Case Study: Estimation of Coastal Populations of 22 Pacific Island Countries and Territories.

Prepared by SPC's Statistics for Development Division, University of Wollongong and World Fish Centre for DRSF of the Asia-Pacific Expert Group on Disaster-related Statistics. This Case study refers to a forthcoming publication by Andrew et al[i]

Purpose

- This analysis aims to estimate populations settled in coastal areas in 22 Pacific Island Countries and Territories (PICTS) using the data currently available. In addition to the coastal population estimates, the study compares the results obtained from the use of national population datasets (census) with those derived from the use of global population grids.
- Accuracy and reliability from national and global datasets derived results have been evaluated to identify the most suitable options to estimate size and location of coastal populations in the region.

Background

- In PICTs', the livelihoods of the coastal communities, depend to a large extent on the coastal areas' resources in terms of food security, employment and development.
- Pacific communities are at an increasing risk situation, facing a series of implicit challenges and threats within its geographic and environmental context. Problems derived from climate change, overfishing, degradation of ecosystems and natural disasters, combined with a population in constant growth, limited fishing and agricultural resources.
- Access to reliable and accurate population data at subnational level, is essential to design evidence-based development strategies and policies in fields such as food security, coastal fisheries, natural disaster risk management, coastal planning, water and sanitation, education, natural resources management among others.

Coastal Strips "Buffers"

- Distance to the coast defined buffers are usual to estimate coastal populations. The most utilized method to define coastal zones is the Low Elevation Coastal Zone defined (LECZ), which includes all land areas up to 10 m elevation connected to the ocean (McGranahan et al., 2007).
- UN defines the indicator Coastal Population as the percentage of total population living within 100 kilometres of the coastline. It also considers the option of using LECZ methodology to generate the indicator[1].
- The idea of using these zones for PICTs, is based on a discussion stablished among various experts (coastal fisheries, food security, natural disasters management) who have been interested and have been requesting for this type population data. Throughout the discussion, it was agreed that the use of this type of buffer zones to delimit coastal populations was a suitable option. Distance to the coast is a concept that is easy to understand in order to produce coastal population indicators, furthermore 1 up to 10 km buffers are well adapted to the context of the region, where many countries are formed primarily by atolls were elevation rarely exceeds 10m.
- 1, 5 and 10 km coastal buffers were used to subset populations according to where they live. People within the 1km buffer is considered those who live on the coast, within 5km one, those

[1] http://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/oceans_seas_coasts/pop_coastal_areas.pdf

who could still easily walk to the coast and then 10km, those who interact with coastal communities though who would only be able to easily get to the coast with some form of transport. In reality a large proportion of PICTs are fully contained within 10 km of the coast. (*Andrew et al. , forthcoming*)

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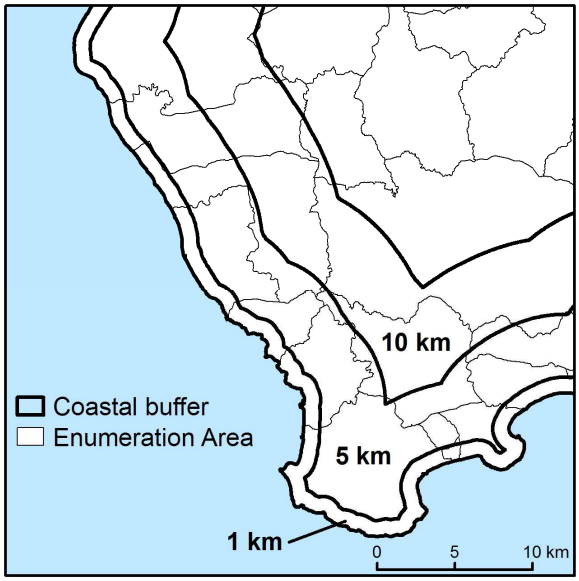

Figure 1: Illustrating 1, 5 and 10km buffers for South-West Santo, Vanuatu

- The land boundaries datasets utilized to generate the coastal strips came from these two main sources:

Datasets and Source	Year	Format	Scale/Level
Global Administrative Unit Layers (GAUL) [2]	2015	Vector	Global
Census administrative levels (Enumeration Area or Villages, where available)	Between 2000 to 2016	Vector	National

Table 2: Data sources for coastlines

National Census Datasets – Country categories

- Datasets from national censuses were utilized to produce and compare the coastal population estimates.
- The following datasets were compiled from the most recent national censuses:
  a) Households and population counts at the lowest geographical level available.
  b) The corresponding geographic layers in vector format.
  c) GPS household locations with respective household population counts from the most recent census (between 2000 and 2015) were used when available otherwise, an average household size, previously calculated, was assigned to each of household locations.
- The analysis of national datasets was highly dependent on the availability and quality of the population data for each country.

[2] Global Administrative Units Layer. http://www.fao.org/geonetwork/srv/en/metadata.show?id=12691

- Three cases were defined for the coastal population estimates from national-level datasets. Each case was determined according to the availability of population data.
  Case 1 where GPS household locations with attached population figures are the gold standard. In case 2 we previously calculated the Average Household Size for each administrative unit from the most recent census dataset, then the value was allocated to each of the GPS hh locations.

$$AHS_i = \frac{(Population)_i}{(GPS\ locations)_i}$$

  For case 3, where GPS household locations were not available, we assumed that population is homogeneously distributed across of each of the administrative units. There is then a drop in precision if household level population does not exist, and lastly the model becomes much more simplified if GPS points do not exist either. Table 2 outlines where countries fall in each of the three cases. (ref paper)

Case 1	**Case 2**	**Case 3**
GPS household locations + population data attached from recent census.	GPS household locations without attached population data. Disaggregated population data from census used to calculate average household sizes.	Census population figures assigned to lowest-level administrative boundaries such as Enumeration Areas. Population homogenously distributed.
Countries:		
- Tonga - French Polynesia	- Fiji - Northern Mariana Islands - Palau - Solomon Islands - Vanuatu - Samoa - Federated States of Micronesia - Wallis and Futuna	- American Samoa - Cook Islands - Guam - New Caledonia - Niue - Nauru - Papua New Guinea

Table 2: Three different cases depending on data availability

- Once the population counts were displayed over the correspondent geospatial framework (either Household locations or EA polygons), coastal populations were estimated by extracting the population within the 1, 5 and 10 km coastal strips previously generated. For case 1 and 2 population was calculated by adding the population allocated to each point located within the buffers. In case 3, population was extracted calculating the proportion of the area of each administrative unit intersected by the coastal buffers.

	Country Census				
	Data Availability	Year	% 1km	% 5km	% 10km
MELANESIA			**18%**	**38%**	**47%**
MELANESIA (excluding PNG)			**47%**	**85%**	**94%**
Fiji	**2**	**2007**	27%	76%	91%
New Caledonia	**3**	**2014**	57%	90%	94%
Papua New Guinea	**3**	**2000**	8%	21%	30%
Solomon Islands	**2**	**2009**	65%	91%	98%
Vanuatu	**2**	**2009**	64%	94%	99%
MICRONESIA			**72%**	**99%**	**100%**
Federated States of Micronesia	**2**	**2010**	89%	100%	100%
Guam	**3**	**2010**	30%	97%	100%
Kiribati	**100% coastal**	**2015**	100%	100%	100%
Marshall Islands	**100% coastal**	**2011**	100%	100%	100%
Nauru	**3***	**2011**	93%	100%	100%
Northern Mariana Islands	**2**	**2010**	69%	100%	100%
Palau	**2**	**2015**	93%	100%	100%
POLYNESIA			**74%**	**99%**	**100%**
American Samoa	**3**	**2010**	61%	100%	100%
Cook Islands	**3**	**2011**	91%	100%	100%
French Polynesia	**1**	**2012**	79%	100%	100%
Niue	**3**	**2011**	25%	83%	100%
Pitcairn Islands	**100% coastal**	**2012**	100%	100%	100%
Samoa	**2**	**2011**	61%	97%	100%
Tokelau	**100% coastal**	**2011**	100%	100%	100%
Tonga	**1**	**2011**	84%	100%	100%
Tuvalu	**100% coastal**	**2012**	100%	100%	100%
Wallis and Futuna	**2**	**2013**	92%	100%	100%
PACIFIC region			**26%**	**47%**	**54%**
PACIFIC region (excluding PNG)			**57%**	**90%**	**97%**

Figure 2: Coastal population estimates from Country Census data.

Global population datasets

- For the cases where Census data was not available or the precision was not suitable enough to generate the estimates, global population datasets were utilized to complete the estimates across the region.
- Two main global population grids were selected

Datasets and Source	Year	Format	Resolution	Scale/Level
LandScan™ 2015 Global Population Dataset[3]	2015	Raster	30 arc-second	Global
SEDAC-CIESIN Gridded Population of the World, v4 (GPWv4)[4]	2015 (UN-Adjusted Population Count)	Raster	30 arc-second	Global

[3] LandScan™ 2015 Global Population Dataset. Oak Ridge National Laboratory (ORNL), Oak Ridge, TN, U.S. http://web.ornl.gov/sci/landscan/index.shtml

[4] SEDAC-CIESIN Gridded Population of the World (GPW)v4 http://sedac.ciesin.columbia.edu/data/collection/gpw-v4

Table 3: Global dataset details

- Data processing for global datasets was very similar to the process carried out with the national datasets. The main difference was in the coastlines utilized to generate the coastal strips. GAUL boundaries[5] were used to generate the coastal buffer zones. Population grids were clipped to extract the pixels contained within the coastal buffers, and then the coastal population was calculated by adding the values of each extracted pixel.

Results

- Results were not quantitatively comparable because the period in which datasets were generated, ranges from 2001 to 2016. This is the reason why results are normalized across the total population figures, corresponding to each of the datasets utilized **(ref. paper)**
- Coastal population estimates generated from both national and global datasets are summarized in the table below.

	Country Census					LandScan 2015			SEDAC-CIESIN GPWv4 2015		
	Data Availability	Year	% 1km	% 5km	% 10km	% 1km	% 5km	% 10km	% 1km	% 5km	% 10km
MELANESIA			**18%**	**38%**	**47%**	**27%**	**41%**	**47%**	**12%**	**30%**	**39%**
MELANESIA (excluding PNG)			**47%**	**85%**	**94%**	**56%**	**86%**	**93%**	**38%**	**81%**	**92%**
Fiji	**2**	**2007**	27%	76%	91%	41%	80%	87%	32%	82%	91%
New Caledonia	**3**	**2014**	57%	90%	94%	57%	86%	96%	43%	66%	81%
Papua New Guinea	**3**	**2000**	8%	21%	30%	17%	28%	33%	5%	16%	25%
Solomon Islands	**2**	**2009**	65%	91%	98%	74%	92%	97%	42%	84%	95%
Vanuatu	**2**	**2009**	64%	94%	99%	68%	94%	99%	46%	90%	98%
MICRONESIA			**72%**	**99%**	**100%**	**75%**	**100%**	**100%**	**67%**	**99%**	**100%**
Federated States of Micronesia	**2**	**2010**	89%	100%	100%	94%	100%	100%	85%	99%	100%
Guam	**3**	**2010**	30%	97%	100%	35%	100%	100%	27%	99%	100%
Kiribati	**100% coastal**	**2015**	100%	100%	100%	99%	100%	100%	100%	100%	100%
Marshall Islands	**100% coastal**	**2011**	100%	100%	100%	97%	98%	98%	98%	99%	99%
Nauru	**3***	**2011**	93%	100%	100%	93%	100%	100%	70%	100%	100%
Northern Mariana Islands	**2**	**2010**	69%	100%	100%	77%	100%	100%	54%	100%	100%
Palau	**2**	**2015**	93%	100%	100%	87%	100%	100%	81%	100%	100%
POLYNESIA			**74%**	**99%**	**100%**	**78%**	**99%**	**100%**	**39%**	**80%**	**97%**
American Samoa	**3**	**2010**	61%	100%	100%	72%	100%	100%	64%	100%	100%
Cook Islands	**3**	**2011**	91%	100%	100%	91%	100%	100%	57%	100%	100%
French Polynesia	**1**	**2012**	79%	100%	100%	83%	100%	100%	36%	77%	97%
Niue	**3**	**2011**	25%	83%	100%	63%	100%	100%	27%	86%	100%
Pitcairn Islands	**100% coastal**	**2012**	100%	100%	100%	100%	100%	100%	70%	100%	100%
Samoa	**2**	**2011**	61%	97%	100%	69%	97%	100%	17%	63%	96%
Tokelau	**100% coastal**	**2011**	100%	100%	100%	100%	100%	100%	100%	100%	100%
Tonga	**1**	**2011**	84%	100%	100%	77%	100%	100%	58%	99%	99%
Tuvalu	**100% coastal**	**2012**	100%	100%	100%	99%	100%	100%	99%	100%	100%
Wallis and Futuna	**2**	**2013**	92%	100%	100%	88%	100%	100%	60%	100%	100%
PACIFIC region			**26%**	**47%**	**54%**	**33%**	**48%**	**54%**	**16%**	**36%**	**45%**
PACIFIC region (excluding PNG)			**57%**	**90%**	**97%**	**64%**	**91%**	**95%**	**43%**	**84%**	**94%**

Figure 3: Coastal population estimates generated from both national and global datasets

- Across the Pacific region, using only country census data (green), one notices that roughly 26% live within 1km of coast, 45% within 5km and 54% within 10km. Excluding PNG 57% live within 1km of coast, 90% within 5km and 97% within 10km. **(ref. paper)**

Discussion

[5] Global Administrative Units Layer. http://www.fao.org/geonetwork/srv/en/metadata.show?id=12691

- A selection of the best options for estimating coastal population was undertaken for each of the countries (Highlighted in green in Figure 4). The key factor is to what extent, recent and reliable census data is available. When recent population data with GPS household locations attached is available, it is very complicated to improve the resolution and the accuracy of these combined datasets. **(***Andrew et al. , forthcoming***))**
- When census data is out-of-date, or HH locations are required to attribute aggregate populations across administrative units, both Landscan, and census-based methodologies' results are very similar to each other for most of the cases. *Andrew et al. , forthcoming*)**)** For GPWv4, we find for many countries that the estimates are far from both Census and Landscan results. The explanation lies in the administrative level the model uses to distribute the population across de surface. Checking in the GPWv4's sources documentation[6], we find that for FSM's case, population data at Enumeration area level from SPC-SDD's PopGIS2[7] online mapping tool, was used to generate the population grid providing very close results. The opposite occurs for the case of Samoa, where population data was collected at Statistical region level, which is too coarse to produce an accurate enough population grid.
- When either census data is too old or GPS household locations are not available, the best option is to rely on global population datasets, given that the methodology to estimate coastal populations for countries classified as case 3, is much simpler than the other options. (*Andrew et al. , forthcoming*)

	Country Census					LandScan 2015			SEDAC-CIESIN GPWv4 2015		
	Data Availability	Year	% 1km	% 5km	% 10km	% 1km	% 5km	% 10km	% 1km	% 5km	% 10km
MELANESIA											
Fiji	2	2007	27%	76%	91%	41%	80%	87%	32%	82%	91%
New Caledonia	3	2014	57%	90%	94%	57%	86%	96%	43%	66%	81%
Papua New Guinea	3	2000	8%	21%	30%	17%	28%	33%	5%	16%	25%
Solomon Islands	2	2009	65%	91%	98%	74%	92%	97%	42%	84%	95%
Vanuatu	2	2009	64%	94%	99%	68%	94%	99%	46%	90%	98%
MICRONESIA											
Federated States of Micronesia	2	2010	89%	100%	100%	94%	100%	100%	85%	99%	100%
Guam	3	2010	30%	97%	100%	35%	100%	100%	27%	99%	100%
Kiribati	100% coastal	2015	100%	100%	100%	99%	100%	100%	100%	100%	100%
Marshall Islands	100% coastal	2011	100%	100%	100%	97%	98%	98%	98%	99%	99%
Nauru	3	2011	93%	100%	100%	93%	100%	100%	70%	100%	100%
Northern Mariana Islands	2	2010	69%	100%	100%	77%	100%	100%	54%	100%	100%
Palau	2	2015	93%	100%	100%	87%	100%	100%	81%	100%	100%
POLYNESIA											
American Samoa	3	2010	61%	100%	100%	72%	100%	100%	64%	100%	100%
Cook Islands	3	2011	91%	100%	100%	91%	100%	100%	57%	100%	100%
French Polynesia	1	2012	79%	100%	100%	83%	100%	100%	36%	77%	97%
Niue	3	2011	25%	83%	100%	63%	100%	100%	27%	86%	100%
Pitcairn Islands	100% coastal	2012	100%	100%	100%	100%	100%	100%	70%	100%	100%
Samoa	2	2011	61%	97%	100%	69%	97%	100%	17%	63%	96%
Tokelau	100% coastal	2011	100%	100%	100%	100%	100%	100%	100%	100%	100%
Tonga	1	2016	84%	100%	100%	77%	100%	100%	58%	99%	99%
Tuvalu	100% coastal	2012	100%	100%	100%	99%	100%	100%	99%	100%	100%
Wallis and Futuna	2	2013	92%	100%	100%	88%	100%	100%	60%	100%	100%

Figure 4: Coastal population estimates generated from both national and global datasets, with figures likely to be the most representative of actual populations highlighted in green.

Conclusion

- High quality GPS-based household locations are always going to be the most accurate. Converting this data to an interpolated grid then promoted a wider user of the data for a variety

[6] GPWv4 Country level Information and Sources Revision: http://sedac.ciesin.columbia.edu/data/set/gpw-v4-population-count-rev10/docs

[7] SDD's PopGIS2 Online Mapping tool portal: http://prism.spc.int/regional-data-and-tools/popgis2

of spatial analyses. This can also remove issues with confidentiality if sensitive information is attached to the HH locations.

- The authors recommend all countries record GPS-based household locations when conducting census and survey projects. Where possible, this data should be made freely downloadable. This study provided the repeatable analysis framework to estimate the coastal population by utilizing the best available global and national datasets in Pacific (poor data environment).
- In the event that GPS data is not available, grid-based estimation techniques can be applied, though these models get revised as higher resolution and more recent data is made available.

[i] See forthcoming publication:

Coastal proximity of populations in 22 Pacific Island Countries and Territories

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