CADASTRAL RECORDS AND THE IMPACT OF SEA LEVEL RISE

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1. INTRODUCTION

In 2009 the International Community-University Research Alliance (ICURA) initiative, jointly supported by Canada's Social Sciences and Humanities Research Council (SSHRC) and the International Development Research Centre (IDRC), funded researchers from Canada and the Caribbean region to study the potential socioeconomic impacts of climate change on coastal communities in Canada and the Caribbean. The coastal village of Grande Riviere in Trinidad and Tobago, an important nesting site for leatherback turtles that are of economic importance to the community, is one of the project's study sites. The project aims to provide policy makers and planners with data and information to support the development of appropriate mitigation and adaptation strategies.

Sea level rise is one deleterious effect of climate change. The Intergovernmental Panel on Climate Change (IPCC) has projected that global sea level will rise by 0.6m or more by 2100 (IPCC 2007). Other sources such as Warrick, Barrow and Wigley (1993), Burkett, Zilkoski and Hart (2003), Walsh (2004), Meehl (2005), and Australian Academy of Science (2008) have projected/predicted more or less drastic changes. Since sea level rise may be of more serious concern to coastal communities in Small Island States (SIDS) the potential socioeconomic impacts of sea level rise are the project's foci with regard to Grand Riviere.

A multidisciplinary methodological approach, i.e., the use of 2- and 3-dimensional (2D and 3D) sea level rise models as the basis for estimating socioeconomic impacts, was used in relation to the study site. The sea level rise model was comprised of primary and secondary spatial data including topographic and hydrographic data collected via field surveys, 1m aerial photography of Grande Riviere, and previously collected vector datasets such as contours, buildings, roads, property rights boundaries, coastline, river and vegetation. With the exception of the buildings dataset, which bears an accuracy of ±2m, the other datasets were found to be accurate to within ±5m. The hydrographic and topographic data have horizontal accuracies of ±0.02m and vertical accuracies of ±0.20m.

This paper focuses on the property rights dataset that was scanned from an index map. The concern is whether the method of the dataset's creation and the dataset's resulting accuracy would impact any mitigation or adaptation strategy developed to address the threat of sea level rise to property rights in the community of Grande Riviere, or in similar communities.

2. SEA LEVEL RISE MODEL RESULTS

Some of the sea level rise impact visualizations are illustrated in Figures 1 to 4. It can be noted that even in the scenario visualizing Mean Sea Level (MSL) (Figure 1) the property boundaries seem to be misaligned with other coastal features, and significantly intersects the MSL landward boundary. Figures 2 to 4 show the intersection of the property boundary layer with sea level rise projected at 0.4m, 0.6m and 0.8m above MSL. Assuming that the other datasets are accurately collected and processed, any assessment of the impacts of sea level rise on property rights would require an investigation of the relative position of the boundaries to the position of the encroaching sea and an examination of the legal principles that will be used as sea level rises.

Figure 1: Simulated MSL (blue polygon) at Grande Riviere Beach

Figure 2: Simulated 0.4m above MSL at Grande Riviere Beach

Figure 3: Simulated 0.6m above MSL at Grande Riviere Beach

Figure 4: Simulated 0.8m above MSL at Grande Riviere Beach

3. ASSESSING THE ACCURACY OF THE CADASTRAL DATA

To determine the conclusions that can be drawn from the results of this study as it applies to land tenure, the precision of the cadastral dataset and its relative precision with respect to the other datasets used must first be examined.

The cadastral data used for this study were originally prepared as an index where the topology was adequate for locating the parcel and its reference codes and thus gaining access to the more accurate survey plans. The index at 1:10,000 scale was scanned and vectorised to obtain the dataset and therefore the data contain an inherent positional error. The data were then shifted from the UTM grid based on the Naparima datum on which the index was constructed to the UTM grid based on the WGS 84 datum. This shift also contributes to the positional error in the data. This 1:10,000 scale data is here being compared with 1:2500 scale topographic data.

The result of the accumulation of the several factors that produce the displacement of the cadastral lines from the visible position of the physical features can be determined by computing an accuracy statement for the cadastral data.

The National Standard for Spatial Data Accuracy (NSSDA) of the United States Geological Surveys (USGS) was used to compute an accuracy statement for the cadastral data. The statistical testing methodology outlined in this standard (FDGC 1998) was used to determine the accuracy of the data. Twenty points were chosen at random from the cadastral data as specified by the standard. The equivalent points were coordinated on the digital topographic map which was used as the independent source of higher accuracy. These points had to be well defined points identifiable on both the map and the ground. This is especially difficult for cadastral data since boundary points are intangible, theoretical entities. The sample was taken from the area of Port of Spain, as shown in Figure 5, since the details could be found that could be located on both the cadastral sheet and the topographic data and in many instances the physical extent of the buildings corresponded with the boundary location. In more rural areas it would be difficult to obtain cadastral points that could also be identified on the topographic area or could be assumed to be close to or equivalent to the cadastral points. There was good alignment of the cadastral data to the topographic data in this area as shown in Figure 6.

The digital cadastral map area was segmented into four quadrants and five points were selected from each quadrant as shown in Figure 5. In this way it was ensured that the accuracy statement would prove valid for the map area selected.

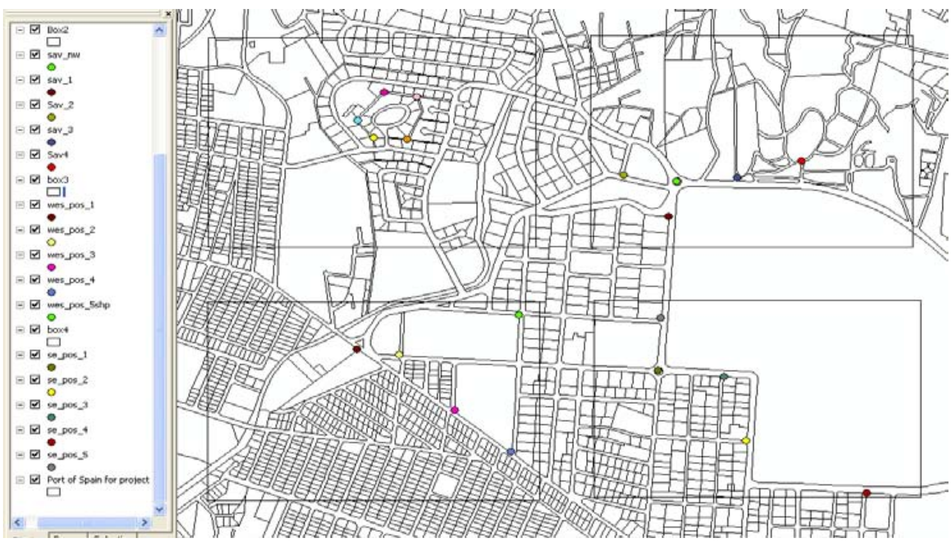

Figure 5. Points selected for comparison with topographic data

The results indicated that the RSME in the x direction was 2.18 m and in the y direction 2.43m. The NSSDA standard specifies that if $RMSE_x \neq RMSE_y$ and the $RMSE_{min}$ /$RMSE_{max}$ lies between 0.6 and 1.0m (where $RMSE_{min}$ is the smaller of the two and $RMSE_{max}$ is the larger of the two values) then the circular standard deviation may be approximated from the equation:

$RMSE_r \approx 0.5(RMSE_x + RMSE_y)$ and

$Accuracy_r \approx 2.4477*0.5(RMSE_x + RMSE_y)$

The final accuracy statement for the cadastral map in that particular test area, which should be tested in other areas as well, is therefore 5.64m at the 95% confidence level. Therefore, 95% of the points in the area test are predicted to fall within 5.64 m from its coordinated position. The particular area at Grande Riviere should also be tested to determine the equivalent accuracy for that area.

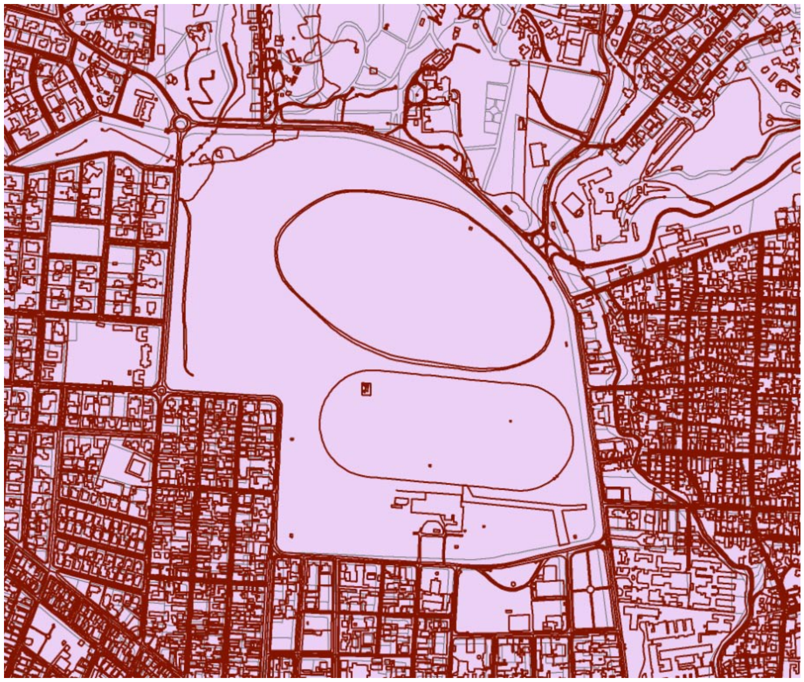
Figure 6. Port of Spain cadastral data superimposed on topo data

4. ASSESSING THE POTENTIAL IMPACT ON TENURE

The effect of the sea level rise on the area of land parcels is directly related to the slope of the profile of the coastal area if shown in cross section. A shallower grade of slope will therefore result in a larger area of impact than would a steeply rising coastline. The minimal impact of the sea level rise in this area can therefore not be taken to be typical of the impact in other areas of Trinidad and Tobago and elsewhere where the slope of the coastline is shallower.

Typically, cadastral lines, being intangible, identify abstract legal positions. They therefore do not necessary exactly relate to the location of physical features constructed or identified to represent them. For example, a road constructed within the road reserve allocated for its construction would not fill the entire road reserve. Roadways sometime develop along paths used over time and therefore bear no relation to the legal position. Property boundaries tend to be constructed closer to their designated legal positions but if precision is required, redefinition surveys would be required to be performed.

Legally, it is acknowledged internationally that riparian and littoral boundaries, being ambulatory boundaries, allow for change in ownership where the change in the boundary is slow and imperceptible and also a natural occurrence. Sea level rise is a slow and imperceptible occurrence and considered to be of natural origin. The loss of land will be gradual but may still affect the landholders drastically. As beaches will be affected, conflicts over access to beaches and encroachment of beachgoers on private property will escalate. Therefore, even though the issue may be thought to be one of private loss of land, since it will affect the public at large, actions must be planned at the level of the state to deal with the potential impacts.

5. CONCLUSIONS

The spatial impact of potential sea level rise can be predicted using models based on existing map data. Models were applied to the Grande Riviere coastal area to predict the impact of sea level rise to 0.4, 0.6, and 0.8 m above mean sea level. These impacts are specific to the area modelled as the topography of the coastal area greatly influences the horizontal distance of incursion of the sea as the level rises. The impact on the land tenure, however, must depend on the current cadastral data. These cadastral data were originally compiled as an index so spatial precision was not a priority. The actual accuracy can be computed for various areas to produce an accuracy statement either generally for the map based on an average accuracy determined from urban and rural areas or specifically by location or tile extent. An accuracy statement was computed for a Port of Spain sample area using the specifications of the Federal Geographic Data Committee Geospatial Positioning Accuracy Standards that pertain to digital data. This standard is called the National Standard for Spatial Data Accuracy. According to the standard, and based on the computations done for the sample area, the following statement may be used for the sample set:

Tested 5.64m horizontal accuracy at 95% confidence level.

This level of accuracy is within the depth of a typical parcel so is adequate for determining how badly the parcel will be encroached on. However, while this accuracy pertained to the dataset sampled, it is expected, from observation that the accuracy for the study area of Grande Riviere is far lower than this. This will impact on whether the first layer of coastal parcels alone can be anticipated to be affected or whether the second layer of parcels will also be encroached on. Legally, the slow and natural movement of the high water boundary will result in loss of rights of the coastal owner. The impact however, will not be limited to the private owner but also extend to access to the beaches for fisherfolk and beachgoers.

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