**The Effect of Using New Technology and Geographic Information System on**

**The Quality of Official Statistics: The Implementation of The General**

**Palestinian Census 2017 as a Case Study**

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**Abstract**

It has been confirmed that one of the most vital requirements necessary for planning and decision making in any field of human endeavor is the quality of information available on its human resources. In this sense, Palestinian Central Bureau of Statistics (PCBS) has always sought to offer the most objective and accurate statistical number relying on the latest techniques and methodologies, in order to be in line with the international recommendations regarding data collection and statistics production.

As Geographic Information System (GIS) technology is used in a wide spectrum of official statistics activities nowadays, from data collection, to statistics compilation, and data dissemination, PCBS is very keen to keep pace with the revolution in GIS technology. PCBS has implemented the third Population, Housing and Establishments Census 2017 using GIS technology in all phases of the census process that improved the overall quality of census activities compared with the last census of 2007. Also, using this technology was of a great benefit in data coverage through the access to many remote areas and buffer zones in Gaza Strip and the West Bank.

The contribution of this paper is twofold. Firstly, it introduces the usage of procedures and methodologies in conducting the census through the technical and field operations in detailed. Also, it shows the main resulting benefits of using GIS applications, arising challenges and obstacles during each phase. Secondly, the paper focuses on the main differences between this census and 2007 census in which traditional techniques has been used, and their effect on data quality and coverage.

This paper aims to come up with new recommendations regarding the use of GIS technology in future statistical surveys and censuses, in order to achieve better data quality and higher coverage rate.

**1. Introduction**

Due to the technological development in telecommunication in terms of the exchange of GIS, and to the huge growth in the use of tablets as a tool for data collection and dissemination; PCBS has decided to implement the 2017 Population, Housing and Establishments Census using new technology and GIS to be in line with 2020 round of the population and housing censuses recommendations adopted by the United Nations Statistics Division (UNSD). International recommendations are strongly supportive of the use of the digital and GIS-based approach for population and housing censuses, taking into consideration national and local circumstances. UN Principles and Recommendations recommends countries to use geospatial technologies to “collect more accurate and timely information about their populations”[[1]](#footnote-1). Census 2017 was the first census to be carried out using such technology that ensures the increase of data quality in terms of accuracy, comprehensiveness and integration as well.

The total area covered in the 2017 census of Palestine was 6,025 km², comprising of 5,660 km² in the geographic region of West Bank, and 365 km² in the geographic region of Gaza Strip. As a first-order administrative division, the state of Palestine is divided into two regions; the West Bank which is divided into 11 Governorates namely: (Jenin, Tubas and Northern Valleys, Tulkarm, Nablus, Qalqiliya, Salfit, Ramallah and Al-Bireh, Jericho and Al-Aghwar, Jerusalem, Bethlehem, and Hebron), and Gaza Strip which is divided into 5 Governorates namely: (North Gaza, Gaza, Deir Al-Balah, Khan Yunis, Rafah). Governorates are divided into localities, which are inhabited places usually with a local administration.

The 2017 census covered the total resident population in Palestine on the midnight of 30th November - 1st December 2017 regardless of their citizenship, nationality or reasons of presence in Palestine. It also covered, the Palestinians temporarily outside of the State of Palestine for a period of less than a year for the purposes of visit, tourism, treatment or any other reason and who have families inside Palestine. It also covered, the detainees and prisoners in Israeli jails regardless of the period of their detention. However, the 2017 census didn't cover the Palestinians with ID cards and families in Palestine who have been absent for a year or more, with the exception of students studying abroad[[2]](#footnote-2).

**2. Methods**

The 2017 Population, Housing and Establishment Census of Palestine was implemented with an integrated electronic system composed in total of six applications for tablets supported with GIS synchronized via internet connection (WI-FI or SIM card) with dedicated servers based at the PCBS Headquarters. Tablets were used for spatial data editing and census data entry, and for evaluating coverage and data quality after the completion of the census enumeration area. Different field activities were monitored centrally from PCBS main premises and at the governorate level by a coordinator and IT specialists whom supported the operations on the ground. Digital high-resolution aerial photos updated to 2016 were accessible on-line and off-line from the tablets through these applications as a base maps.

This integrated system included specific applications for each phase of the overall census activities, which are (maps updating, demarcation and delineation of EAs, listing and numbering of buildings, establishments and housing units, population count, post-enumeration survey, and fieldwork management system). It considered all the relevant aspects that are necessary for a qualitative census operation, in terms of both methodological and operational requirements, as internationally recommended. The applications developed included not only the required tools and functionalities for building a comprehensive census infrastructure for mapping, designing of questionnaires, numbering and household listing, field enumeration and management, data processing and tabulation, evaluation, data dissemination. It considered also quality control measures and quality assurance tools in each of the census phases and applications. Some limitations on the synchronization between tablets and the central geodatabase were due to the fact that only 2G mobile signal was available due to limitations imposed by Israeli occupation.

**3. Results**

**3.1 Preparation Phase**

During the preparation phase, the formed 2017 Census National Committee , composed of representatives of PCBS, governmental ministries, research institutions and the civil society to review & revise the boundaries and localities number, resulting in a total number of 613 localities. Whereas, in 2007 census, there were 557 localities. These changes were reported in the Administrative Classification Manual. Following the revised manual, the boundaries of administrative units were recorded in PCBS geodatabase using GIS tools, and the census geography was appropriately re-defined.

The localities of 2007 census covered only the inhabited areas, which were then divided into enumeration areas (EAs) based on several criterion. After viewing the international recommendations which state that maps must cover the overall areas of the country -inhabited and uninhabited areas - the boundaries of the EAs were Extended through the ArcGIS Desktop software in order to cover all uninhabited areas. In total, there were 6,831 EAs defined in 2017 geodatabase, covering all the territory of West Bank and Gaza Strip in the state of Palestine and excluding the "J1" area in Jerusalem governorate where 463 EAs were delineated on paper maps.

Maps updating was carried out by a field team of approximately 312 field surveyors, each surveyor was assigned between 20 to 25 EAs and their work was coordinated by a supervisor assisted by a Director in each Governorate. EAs were revised taking into consideration all the geographical features (such as roads, streets, pathways, barriers, Israeli expansions and annexation walls, and Israeli settlements) through adding, deleting or modifying buildings, landmarks, building characteristics (such as the number of floors or the number of housing units) in a way that match the reality on the ground. This data was then used to finally define the boundaries of the EAs, by modifying their shape or splitting them or creating new EAs when deemed necessary.

Surveyors checked in the field all the boundaries and edited those when necessary using the application of maps update supported with aerial photos of 2016 on tablets synchronized with the geodatabase at PCBS premises. This application included a set of logical rules that improved the quality of the map updating operations. For instance, surveyors were not able to access other areas than the ones assigned to them or were not allowed to edit buildings located to more than 25 meters from their position (their location was monitored through GPS functions). In the application, surveyors could select different GIS layers to edit (layer on buildings, layer on streets, layer on landmarks), and within each layer each spatial feature could be visualized with a different color or texture according to its characteristics (for example: by type of edit such as new, modified, deleted buildings; by type of building such as intended for residential or business use; or by number of housing units included in the buildings, etc.).

By the end of maps updating phase, an updated geographic database was obtained and submitted to many topological rules such as EAs mustn't overlap and shouldn't have any gaps between them to be used in the delineation of 2017 EAs, during which 2017 localities were re-divided through the Administrative Classification Manual into EAs areas based on the updated geographic data, where each EA contained about 150 - 180 housing units.

After the process of updating all enumeration areas was completed, a preparation for the process of delineation and demarcation of these areas started, where each supervisor (fieldworkers of this stage) was designated 25 enumeration areas, all enumeration areas were uploaded on the tablets supported with a special application using GIS. The supervisors delineated and demarcated each enumeration area on the ground and placed delineation marks on the outer walls of buildings within the external boundaries of the enumeration areas. The external boundaries of the enumeration areas were matched to the electronic uploaded maps on the tablets, taking into account to provide supervisors with certain flexibility to enable them modify the starting point or the external boundaries of some enumeration areas to ensure that the situation on the ground matches the electronic uploaded maps on the tablet. During this phase, all the 6,831 enumeration areas defined previously 2017 geodatabase (with the exception of Area J1 in Jerusalem Governorate with 463 enumeration areas which done by using paper maps) were delineated and demarcated covering all localities in the West Bank and Gaza Strip.

The use of technology along with GIS in the pre-enumeration phase has improved the organization of field operations and facilitated field operations during the data collection phase. However, it should be noted that the modification of the boundaries of the EAs used for the 2007 census were not always recorded in the geodatabase as paper maps were used and all the geographic figures were updated manually, as for the delineation of enumeration areas it becomes more accurate by 2017 census as the induction of the boundaries of enumeration areas on the ground is better than 2007, especially in the remote areas through the use of GIS technique.

**3.2 Data Collection Phase**

This phase is considered to be the backbone of the census as it forms the harvest of the previous phase in which the main census activities are carried out. Tablets were used to collect data for the census with special applications designed for this purpose supported with the maps of the updated enumeration areas for Palestinian localities and aerial photos of 2016. The applications were designed to match the census questionnaires and were supported with logical checks and warning messages for logical data and consistency of the data. The key applications included in this phase were the listing application, designed to fulfill the needs of the questionnaire of buildings, housing units, and establishments questionnaire with their logical checks, the counting application that was designed for the households and housing conditions questionnaire with its logical checks. Also, the fieldwork management application that was designed for monitoring of field workers achievements through using Global positioning System (GPS) as a tracking system.

**3.2.1 Listing and Numbering of Buildings, Housing Units, and Establishments**

This process aimed mainly to collect important data on the number of buildings, and their characteristics for policy making, additionally, the listing of establishments aimed to collect data to configure the structure of the Palestinian economy[[3]](#footnote-3). This process also aimed to facilitate the job of enumerators upon implementation of the population counting.

During this process, every building was marked and classified as census building (population and establishments) and non-census building (such as buildings used for agriculture or for storage purposes), hence, all census buildings, housing units and establishments were listed and numbered by visiting each building and placing census numbers on their entrance; all housing units within the same building were numbered and main data on the characteristics of buildings and housing units were collected to cover their use, number of households and the total number of members per household.

All establishments in Palestine were also numbered and listed to collect data using tablets with an e-application uploaded into the tablets and synchronized with the central database at PCBS designed for the purpose of listing. The application enables the crew leaders (fieldworkers of this stage) to assign unique numbers for buildings, housing units and establishments and collect data on their characteristics based on both building, housing units and establishments questionnaires within each enumeration area[[4]](#footnote-4).

Each supervisor of the delineation of EAs process was responsible of five crew leaders which in turn each one was designated five enumeration areas, they were able to add or remove any building when needed in order to keep pace with all updates at the buildings level, The new buildings were added as points, rather than as polygons. All written numbers on the entrances of buildings, housing units and establishments are matched with the ones on the e-maps of the applications. Also, every hotel management was provided with the hotel guests paper questionnaire to count the hotel guests on the night of the count and hand the questionnaire to the enumerator during the population count.

The listing application was supported with GPS technology in order to ensure that each crew leader will number the right building corresponding to the one on the map where the point of GPS indicates, through a limitation on the distance between the crew leader and the buildings coordinates that guarantees the questionnaire opens on the tablet. The application also allowed the crew leader to be on a continuous read with the daily achievement through smart maps for each EA that indicates the status of each building visualized with a different color or texture according to its characteristics, for both the census buildings (visited, unvisited, incomplete, deleted) and the non census buildings. Also, the application was supported with logical checks regarding listing questionnaire where automatic warning messages appeared on the screen for data wrong entry or when data of different indicators is inconsistent.

The listing phase comprised an initial framework for the next process, where basic data about housing units and households were loaded to the population count application, such as the total number of housing units inside each building, the total number of households in each housing unit.

**3.2.2 Population Count**

This process is considered to be the most important among all census activities as the main aim of the census is to be accomplished by collecting data on housing conditions of households and their different characteristics as well as all members of households covering their socio-demographic and economic characteristics taking into consideration the use of the building and housing numbers at the entrances of buildings and housing units, which were marked during the listing process. A special application uploaded on tablets was used which included an electronic questionnaire for households and housing units directly linked to spatial features representing the place of usual residence of households. Most enumerators (fieldworkers of this process) were designated for one enumeration areas while some were designated for only two areas depending on the number of households obtained from the preliminary listing results so as to ensure completion of the task within the specified enumeration duration, and to overcome the issue of lack of available tablets during the this process.

The application was supported with logical checks for household and housing units questionnaire with automatic warning messages similar to the one used in the listing process that guaranteed a high percentage of data quality. Additionally, the used application allowed the enumerator to recognize housing units to be visited through GPS technique along with basic identification data on each building such as (the name of the head of household and building address) in the assigned EA loaded on the application from the listing process, such quality checks had the advantage of avoiding duplication and dropping any of the housing units. This lead to a higher coverage percentage than 2007 census where enumerators could collect data on the same household twice or drop some of the housing units due to paper maps where the building were sketched manually.

In order to assess the coverage of the main census findings, a post enumeration survey has been implemented right after the population count process was completed. The random sample regarding this survey included 288 enumeration areas covering 4% of the overall EAs, being one enumeration area per every supervision area in the West Bank and Gaza Strip. A special application was used during this process in order to collect data for post-enumeration survey questionnaire where a full count was repeated for all households and individuals in the selected enumeration areas, connected to the enumeration areas’ maps and automated editing bases. In comparison with 2007, the under coverage percentage decreased from 2.7 to 1.7 in 2017.

**3.2.2 Field work management**

One of the significant arrangements done before implementing the census is performing a profound base in each of the 16 governorates in the West Bank and Gaza Strip; in order to do a continuous and closer monitoring of the fieldwork of all the census activities. In this context, an organizational structure of the fieldwork was adopted consisting of a director on each governorate with one, two, or three assistants, supervisors, crew leaders, and enumerators.

During each process of the census, there were special applications used by each of the administrative and supervisory levels, supported with GPS that allowed a daily follow up per supervisor, crew leader, and enumerator through a decentralized monitoring. A centralized monitoring was achieved through a central fieldwork operation room performed in PCBS during data collection phase where timely reports on the daily achievements, dilemmas and difficulties from the field are being reviewed. The field management application controlled each process as it contained special screens with interactive maps that showed the fieldworkers achievements on the building level supported with a tracking system either online (at the time) or offline using GPS. This application is connected to all other applications used in the field, so that each synchronization process on collected data by a fieldworker will be sent directly to the central fieldwork system.

The field management application played a key role in data collection phase, especially in population count process, where the central fieldwork operation room was able to produce reports on the coverage of the census enumeration and on the performance of field staff in which housing units were enumerated, buildings partially visited, and households interviewed, number of refusals or inhabited units that enumerators could not visit because of the temporary absence of occupants. Such monitoring based on the collected data during the previous process of the census of buildings and establishments. Moreover, daily reports on the technical issues faced on the field regarding listing and population count phases were provided at once to the central technical operation room, where data was checked and reviewed for its' logic and the overall consistency, and sending it back to field if there were any errors in data entry to be corrected. Also, the field management system allowed to control data quality through the Comparison of housing units and population count resulting from the count process with the previous processes results and population estimates.

Knowledge management was also applied in census 2017 by documenting the processes of fieldwork describing the obstacles and their solutions in daily bases extracted from different daily report then transforming them (the problem and its solution) into direct instructions sent to all fieldwork staff and updating the work manuals and guidelines. This process was accumulated process and performed in each stage in the census then transferred to the next stage to benefit from the experience of the previous stage. As an example of this process the list of GPS signal weakness areas and ICT Guide of technical support staff in the fieldwork.

The field management application was one of the most powerful and crucial applications developed and used in the 2017 census that ensured continuous mechanisms for monitoring and tracking both the census data and operators during the data collection phase. In this respect, the use of GIS and GPS technologies integrated in the application played a very crucial role in this activity.

**3.2 Dissemination Phase**

Following the conclusion of the 2017 census field operations, the preliminary results of the census were published by the beginning of 2018 in a short time as using technology and GIS in each phase mainly saved time and effort. The final findings were published after the completion of census databases and comparisons with previous censuses and surveys for specific indicators and other related estimations such as population projections produced by PCBS. Using GIS allowed to publish census data on several detailed geographical levels using new techniques.

Thematic maps were used in publishing preliminary results and is being used in each of the published statistical reports or the reports which will be published taking into consideration that those maps are used in the published paper statistical atlas and other atlases. One of the new used techniques during the dissemination phase of 2017 census was the geographic dissemination system that allows data users to get census data as a form of spatial disaggregated data at the locality level through an interactive map with specified indicators and variables on each statistical topic, where the users can choose the type of data representation on the map in a way that meet their needs.

PCBS also used ESRI platform[[5]](#footnote-5) on SDGs in order to create story maps using census data based on SDGs indicators. Using this platform allowed PCBS to publish 2017 census data using images, videos, interactive maps in a way that make it easier to understand statistical numbers through telling stories regarding the most prominent issues.

**4. Conclusion**

It is internationally recognized that the appropriate use of geospatial technology in census operations increases the coverage of the enumerated units (housing units, households, individuals and establishments) and improves data quality and timeliness and reduces the costs of statistical data production for a long-term period for both censuses and sample surveys. The quality and coverage accomplished in this census proved the previous argument, as PCBS adopted a paperless method for data collection operations compared to the previous census conducted in 2007, with extensive use of GIS and tablets integrated in an electronic system composed of several applications organized in a relational database.

In comparison to 2007 census, both data collection and data entry phases were reduced into one phase in 2017 census as data was collected and entered at the same time in the field, therefore, a lot of time and effort were saved.

This paper aims to come up with new recommendations regarding the use of the electronic integrated system developed for the 2017 census for the purpose of conducting of sample-based statistical surveys, and censuses with better data quality and higher coverage rate.

**5. References**

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[3] <http://www.pcbs.gov.ps/Downloads/book2378.pdf>. Final Results - Buildings Report - Population, Housing and Establishment Census 2017

[4] <http://www.pcbs.gov.ps/Downloads/book2384.pdf>. Final Results - Establishments Report-Population, Housing and Establishments Census 2017 -Updated Version

[5] <https://sdg-pcbs.opendata.arcgis.com/>

1. Principles and Recommendations for Population and Housing Censuses, Revision 3, United Nations (New York: United Nations, 2017), para. 3.47 [↑](#footnote-ref-1)
2. <http://www.pcbs.gov.ps/Downloads/book2383.pdf>. Census Final Results Summary, 2017, Palestinian Central Bureau of Statistics, Ramallah, Palestine. [↑](#footnote-ref-2)
3. <http://www.pcbs.gov.ps/Downloads/book2378.pdf>. Final Results - Buildings Report - Population, Housing and Establishment Census 2017 [↑](#footnote-ref-3)
4. <http://www.pcbs.gov.ps/Downloads/book2384.pdf>. Final Results - Establishments Report-Population, Housing and Establishments Census 2017 -Updated Version [↑](#footnote-ref-4)
5. <https://sdg-pcbs.opendata.arcgis.com/>

   [↑](#footnote-ref-5)