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MODERN TECHNOLOGIES IN OMANI CENSUSES

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1. Introduction

Qualitative progress in organizing and implementing large statistical process such as population census is not only dependent on hardware and modern techniques but also on the ability of taking advantages of the technical possibilities for those devices and technologies. For example, though computers/devices are today accessible to the people who are responsible for conducting census anywhere in the world, investing and utilising their capabilities appropriately to serve the various aspects of the census program is more important.

This paper highlights the efforts applied for utilizing the advancement of information and communication technologies in conducting population and establishment census in Sultanate of Oman (Oman). The paper is providing a short introduction about Oman, followed by a brief about Census 1993 and Census 2003 as well as different technologies used in the latest Census conducted in the year 2010. Finally, it includes the summarized recommendations to be considered while utilizing ICT in implementing any statistical process in general and census in particular.

2. Country Profile

Planning is crucially important issue for most developing countries. Oman began its first Five-Year Plan in 1976, and its objective was to consolidate economic growth and to provide continuity into the future. Oman is approximately 309.5 sq. km. in area and is located in the south-eastern corner of the Arabian Peninsula. Oman has a non-contiguous piece of territory in the north, the Musandam Peninsula, which is separated from the rest of the country by a strip of land that forms part of the UAE. The Sultanate has a coastline of some 3165 km along the Gulf of Oman in the north and the Arabian Sea in the south. The capital is Muscat (population approximately 776 thousands in 2010) and the currency is the Omani Riyal, divided into 1000

baisa. One American Dollar currently equals Riyals Omani (RO) 0.365. The official language of Oman is Arabic although many Omanis speak English, especially in the Muscat area. Indigenous Omanis account for approximately 70 percent of the total population (circa 2.7 millions) according to the 2010 census.

3. Census 1993

In 1993 the Government of Oman successfully conducted the first General Census of Population, Housing and Establishments. His Majesty's patronage had continued throughout the Different phases up the reference time of the Census when His Majesty addressed the Omanis and the residents in a Royal Speech on 30th November, 1993, encouraging them to provide the required information and Co-operate with the Census staff to make this endeavour a success.

The process involved population, housing and Establishments censuses, in addition to counting of all the buildings in the Sultanate. The Concerted efforts exerted during the actual counting and preparation phases enabled the National Centre for Statistics and Information (NCSI) to promulgate and publish the preliminary results of the census within a record time of only two weeks after the completion of the exercise.

Census project management required critical arrangements leading to the preparing for data processing. First, by defining Census data processing as a special task, separate from the data-to-day activities of the parent organization, management freed the Census Data Processing Unit (CDPU) to carry out its task (a) without any restraints imposed by persons not familiar with the specific characteristics of such activity, and (b) without having to content for resources by other data processing systems. Second, by simplifying the hardware options, Census Project management ensured that the complications of maintaining hardware were kept to a minimum. Third, that hardware which was chosen was stand-alone, DOS-based microcomputers and the operating systems was the basic DOS, Release 5. For the processing software, the choice was equally clear. Of all possible off-the-shelf software packages with appropriate facilities for statistical data processing, from data entry through tabulation the one which combines greatest ease of use with

maximum capabilities was the Integrated Microcomputer Processing System [IMPS]. Finally, few databases were created such as Geographic data base which served as a gazetteer of all localities in the Sultanate, even those uninhabited at the time of the enumeration. It would also serve as the basic control file during processing of Housing and Population Census (HPC) data, against which the completeness of processing could be verified. Also, Book control data base was created. The purpose of this data base was track the containers of Census Books as they moved through the phases of processing, from pre-entry editing and coding, through key data entry and verification, and finally through the manual editing and correction process.

4. Census 2003

Census 2003 had some new and enhanced contemporary data capture methodologies & been applied in many different census aspects. In census 2003 there were two data capture methods allocated according to areas. In Muscat region data capture was carried out pioneering the use of handheld devices (PDA) which had a pre-loaded data capture application. Data collectors gathered data from fields by the handheld device then all collected data synchronized into the main machine at NCSI for further verification & processing.

In other regions the data capture was carried our by the same traditional methods as used in census 1993. Yet the collected data was summarized, verified, and summaries were entered at different census offices located in regions. After that, data was posted to the main database in NCSI using client-server application for quick indicators.

Data collected via handheld devices was verified immediately by the server using a certain pre-installed application. On the other hand, data collected from other regions and Wilayats was manually verified. Eventually, all collected data from regions was populated at the central census office and merged with the data collected from handheld devices to be verified again.

The areas and activities that used those techniques were many and included following:

Mapping updates

1. Modern techniques and technologies had been used for the creation and updating of maps leading to faster data processing with a higher degree of quality as follows:
    a. The use of remotely senesced Satellite Images to verify the completeness and exact locations of all communities, buildings and access roads which had been prepared on the previous census (1993) and update accordingly.

    b. The use of GPS devices for navigation, verify locations and fixing the coordinates of any new locations.

    c. The use of Geographic Information System (GIS) for mapping, spatial analysis, integrity check and cartographic representation.

2. In the Organization and management of census field team
    a. Use the enumeration area ID to create a list of census blocks.

    b. Right after the end of the training course and before commencing the field work, we could enter the enumerators names in the database and link them to area he/she assigned to.

3. Distribution and recovery, storage and moving the containers that holding the paper-based questionnaires

    a. Determine the number of questionnaire required in each block and subsequently in each enumeration area.

    b. Re-collect the records from enumerators to extract preliminary results.

    c. Control the movement of the questionnaires from field to the head quarter for further data processing.

    d. and store

4. Communication with the field worker team and monitoring its work

5. We used imputations for auto check and correction.

6. Enumeration process in Muscat Governorate

7. Data was entered in a small handheld computer, personal digital assistance (PDA). A customized application has been developed and installed into these devices to allow the questions to appear sequentially and according to a certain order. Many audit rules have been embedded into this application to prevent entering any inconsistent data by alerting the enumerators when it happened.

5. Census 2010

Census of population, housing and establishments of 2010 was implemented during the period (12-21) December 2010 and in conjunction with other Gulf States. This census was the third after 1993 and 2003 censuses. This one was carried out after 7 years from the second census in 2003 instead of the normal frequency of 10 years.

Generally, any successful modern census must enjoy full coverage of enumeration units without missing and/or duplication, and should also enjoy highest quality with respect to the information collected. Moreover, the census should be environmentally friendly (paperless), should contribute to enhancing global census methodology and approaches, and operate under the rights-based approach whereby the population and data users are the “Rights holders” and the Census Staff are the “Duty bearers”. Data confidentiality must be guarded and ensured in keeping with the Statistical Law.

In keeping with these determinants, the General Census of Population, Housing and Establishments 2010 developed and adopted the “Total Quality and Improvements” approach. This approach aims at capturing accurate and comprehensive picture of the social, economic and living conditions of the population in the Sultanate of Oman as well as key information concerning the establishments. This is imperative for relevant and effective policy, planning and decision making purposes for the upcoming 10 years.

To that end, and in accordance with his Majesty Sultan Qaboos bin Said’s vision, enthusiasm and directives in utilizing cutting-edge technology to enhance the performance of governmental institutions, an innovative suite of integrated systems specifically developed to fully handle all aspects of the census 2010 has been

adopted. State-of the-art technology has been harnessed and used in all components of the census operations to ensure the optimal results of full coverage and total quality and improvements approach.

Quality control in traditional paper-based census is done in a separate phase that took place before data entry. It was done manually which was time consuming. Spotting data violations and inconsistency manually can be difficult especially when validating across different entities.

The General Census of Population, Housing and Establishments 2010 adopted the "Total Quality and Improvements "approach, thus uses multiple quality checks enforced at different levels. PDA applications and online questionnaires enforce business rules electronically on the spot. Electronic synchronization avoids the need for data entry and all problems associated with it.

To further ensure data quality and completeness, Satellite photos and digital mapping is utilized for ensuring full coverage, CATI system operators check questionnaires collected by the PDA and through the I-Census website and contact the households in case of any violations.

The above means greatly enhance data coverage, quality, consistency and completeness and avoid the need for field revisits where possible.

The Census project is a suite of integrated systems specifically harness and developed to fully handle all aspects of the census process. This was presented in the electronic data collection tool that was used to replace the old and traditional paper-based form tool, in the communication technique that has been used to ease the communication between the field workers themselves and between them and the head quarter, and intelligent automated reporting tool designed to follow up the counting progress according to the various operational levels. All components integrate seamlessly ensuring flawless execution, superior performance and smooth transition from one component to the other and from one phase to the next. The success of the census as a whole depends on a temporary organization of 6500+ people and a number of specially developed and tested applications. Any failure or

shortcoming in any part may put the whole project at risk. To marginalize any risk factor, all systems were extensively tested and a number of pilots were performed. Based on that, systems refinements were introduced where necessary. Each staff members were heavily trained according to their assigned responsibility.

6. Digital Mapping

High quality satellite images covering the Sultanate were obtained reflecting all surface structures. These were captured and digitised using Geographic Information System and then turned into a multi layered digital maps. Digital maps were delineated into enumeration areas (EA's) and further into zoned enumeration blocks. Enumeration areas and blocks were loaded into the PDA's for field ground truthing and validation of buildings, establishments and housing units. Field data are automatically synchronized with a central geodatabase which allow fast and correct representation of results and quality checking.

7. Data Collection Processes

The data collection process has been completely reinvented. The traditional paper-based questionnaires took a lot of time to fill and were costly due to printing and dissemination expenses. It was hard to validate on the spot which led to low data quality, inconsistency and the need for field revisits. Huge data entry efforts were required and resulted in multiple risks and problems regarding data quality and time effectiveness.

5.2.1 Mobile Application

So, an advanced data collection methods have been employed with the purpose of easing the response burden of the population while ensuring highest completeness and quality of the data to be collected. Enumerators armed with PDAs will conduct door-to-door interviews. Information gathered will be validated and corrected by means of internal consistency checks using automatically enforced business rules and question skip patterns. All mobile applications contain geospatial data utilized in digital maps to help enumerators navigate their surroundings

and electronically fence them in their allocated enumeration work area. Fieldwork will be organized and coordinated by a well-designed hierarchical structure of crew-leaders, assistant supervisors and supervisors in regional offices located throughout the Sultanate and assisted with a number of applications. Regional office systems will provide full control over fieldwork and the ability for real time immediate follow up and intervention to ensure smooth execution, full coverage and qualitative data. Data collected by enumerators will be automatically synchronized to regional offices. After synchronization data can be reviewed and assessed for any red flags through predefined key indicators before being transferred to the central database. Following is its main features:

- Applications are guarded with a username/password specific for each field enumerator to ensure data security and confidentiality.
- Global positioning system (GPS) technology used to accurately capture
  the position of enumerators.
- Geographic Information system (GIS) maps used to guide enumerators and help them navigate their surroundings.
- Use of color coding and different icons to distinguish buildings according to completion status.
- Electronically fence enumerators in their allocated work areas thus eliminating duplication and overlap during fieldwork.
- Electronic and user-friendly questionnaire designed in a wizard-like approach.
- Automatically enforce business rules to ensure data quality, validity and consistency.
- Automatically enforced question skip patterns utilized to avoid unnecessary or irrelevant questions per nationality, age and gender of the respondent.

- Automatic data synchronization eliminating the need for data entry and all problems associated with it.
- Automatic synchronization of enumerator tasks to and from the PDA.
- Search features to filter through long lists.
- A handy help feature available for all questions to assist enumerators during interviews.
- Mobile reporting for work progress at enumerator and crew leader levels.
- Comments can be added for further clarification and can be viewed at the back end systems.

5.2.2 I-Census Website

During the population phase of the census, internet-based census website was accessible throughout the Sultanate. This approach was adopted to accommodate households that would rather fill their census information online without the need to be interviewed by enumerators. It enables any computer literate member of the household or outside of the household to fill an online and user-friendly wizard-like questionnaire whenever suitable. All entered information is validated and corrected on the spot to ensure internal consistency using automatically enforced business rules and question skip patterns. Members can logon to their accounts and submit their information online. The website has the following features:

- Accounts are guarded with a username/password specific for each household to ensure data security and confidentiality.
- Enable households across the Sultanate of providing their information whenever they find suitable instead of being interviewed by enumerators.
- I-Census households will be clearly marked and blocked on PDAs to avoid being visited.

- Bilingual interface with multi-browsers support.
- Intuitive and user-friendly.
- Wizard-like approach to facilitate data entry
- Automatically enforced business rules on the spot to ensure data quality, validity, and consistency.
- Automatically enforced question skip patterns utilized to avoid unnecessary or irrelevant questions.
- The ability to save the questionnaire and continue at a later time.
- Business rule violations are presented in a user-friendly tooltip clearly explaining the violation.
- A summary of all business rule violations are presented at the end of the questionnaire.
- Business rules can be added/deleted/modified and reflected on the website instantaneously
- Uses a Secure Socket Layer (SSL) connection to ensure data security during transmission.

8. Computer-assisted Telephone Interviewing (CATI) System

Data quality, validity and cleanliness are of utmost importance in this census project. Accordingly, data collected through PDA applications and the I-Census website will be further checked and validated by a Computer-assisted Telephone Interviewing (CATI) system. The CATI system developed will enable trained operators conduct telephone interviews with households to complete and validate their data avoiding the need for field revisits where possible. It will also be used for response coding, communicating with the public and answering inquiries.

A CATI system will be deployed and used to validate the gathered information through the telephone. “The Call Centre and Quality Assurance” uses this CATI System for re-interviewing households by means of sampling for double assurance of coverage and content quality. The following are the main features:

- Full telephony features to communicate with the public.
- All conversations are recorded and can be played back when needed.
- Will serve 300+ operators simultaneously.
- Communicate with the public in 6 different languages.
- Provide support and help for the public throughout the census period.
- Send promotional and informational emails/SMS to households participating in the I-Census.
- Communicate with the public to validate their information through telephone thus avoiding extra field revisits where possible.
- Review and validate all collected data through automatically enforced business rules.
- Business rules can be added/deleted/modified and reflected on the system instantaneously.
- The system is guarded with a username/password to limit access and ensure data security and confidentiality.
- Authorization on specific screens and data is granted according to predefined user roles that match their responsibilities.
- Perform response coding tasks.
- Advanced search features to filter long lists and huge record sets.

9. Regional Office Systems

In order to complete the census on time, huge number of employees are hired most of which are enumerators. Using traditional approaches to control fieldwork, assess performance, progress and quality and assign tasks can be very difficult if not impossible. Dedicated systems were developed to facilitate such a process. Supervisors and assistant supervisors can follow up on all tasks assigned to their team members, the progress on each task and coverage. Predefined key indicators are used to assess the performance, coverage and progress and spot any red flags that might hinder or jeopardize field work for immediate corrective intervention.

Regional office applications with the following features were installed in these offices:

- Systems are guarded with a username/password to limit access and ensure data security.
- Authorization on screens and displayed data according to predefined roles and responsibilities. Each user can only see data belonging to team members reporting to her/him.
- Electronically synchronize collected data to the central database.
- Database backups for protection against unexpected hardware/software malfunctions and disasters.
- Track progress, performance, coverage and spot any red flags through key indicators.
- Drilling through key indicators for more detailed information.
- Display collected information for reviewing.
- Advanced search features to filter huge record sets.
- Logging of certain features such as data transfers for editing purposes.

10. Operation Room Systems

Effectively managing a temporary organization of 6500+ employees dispersed all over the Sultanate posed a great challenge. The Census Administration at headquarters must be able to track progress, performance and spot any red flags that might risk the success of the census. Effective control is impossible to achieve with the lack of accurate, timely and up to date information which in turn is impossible to attain using traditional census techniques.

Operation room applications will be installed in the headquarters to help officials and census managers track performance, progress, coverage completeness, quality and to identify any red flags that might hinder or jeopardize the success of the census through the use of predefined key indicators.

Dashboard applications were developed to provide control over the census process all over the Sultanate. Key indicators were updated regularly helping officials to follow up on progress, performance, coverage and quality on a general or granular level. It also allows them to spot any red flags early on to avoid any risks that might jeopardize the census. Below are the system's main features:

- The systems are guarded through a username/password to limit access and ensure data security.
- Authorization on screens and displayed data according to predefined roles and responsibilities. Each user can only see data belonging to team members reporting to her/him.
- Track progress and performance and spot red flags for the whole Sultanate through key indicators.
- Drilling through key indicators for more detailed information.
- Generate reports that help monitor census progress and coverage.

11. Communication System (E-Office)

Communication amongst the 6500+ census staff dispersed all over the Sultanate can make or break a project of this magnitude. Making sure that information reaches all parties instantaneously is imperative to guarantee success.

A dedicated communication and collaboration system was deployed. Through this system, staff can share memos, announcements, bulletins, minutes of meeting, folders. Furthermore, recipients will be notified through SMS/email of any new communication. Some main features look like the following:

- Used to communicate and collaborate through Memos, Minutes of Meeting, Announcements, Bulletins, SMS Push & Pull, Shared folders and Shared links.
- Define multiple surveys with different hierarchical structure, access policies and users.
- Notify recipients of memos, announcements, etc… through SMS and email through integrating with SMPP (SMS) and email gateways.
- Give users the look and feel of each survey by customizing the logo and theme.
- Users can switch between the different surveys assigned to them.

12. Government Resource Planning System (GRP)

A Comprehensive resource planning solution specially implemented to automate the Census back-office operations to handle around 6500+ employees. It consists of the following modules:

- Financial Management
- Human Resource Development Management
- Payroll
- Fixed Assets Module
- E-Procurement and Inventory Management
- Transportation Management System
- Document Management System
- WavePortalT
- WaveFlowT
- Communication Server

13. Inter-active Voice Response (IVR) System

In its efforts to create wider knowledge and understanding about the 2010 Census, the Census Administration introduced the IVR system as one of other approaches to reach a wider segment of the population in the Sultanate of Oman, both nationals and expatriates. In addition, the IVR includes an all inclusive competition about the 2010 census to contribute in creating census awareness among the population.

14. Summary and Conclusion

It is clear enough that selecting & applying appropriate information and communication technologies in the implementation phases of census operation would lead to a time efficient processes, & resulting in better data quality, consistency and validity, better control over field work, better management of the whole census process on a macro and micro level, and better communication and collaboration. However in order to achieve this, reengineering of census processes need to be considered as well as provide training in order to acquire the required

diverse skill sets to all the staff ranging from planners, implementers and field workers.