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**Mapping Census Infrastructure in the Pacific Islands:
Institutional and Capacity Building Issues***

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INTRODUCTION

Across the Pacific island region (15 countries and 7 territories), as is the case with many developing countries, population and housing censuses undertaken every five or ten years represent the only truly national stock-take of demographic, social and socio-economic features and developments. Such information is often supplemented by *ad hoc* household surveys (household income and expenditure surveys, and more recently also demographic and health surveys), and various types of administrative records. In light of this, and the fact that civil registration systems do not yield consistently reliable demographic data in most Pacific island countries (PICs)¹, particularly pertaining to mortality assessments, regular population censuses represent the main pillar, the very foundation of most Pacific islands national statistical systems.

CENSUS TAKING IN THE PACIFIC ISLANDS

Census taking in the Pacific goes back quite a few years with administrative population records dating back in some countries to the early 1900s. Modern, regular and enumerator implemented population counts date back to the 1950s and 1960s in most countries², being then administered by Australian, British, French, New Zealand and US administrations. With most countries gaining political independence in the 1960s and 1970s, the Secretariat of the Pacific Community has been providing technical assistance with census taking in its member countries and territories with the collection, analysis and dissemination of population census data from the 1980 round of censuses onwards.

Unlike other regions in the world, all Pacific Island countries and territories (PICTs) conducted a census in the 2000 round, as they have in earlier rounds. But unlike the situation during the 1980 and 1990 round of censuses, when external financial assistance and technical support was widely available to most countries and territories (most notably UNFPA, UNESCAP and SPC), many island countries experienced some difficulties in financing their census operations during the 2000 round, which led to the adoption of various short-cuts of generally accepted best-practice procedures, adversely affecting the quality of census coverage and outputs.

While it is recognized that no census or survey is ever perfect – considering that even well developed and widely recognized statistical systems such as in neighboring Australia and New Zealand experience some degree of undercounts – it is absolutely critical to acknowledge the likelihood of imperfection. There is always a need to have control procedures in place to keep errors, omissions and inconsistencies to an absolute minimum, and be able to accurately report on them.

While census methodology, including timing and length of enumeration period vary from country to country, all censuses share certain features that include the following distinct operations: preparatory work; enumeration; data processing (including data entry, edits and database construction) and tabulation; final data evaluation; analysis and report writing; and dissemination of results. With errors likely to occur at every step of census operations, good quality control strategies are recommended at every stage.

In the 2000 round of censuses, many Pacific Island countries failed to develop good census quality management strategies, which led to many instances of “coverage” and “content” errors. Regarding coverage errors, these type of errors occurred as a result of omissions or duplications of persons or housing units in census enumeration. The main sources of coverage error were:

¹ Civil registration works well in the three French Pacific territories of French Polynesia, New Caledonia and Wallis and Futuna, as well as in the 3 US Pacific territories of American Samoa, the Commonwealth of the Northern Marianas and Guam. There have also been recent improvements in some of the smaller PICs.

² SPC, 1995, Statistical Bulletin 42, Table 1.

- incomplete, inaccurate, or no census maps;
- incomplete or inaccurate list of dwelling units within enumeration areas;
- failure by enumerators to cover all dwelling units in their work assignment area;
- duplicate counting;
- omission of persons who were not willing to be enumerated;
- omission of persons who were absent from home on census night;
- erroneous treatment of certain categories of persons such as visitors or non-resident aliens; and
- loss or destruction of census records after enumerations.

Content errors occurred as a result of incorrect reporting or recording of the characteristics of persons, households or housing units. During the 2000 round, major content errors were largely caused by:

- poorly designed questions or poor sequencing of questions;
- poor communication between respondents and enumerators;
- mistakes in coding and data entry;
- errors in manual and computer editing; and
- erroneous tabulations of results.

These types of errors could have been avoided had census plans contained provisions for quality control strategies specifically addressing these issues. The main reason for underdeveloped census plans was a lack of resources, both financial, but most importantly skilled and experienced human resources, with most PICTs conducting their censuses with people without previous census experiences, and limited external technical assistance.

While it is mission critical for countries and their development partners to accord coverage and content errors equal priority when planning the next population and housing census, the thrust of this presentation will be on improving census cartography and mapping. Without accurate census maps it is very difficult to prepare household listings, to facilitate enumerators covering all households in their respective enumeration areas, and to allow effective utilization of the resulting census data. Most National Statistical Offices (NSO) historically have lacked the technical know-how to carry out such activities due to a lack of technical expertise and financial resources. In this context, geographic information systems (GIS) and other technologies used in census mapping (GPS, Digital Imagery) play a vital role.

CENSUS MAPPING IN THE PACIFIC ISLANDS

Pre-census preparatory activities including census mapping, to ensure accurate pre-enumeration household listings and delineation of enumeration areas (EAs), is one of the most difficult challenges faced by Pacific Island NSOs. EA maps ensure consistency and facilitate census operations (pre-enumeration)³, and are needed to identify areas where census interviewers have to work, identify the exact location of households, and serve as basic geographic units for which statistics are generated later on⁴.

Experience from past censuses indicate that systematic census mapping work has been given low overall priority, often being attended to quite late in the census (planning and implementation) cycle, with most associated work best described as proceeding on an ad hoc, rather than systematic and planned basis.

³ U.N. Department of Economic and Social Affairs Statistical Division (2000): Handbook on geographic information systems and digital mapping

⁴ Langeraar, W. D Timor-Leste 2004 Census Mapping and GPS operations

Regarding the production of enumeration area maps, basic sketch maps have long been the norm guiding most Pacific island countries' census operations⁵. It has been noticed that inaccuracies and incompleteness of maps have direct impact on the coverage and quality of the census. During the enumeration phase when the actual data collection takes place⁶, these maps support and can help monitor census activities and in association with other technology can help prevent problems of under enumeration. For example, remote sensing might also help with the census undercount problem⁷. One source of a census undercount is the failure to recognize a physical structure that is a dwelling unit. For relatively remote rural areas (particularly relevant in Pacific Island countries), finding dwelling units is a difficult undertaking and can contribute to undercounts.

The production of post-census thematic maps is a good way of presenting and visualizing spatial patterns and trends and improving communication of census results. While census data across the region are captured at various levels of administrative geography, such data are rarely analyzed and presented at these levels, because of time, staffing and cost constraints. Technological change, however, has facilitated other and more efficient and effective ways of disseminating census data compared to the traditional fare of printed tabulation and analytical reports; this includes a greater emphasis being placed on the production thematic maps, including population atlases, electronic media CD-ROM, interactive GIS databases (Population GIS), population and development profiles, customized/on-request data analyses, and more recently, internet based map servers⁸ deployed in many Pacific Island countries.

MAPPING CHALLENGES ENCOUNTERED IN 2000 PACIFIC CENSUSES

A major problem encountered in the 2000 census round in many Pacific island countries was the *lack of digital automated mapping systems*. Maps used for census enumeration were manually produced hard copies based on maps from previous censuses, so NSOs experienced difficulties updating and maintaining the maps. For example in Vanuatu, no up-to-date maps existed of the whole country for the 1999 census. The most recent maps had been produced in the 1980s, and most of them were thought to be inaccurate. As a result, EAs were of very variable population size, which meant unequal work loads for enumerators. Consequently population numbers in some of the urban EAs of Port Vila and Luganville were found to be too large and difficult to manage, resulting in unreasonable workloads. This led to more enumerators being assigned to the same large area, rather than adjusting (subdividing) former EAs into smaller and more manageable units for individual enumerators.

Another significant problem associated with inadequate census cartographies, is the *lack of specific geographic identifiers* limiting the spatial analysis of census data at various levels of sub-national aggregation, with most censuses planned and collected without a specific GIS capability in mind. While census data in all PICTs have been captured and geo-referenced down to the village level, this location reference has tended to be inaccurate in many cases, with no further household identifiers, such as street addresses available in most cases, thus hindering more advanced spatial analyses, which are of growing relevance and importance in policy and action-oriented research and analysis, particularly in the context of rapid urbanization in most island countries and territories.

⁵ Census operations in the US and French territories, however, are usually guided by state-of-the-art census cartography (as illustrated in the use of US Census Bureau-produced *TIGER* in the US Pacific territories).

⁶ Like in most developing countries this is done through door-to-door visits in the Pacific region.

⁷ *People and Pixels Linking remote sensing and social science* National Research Council (US), Diana M. Liverman by National Research Council

⁸ Interactive Web Servers deployed in country and provide digital maps and some cases limited census data to a wide range of end users. <http://www.sopac.org/mapserver> <http://maps.tikiwiki.org>

While it is important for NSOs to develop a continuing mapping capability to serve their specialized needs, the development of census mapping requires considerable knowledge of mapping concepts, cartography and GIS⁹. If these skills don't exist within NSOs, they might need to contract out the preparation of the census maps¹⁰. One of the ongoing challenges for most Pacific island NSOs is not just *developing capacity* across a broad spectrum of statistical and associated activities, but to *maintain this capacity* in house. This is of critical importance for small Pacific island statistics and planning offices, which are more than often understaffed, and also experience a high degree of staff turn-over, including regular "losses" of their most trained and experienced staff to other government agencies associated with conveying more prestige, better pay and career advancement, or to the private sector or overseas migration. In this environment, technical assistance and training, as well as ongoing (and in some cases growing) capacity supplementation represent ongoing challenges.

An additional challenge to census mapping and data collection faced by most Pacific island countries are their respective *physical geographies*, with many countries comprising of between dozens and hundreds of islands, often scattered over vast ocean areas. The Pacific island region itself is composed of thousands of islands spread over more than 34 million square kilometers of ocean, and this scattered geography presents extraordinary challenges in terms of transport and communication. Transport is costly and often unreliable, whether by air or sea, and telecommunications in many areas is non-existent. Many islands comprise of very small land areas, which, when isolated from larger land areas are not usually captured by satellites; isolation also means, other mapping options are unavailable due to high costs involved. The Republic of Kiribati is a good example of this, with 26 inhabited islands spread over an area of five million square kilometers of the central Pacific Ocean, featuring a combined land area of only 810.5 sq. km.

Customary land boundaries and perennial land ownership issues represent another serious challenge to census mapping in the Pacific island region. Land holds a very special role in Pacific island culture; it is more than a physical (and economic) commodity, with people's roots and identity, their social standing, including political power associated with it. Defining (or rezoning) enumeration areas can become problematic and contribute to disputes between communities about where village or community boundaries actually lie, when the role of administrative area maps (to facilitate a census or survey operation, for example) is mistaken to represent cultural or legal land boundaries. NSOs face a formidable challenge to stress the value and importance of such administrative boundaries for the purpose of statistical data collection and representation, which may not always correspond to customary land boundaries. Problems of this nature have recently been experienced in Wallis and Futuna, as well as in the Federated States of Micronesia, where it became impossible to accurately depict census data at village level.

The multi-lingual nature of many Pacific Island countries, particularly in case of the larger and more populated Melanesian countries and territories of Papua New Guinea, Solomon Islands, Vanuatu and New Caledonia, also introduces significant difficulties associate with labeling, misspelling and coding of villages, because several languages or dialects are in use within the same country, and with village or settlement names sometimes written phonetically. While this creates formidable difficulties in labeling and identifying the location of places recorded in the census, this situation could be quite easily overcome with a systematic use of GPS (Global Positioning System) technology in the collection of village data, as successfully shown in the recent census of Timor-Leste in 2004.

⁹ UN Handbook on geographic information systems and digital mapping

¹⁰ Data collection in developing countries Casley D.J and Lury D.A

Collaboration with other government agencies and managing the relationship and any possible conflict is of critical importance to any census mapping project. For example despite the use of GPS technology in the 2000 Papua New Guinea census¹¹, the National Mapping Bureau who was carrying out this work did not fully understand census project requirements (timely production of census maps) and placed a higher priority on their functional activities (completion of village updates). This led to delays in map-dependent 2000 census activities, and there was always misunderstanding between the two organizations. In the end, the census was conducted with incomplete maps and most of the GPS capture was not done during the data collection phase of the census and actually took place after the enumeration of the census had already been done.

GIS FOR DATA DISSEMINATION / UTILISATION

A Regional Seminar on Population and Development in Noumea in 2001 stressed the need to simplify population data, and to make these data more accessible at levels of geography below simply national levels. Knowing that specialized GIS skills required for Census Mapping, were generally not widespread across the region, the SPC developed a customized population geographic information system (SPC PopGIS) for many of its member countries.

Given the scope and scale of typical Pacific Island Country conditions, featuring limited technical capacity and financial resources constraints, the pursuit of a smart and cost-effective ICT solution was of great importance. The same applies to ownership and the active involvement of national staff in trying to design and promote customized geographic information systems in Pacific island countries and territories, and tailoring these systems to particular country needs¹². To date, 8 national systems have been developed covering the Federated States of Micronesia, Kiribati, Samoa, Vanuatu, Solomon Islands, Cook Islands, Marshall Islands and Wallis and Futuna, with similar applications currently being developed for Tonga and Papua New Guinea, and in the pipeline for other Pacific Island countries and territories.

This application was primarily developed for statisticians and planners, to improve the effectiveness of census (and other socio-economic) data dissemination and utilization. Widely used in some countries and extending well beyond its original objective, it has sensitized the producers and users of statistics to the importance for accurate census and survey mapping, and motivated several countries to move from a traditional census mapping approach to an automated digital process in the collection and storage of geographic information.

The Population GIS tool has been extremely useful to the national level planners as an alternative means for presentation and analysis of geographically indexed data. Its development represents in many PICTS the first efforts to utilize the true capabilities of GIS for applications other than simple location mapping that has traditionally been driven by external projects.

FUTURE OUTLOOK

Greater use of long term training attachments has been found to be very effective in building capacity in many Pacific Islands. This approach is relatively less expensive and not as resource intensive on NSOs. For instance NSO staff in the Kingdom of Tonga recently worked on long term attachment with their Ministry of Lands Survey and Natural Resources Department, thus combining census mapping work with a Land Hazard and Information Management project being undertaken in the country. If there are expert staff resources located in national mapping agencies it is proposed that more frequent

¹¹ Jorari, Arthur (2000) *Pacific experiences and views on the themes of the Symposium*

¹² See also: Hall, G.B., R.L. Bowerman and R.D. Feick. (1997) Problems and Prospects for GIS-Based Decision Support Applications in Developing Countries. *South African Journal of Geo-information* 17(3), pp 81-87.

and longer training attachments would be used to transfer key skills, preferably in small groups from NSOs with similar needs.

Building an effective mapping capacity is very much tied to relationships built with other spatial data gathering agencies; and these must be maintained and nurtured overtime¹³. Users of GIS across the Pacific region have indicated the need to make data sharing and compatibility easier between organizations, both within countries and across regional agencies. The relationship and collaboration between NSOs and other government departments such as national planning and national mapping agencies has often been challenging and requires ongoing cooperation. The development of a Population GIS within PICTs was seen by many users as a vehicle in bringing together the main users of official national statistics – planners, policy analysts, policy-makers – with the producers (statisticians) of these data and statistics establishing and maintaining a dialogue between these two groups. This approach has worked very well in some countries.

At the ‘wider’ regional level the increasing number of GIS graduates from the University of the South Pacific (USP) and other overseas training institutions will increase the ***skills availability*** for future development of census mapping.

In the Marshall Islands, two staff from the country’s Economic Policy, Planning and Statistics Office attended an introduction to GIS training course run through the local USP extension centre in 2006, sponsored by SOPAC¹⁴. As a result, these two staff members were able to map the results of the 2006 Marshall Islands Community Survey using ARCGIS for data dissemination. The survey was undertaken using small hand held GPS units (data collection) and high resolution satellite imagery to identify the location of each of the randomly selected households on a map. Since GIS was used in the planning phase of this survey the amount of data and analysis available due to the availability and utilization of GPS and satellite imagery opens up many additional avenues for explaining trends and causal relationships between key variables of interest. This presents an ideal situation, where this office now has established its own mapping capacity, and now all future censuses and survey related mapping should be able to be maintained internally.

Unlike the situation during the 2000 round of censuses, there is a growing recognition amongst Pacific Island NSOs of the importance to ***establish some form of census mapping/cartography capacity***. Currently 11 of the 22 NSOs have established a census mapping capability of varying degrees of complexity and technical sophistication, with Fiji and Marshall Islands NSOs having staff with advanced GIS skills and experience with GPS technology, and Papua New Guinea, Tonga and Vanuatu also improving their capabilities in this area. As stated earlier, 8 countries and territories are using the SPC Population GIS software for dissemination of their census data. Another positive development has been the establishment of national GIS user groups throughout the Pacific region.

For example, in the Marshall Islands, Papua New Guinea and Vanuatu, GIS users have formed a national user group to facilitate communication between people working in all areas of GIS, with these groups meeting regularly (monthly) to allow its members to share and learn more about current activities and technologies within the industry and to network with their peers.

The ***use of GPS*** for census taking has a distinct advantage in allowing the linking of census records to an actual physical location. In most PICTs, as is the case in many developing countries, no exact location database of dwellings exist for census project use, and a lack of street names and numbers mean no address lists are available.

¹³ St Catherine, E. Experiences with the Use of GIS capabilities in the Preparation of Census maps and the Implications for the Data Dissemination. (St. Lucia) Census Symposium, Bahamas, 2005

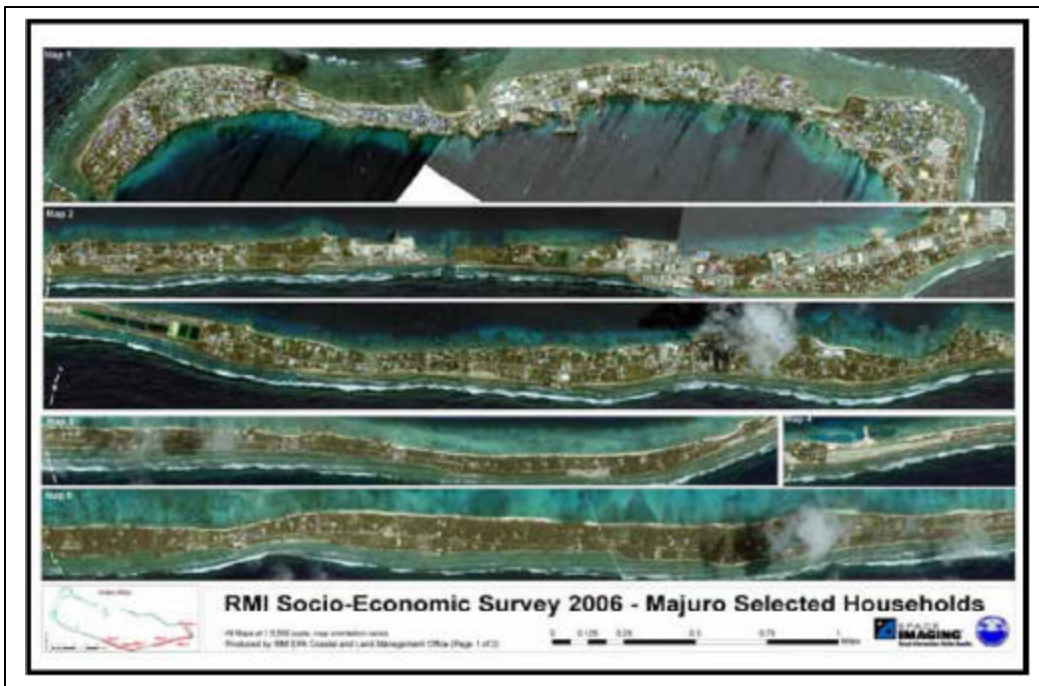


Figure 1. Example of Planning map utilized by survey design and planning team in Marshall Islands

As a result, enumerators charged with finding each settlement or village can have a difficulty locating where all the people are. In this situation handheld GPS and satellite imagery will greatly increase the accuracy of residence locations particularly in rural areas where settlements are harder to find. It is also expected to streamline the process for census workers and managers as was the experienced in the 2004 Timor-Leste census 15.

In the Pacific Region, there has been for some time, a *growing demand* for small area statistics below the standard census collection unit levels (EA). A prime example is the need for village level population and housing data required for assessing, monitoring and managing disaster preparedness, given the Pacific islands' annual exposure to cyclones, as well as the very imminent threat of sea level rise to low-lying coral atoll countries. More recently an earthquake measuring 8.1 struck the Solomon Islands on 2 April creating a tsunami causing significant damage in the Solomon Islands. Information on displaced village population was needed in targeting emergency response work. Demand for information at lower levels of geography is expected to grow in future.

Census mapping in the Pacific Island region work with a very *limited budget*. For this reason training, investment and maintenance of software and acquisition of satellite imagery are serious financial issues. One possible solution would be to switch to an open source software platform once such products are available in a quality allowing census mapping applications. It is expected that such products will become available within the next few years 16.

¹⁴ South Pacific Applied Geosciences Commission

¹⁵ Langeraar, W.D *Timor-Leste 2004 Census Mapping and GPS Operations*

¹⁶ <http://grass.itc.it/grass63/>

Likewise *high resolution satellite imagery* of Pacific Island countries is very expensive and coverage usually is limited to selected urban centers in the most populated countries. Individually, countries cannot normally afford to purchase imagery so a pooling of resources is needed and related purchases need to be calculated in to census budgets not just relied on being provided by other external projects. There is also added complexity in the Pacific¹⁷ as frequent cloud cover jeopardizes the quality and hence possible use of satellite imagery. A mobile ground receiving station would provide faster and more cloud free image data¹⁸.

Internet communication holds great hope for widely scattered island countries and territories of the Pacific region, by allowing instantaneous communication and information transfer. Traditionally though, high cost of bandwidth due to low usage has been a major barrier in its adoption. However low cost small satellite terminals enabling affordable Internet connectivity are currently being proposed that can reach remote areas in the Pacific and can enable rural communities to have access. Maps have become common place on the internet with the recent emergence of new “geobrowsing” technologies such as Google Earth, Google Maps and NASA World Wind. These applications present exciting possibilities for census mapping because they are low-cost, easy-to-use alternatives to the more traditional heavyweight GIS applications. Internet based map servers being deployed in many Pacific Island countries will also make dissemination of census data to a wider audience also possible.

Earlier references to financial and technical resources constraints experienced by most Pacific Island NSOs in terms of developing and maintaining an effective cartographic and GIS capacity calls for innovative approaches that are sustainable in the long run. This is of particular relevance for the smaller NSOs in the region, where a *regional approach to capacity-sharing*, or *capacity-supplementation* would appear more effective and sustainable compared to building and maintaining national NSO-based specialist cartographic/GIS capacity. With 10 out of the region’s 21 NSOs comprising of less than 8 staff, South-South cooperation, or establishing a regional census and survey cartographic capacity with a regional organization, like SPC, would appear as a logical, cost-effective and more sustainable solution. The same could extend to the sharing technology (sufficient hand-held GPS units held by SPC, and provided on loan to small island countries prior to census and survey undertakings).

CONCLUSION

GIS technologies have evolved remarkably since the last census (2000) round yet adoption by the statistical community in the Pacific has been sluggish. There are significant challenges, resource constraints and other institutional issues in PICTs that require innovative solutions and a coordinated and committed (regional) approach to provide the path towards sustainable utilization of GIS for census mapping.

First and foremost, all countries need an up to date database of specific geographic identifiers such as villages, settlements, households, EA’s and other geographic level boundaries. Unlike the situation in the past, censuses and surveys need to be planned and collected with a clear GIS capability in mind. Census (and survey) cartography needs to be given higher priority by Pacific Island NSOs, needs to be

¹⁷ Pacific Islands GIS & RS News Issue 1 2006

¹⁸ With the exception of PNG all pacific islands are outside the footprint of any satellite ground receiving station. Therefore for every image recording by satellite, on board tape space has to be booked therefore last minute decision related to cloud cover is impossible in the pacific region.

properly planned and resourced, and needs to become an ongoing process rather than implemented on an ad hoc basis, and usually too late in the census cycle.

With the assistance of high resolution satellite imagery, and low cost GPS units and other GIS infrastructure, awareness of the importance of accurate and reliable census maps is growing throughout the region. These technologies have shown the potential to improve the accuracy and coverage and overall data quality; and are extremely powerful returns to the investment of incorporating GIS tools in the data collection of a census.

Data analysis and dissemination becomes more effective when accompanied by good maps, as compared to the predominant use tables and charts seen in past census reports. Many PICTs are using SPC developed population GIS software and various other forms of technology (some internet based) to more effectively disseminate their census data to end users. Through this technology, the use of training attachments with SPC and more technologically advanced and experienced NSOs, as well as a wider collaboration within and between countries, between NSOs and other line government agencies, a growing local and regional capacity is being established laying the foundation for further development of census mapping in the Pacific islands .