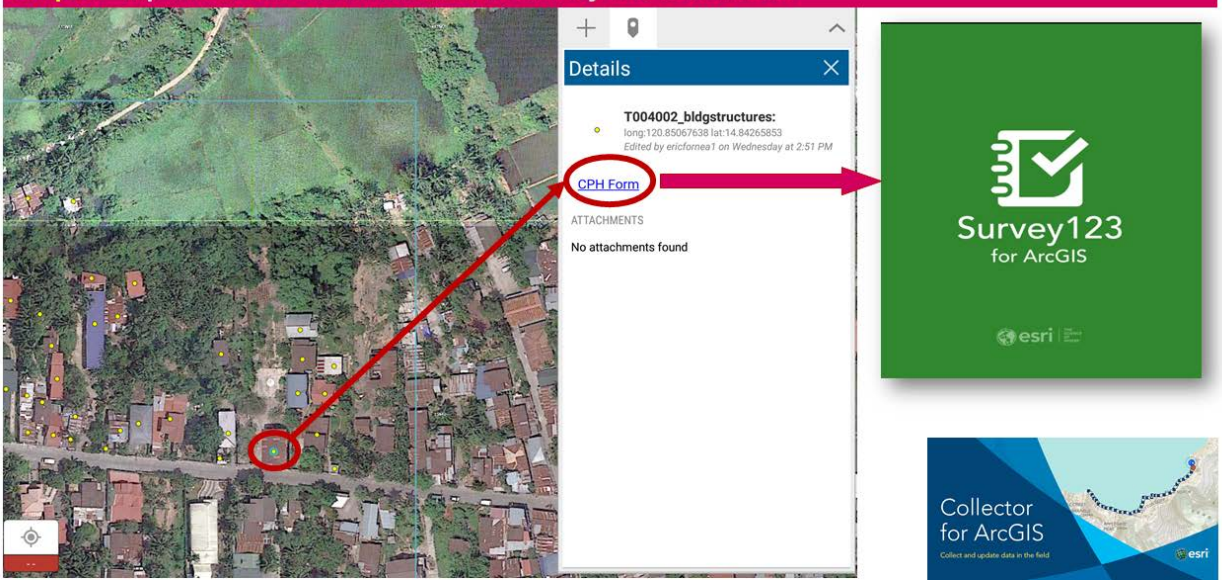
Step 5: Tap one Geo-tagged residential building (starting geo-point) to activate the dialog box containing the geo-point feature



Step 6: Tap the geo-point feature link to load the dialog box containing the link to CPH Form

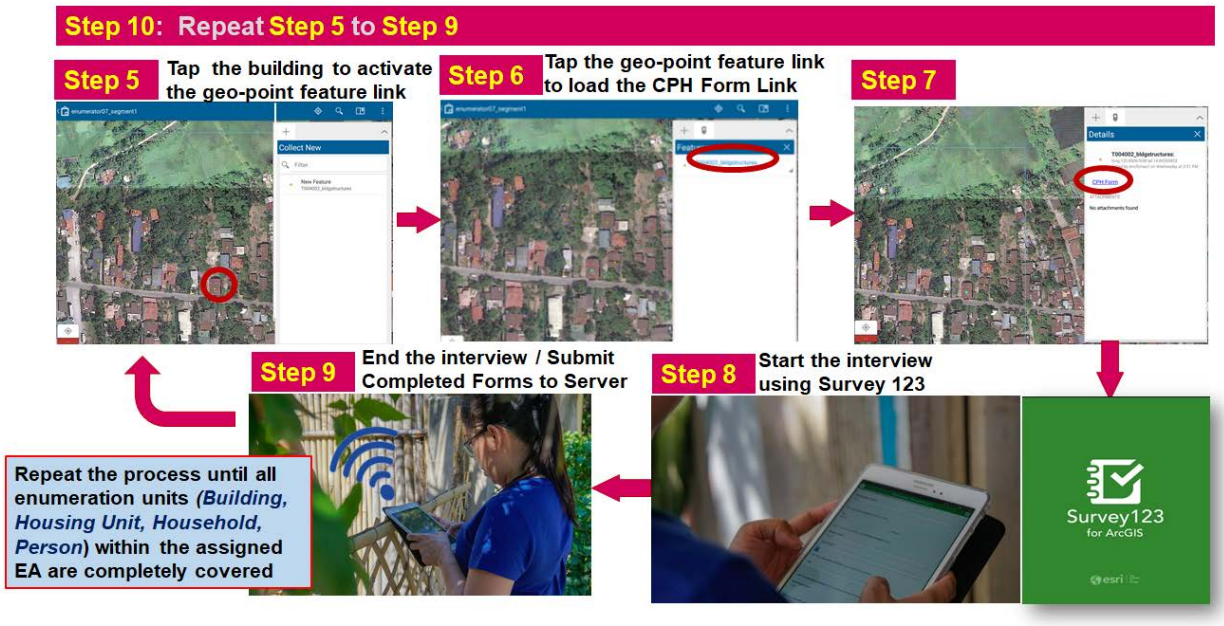


Step 7: Tap the CPH Form Link to Load Survey 123 for ArcGIS



Step 8: Start the Interview

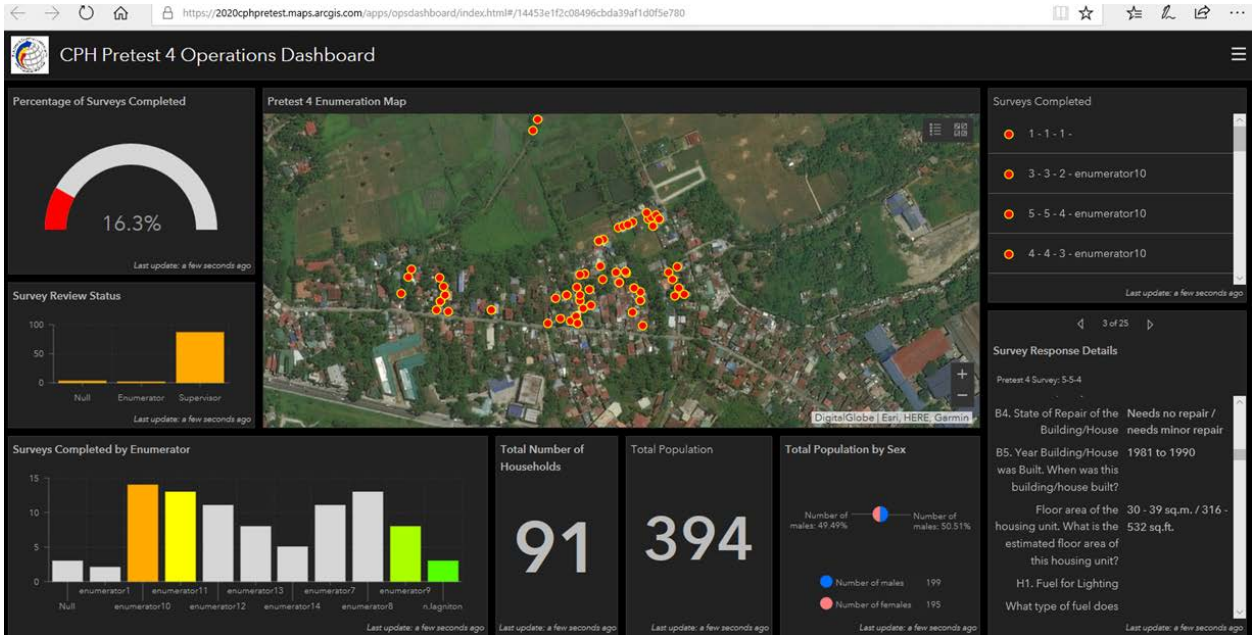
Step 9: End the Interview / Submit Forms to the Server (requires internet connection)



2.2.3 GIS-based Operations Dashboard

During the actual conduct of census operation, the GIS-based operations dashboard (*Figure 6*) can be used by census supervisors (i.e., team supervisors, field offices supervisors and central office supervisors) for real-time progress monitoring for quality assurance and early detection of coverage gaps and timely intervention to address field operation problems.

Figure 6. View of operations dashboard during the conduct of CPH Pretest 4 in Malolos Bulacan



2.2.3 Post-Enumeration/Dissemination

The integrated geospatial data and statistical census information can be stored and managed using the census geodatabase. This allows application of more dynamic dissemination techniques of which data, which has geographical or spatial aspect, can be presented differently using story maps, web maps, web apps and other map-based intelligent data visualization using census as an open data source.

While census taking is intended to collect person level data, no individual information but only in statistical summaries and aggregation can be disseminated or publicly released to ensure compliance to the data privacy act.

3. Conduct of pretesting for the map-based census

The Philippine Statistics Authority (PSA) conducted series of pretests to simulate map-based or location-based census operations. The team from National Censuses Service (NCS) in collaboration with the Geospatial Mapping Unit of Information Technology and Dissemination Service (ITDS) conducted the following series of pretests in selected barangays in the Philippines

- Pretest 1: *Manila* and *San Juan* (September 2017)
- Pretest 2: *Palawan* and *Guimaras* (October 2017)
- Pretest 3: *Pampanga* (November 2017)
- Pretest 4: *Bulacan* (April 2018)
- Pretest 5: *Batangas* (June 2018)

The conduct of pretests aims to test the efficiency and effectiveness of GIS Systems in handling map-based census operations using both the paper and pencil personal interviewing (PAPI) and the computer-assisted personal interviewing (CAPI) methods of data collection. The results obtained from pretesting activities facilitate the improvement in integrating the GIS application systems with the census operational workflows including that of the development of real-time progress monitoring using a customized GIS-based operations dashboard.

4. Recommendations

The map-based census operation using the modern GIS technology will considerably improve the statistical business processes of the Philippine Statistics Authority (PSA). The improvement will be in terms of accuracy by addressing non-sampling error such as non-coverage and over-coverage. This can be done using real time GIS-based progress monitoring dashboard for supervisors for the early detection of coverage gaps and subsequently early field intervention to mitigate coverage problems. The timely release of census results can be assured using the technology since data

processing is already integrated in the technology-aided data collection using tablet device.

The following are recommendations to further improve and modernize not only the conduct of smart census for the 2020 CPH using map-based approach but also for the other statistical business processes of the Philippine Statistics Authority including that of periodic sample surveys and data collection from administrative data:

1. To embrace innovative and transformative solutions through full implementation of GIS Technology, specifically, modern GIS Software to create dynamic and interactive digital maps for a map-based data dissemination of survey/census results, the GIS Enterprise to facilitate the development of PSA GIS Cloud and/or Portal/Server as back-end of client-server model for technology-aided data collection in the conduct of surveys and censuses, and the enhanced GIS-based Survey Apps, Map Data Collector Apps, and GIS-based monitoring dashboard as the front end of tablet-aided data collection.

2. To consider a long-term investment in GIS technology that can be fully applied in our statistical business processes by entering into GIS Enterprise Agreement with the leading GIS Software Industry and the subsequent procurement of GIS-ready infrastructures (servers, desktops, laptops, tablet devices, high-speed and stable internet service provider) to fully enhance and modernize statistical operations of the Philippine Statistics Authority (PSA).

3. To continue adopting innovative GIS applications and techniques in statistical and administrative-based processes of the PSA for a continual development plan of PSA Personnel with by conducting series of GIS trainings, developing GIS-based projects, and participating in local and international fora, meeting concerning GIS technology development.