Tide Coordinated Shorelines in Delineating Between Legal Boundaries and Determining National Maritime Zones

Chibueze Ojiako, Mitchell Eboigbe and Emmanuel Ajie

Abstract-Boundary disputes especially along the coastal regions are now a global phenomenon. African is no exception as there are presently disputes along the maritime zones, between states within a country and most especially in areas with massive coastal flooding. There is no effective Land administration and control without a definite definition of the respective maritime zones. Information derived from shoreline management and monitoring is vital for delineating boundaries between legal properties and monitoring of the regular changes as caused by coastal flooding. This study therefore evaluates the use of Geospatial Data Techniques in shoreline change detection. The study area is the Buck Mill in Devon, United Kingdom. Emphasis is on tide-coordinated shorelines using the Global Positioning System (GPS), the Light Detection and Ranging (LIDAR) and the Ordinance survey master map 1:10,000 scale showing the study area. Changes along this shoreline were ascertained from variations on the mean low water observed for four different years. The software used is the ArcGIS 10.1 and Hardware is Pentium 4 among others. Both manual and semi automatic extraction techniques were used to extract the mean low water marks for these years. Results obtained are represented in form of charts, tables and digital maps. An evaluation of these results shows that the use of geospatial data technique is capable of constant monitoring of a coordinated tidal surface along the maritime zones. It is therefore recommended for an effective and complete land administration. It is also a sure means of protecting existing infrastructure from coastal flooding.

Index Terms: Effective Land Administration, Coordinated tidal surface, Maritime Zones.

1. INTRODUCTION

Coordinated tidal surface is very vital for determining fixed Legal properties (Liu et al 2011; Lee et al, 2011 and Li et al, 2012). It is also needed for effective and continuous monitoring and management of Maritime Zones (Li et al, 2012).. Recent studies by (Snoussi et al, 2009) has further elucidate the fact that the sea-level rise and changes on the coastal region are at risk to changes of about 4m to 11m which is enough to affect socio-economic activities. They also suggested a "GIS- based inundation" tied on digital tidal surface. In this study, charts showing the respective tidal heights along the sea for the years under review were downloaded from the United Kingdom hydrographic office online. Since the climatic conditions differ from one part of the world to another cum other physical activities, the Mean Low Water (MLW) is preferred for this study as previous research have shown that the Mean High Water (MHW) is likely to be more stable for rugged shorelines. LIDAR imageries were from the Channel Coast Observatory with Data Datum as: D_OSGB36 and prime meridian as Greenwich.GPS surveys and LIDAR imageries were relative to both the MHW and the MLW. Further referencing and visualization were achieved with the Digimap ordnance survey master map. The master map has a clear description of both the MHW and the MLW. Shorelines were extracted by manual digitizing of the LIDAR imageries. Manual digitizing from previous research has high degree of accuracy (Robertson et al, 2004; Li et al, 2012). LIDAR has very precise elevation measurements for shoreline delineation irrespective of the distance been considered (Zhang et al, 2003).

The results from this study are realistic for the monitoring of shorelines irrespective of any environmental problems and very useful for regular monitoring especially for such shorelines that stretches into hundreds of kilometres thereby reducing disputes from maritime zones.

1.1 The Study Area

The study area for this study is the Buck Mill shoreline in Devon, United Kingdom.

This shoreline is located around the woolfardisworthy towards the north coast of Devon, England. It is in south west England having geographical coordinates 50.9863^{0}N and 4.3418^{0}W. As with several other shorelines, there is accelerated sea-level rise which makes the sand dune very unpredictable. As with other shorelines, these environmental problems make shoreline definition very difficult. Consequently, it is pertinent to have a coordinated tidal surface which does not necessary depend on the actual physical surface of the terrain but more of a digital tide-coordinated (Li et al, 2002). This shoreline stretches over 65km from Brideford to Wadebridge.

1.2 The Mean Low Water (MLW)

In our previous studies, both the Mean High Water (MHW) and the Mean Low Water (MLW) has been ascertained to be a stable surface along the dune shorelines although the MHW is more stable for rugged terrains. But for the purpose of this study, the MLW surface will be adopted to boost the applicability of this methodology in most parts of the world. The Mean Low Water is the average of all daily low water level as observed for about nineteen years (Queensland Maritime Safety, 2013). This Mean Low Water is best controlled as constantly referenced to some controlled datum.

DATE	LOW TIDE	LOW TIDE
10-06-13	01:42 1.50m	13:53 1.50m
20-06-13	09:36 1.90m	22:07 1.80m
30-06-13	05:42 1.90m	18:04 2.20m
10-07-13	01:57 1.50m	14:07 1.50m
20-07-13	10:21 1.80m	22:54 1.50m
30-07-13	05:47 2.20m	18:12 2.50m
10-08-13	02:39 1.20m	14:50 1.20m
20-08-13		12:10 1.00m
30-08-13	07:02 3.00m	20:05 3.00m
10-09-13	03:22 1.30m	15:39 1.40m

Tab. 1.2 MLW at 10day interval for 3months

Data were downloaded from the Channel Coast Observatory. Data Datum is: D_OSGB36 with Prime Meridian as Greenwich. All Bathymetric and other ground surveys of which the LIDAR imageries were tied to are relative to the MHW and the MLW (Channel Coast Observatory). Further referencing and visualization were achieved with the Digimap ordnance survey master map. The master map has a clear description of both the MHW and the MLW.

1.3 LIDAR Data:

From the channel coastal observatory, the LIDAR data downloaded for 2008, 2009, 2010 and 2012 has the following attributes

- LIDAR Type: Profiles and Filtered
- Planar coordinate encoding – Row and Column
- Resolution of X axis 0.001
- Resolution of Y axis 0.001
- Planar distance units – meters
- LIDAR projection name- Traverse Mercator
- Grid coordinate system name UK National Grid (OSGB36 ODN)
- Scale factor at central meridian 0.999601272

- Longitude of central meridian - 0.034906585
- Latitude of projection origin 0.855211333
- Horizontal datum name OSGB36
- Ellipsoid name AIRY
- Semi-major axis 0.855211333
- Denominator of flattening ratio 299.3249646
- Depth datum name Ordnance Datum Newlyn
- Depth resolution 0.001
- Depth distance units' metres
- Depth encoding method row and column

1.4 Master Map

References were made to the master map 1:10,000 scale raster downloaded from the digimap Ordnance survey. The MHW and MLW of these maps were manually digitized.

2.0 METHODOLOGY

2.1 Matching of the UK Master Map, GPS Data and the LIDAR for all four years to ascertain the correctness of Heights as gotten from the Hydrographic office

After calibration of the GPS, all field data were superimposed with the UK master map to ascertain the nearness of the XYZ coordinates especially the heights recorded by the hydrographic office. This was also carried out to verify the actual strip of the MLW on the LIDAR imagery. Despite the difference in years, variations were negligible

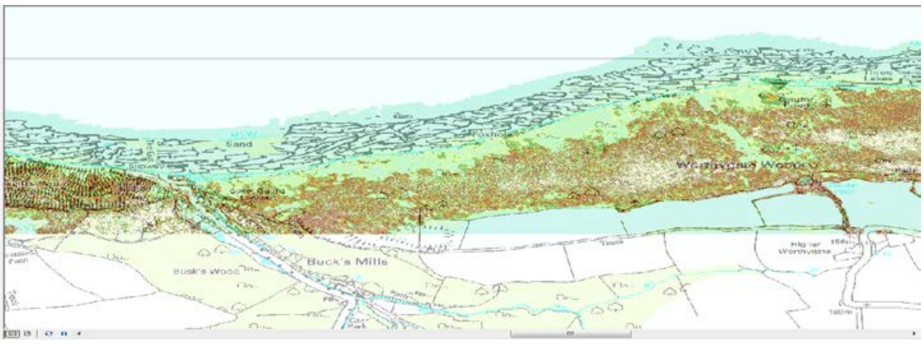

Fig. 2.1 UK Master Map + LIDAR imagery+ GPS Field Reading.

2.2. Extraction of the Mean Low Water from LIDAR Imageries of 2008, 2009, 2010 and 2012.

Digitizing was carried out on ARCGIS10.1 since the elevation of the LIDAR was fixed to achieve accurate delineation of a defined water height; it was difficult and time consuming to digitize LIDAR when the resolution of the image is increased to a very large scale such as 1: 100. But for better results, it is worth doing. An example is shown below of one of the LIDAR scale increased

Fig. 2.2.1 Scale Increased to 1:100 to enhance accuracy when digitizing

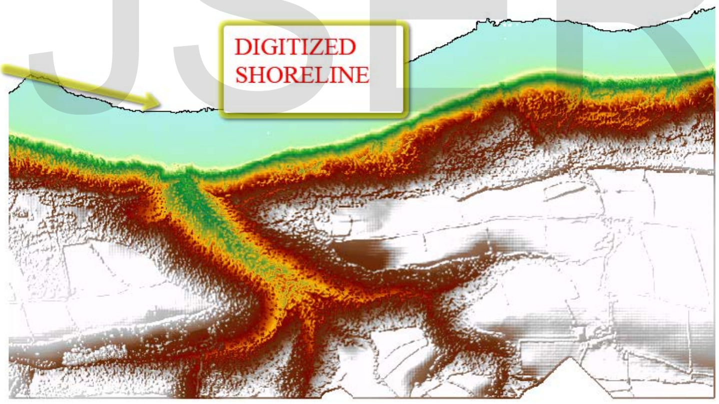

Fig. 2.2.2 Digitized Shoreline for 2008 LIDAR

2.3 Generation of Contours from LIDAR:

Contours were generated from all LIDAR imageries using the ArcGIS 10.1 at 2m contour interval. Since the MLW have already been ascertained as discussed in **2.1,** by compares made on;

- The UK master map
- GPS field readings
- Tidal heights from UK hydrographic office

The contours generated from the LIDAR imageries for all four years under consideration were superimpose on the digitized MLW to ascertain if the heights from the LIDAR corresponds with the former. The result of this is shown below:

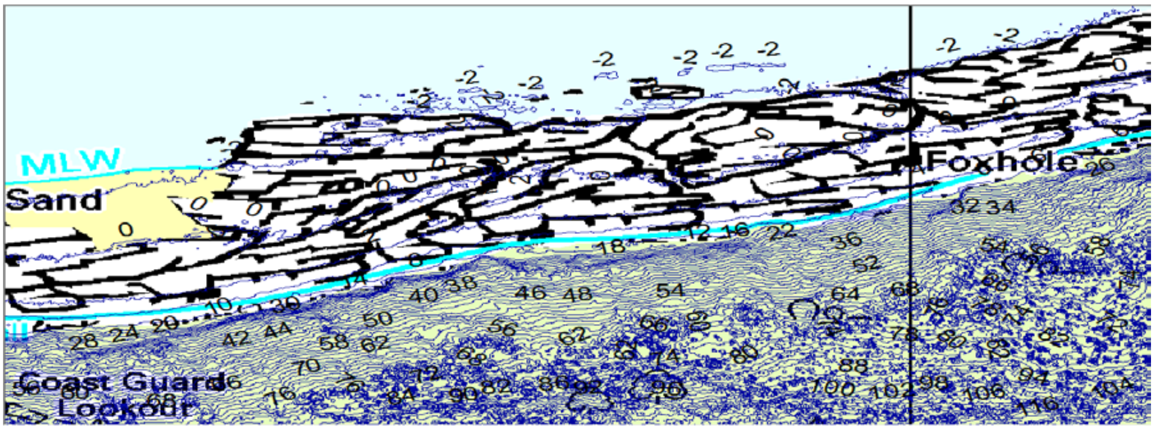

Fig 2.3.1 2008 LIDAR

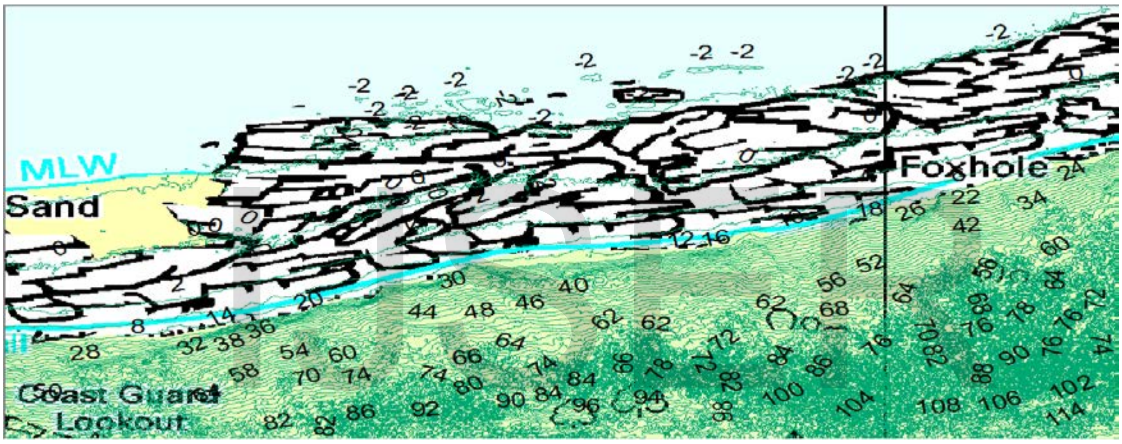

Fig 2.3.2 2009 LIDAR

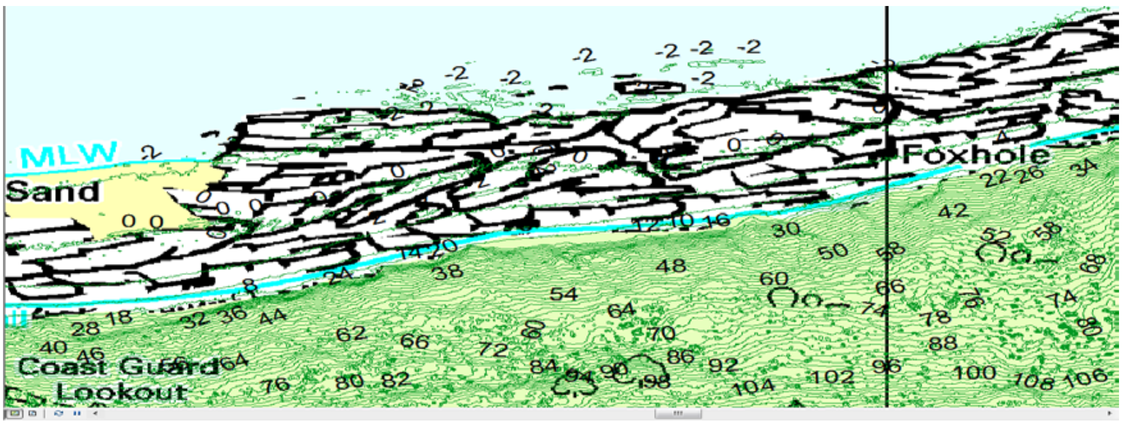

Fig. 2.3.3 2010 LIDAR

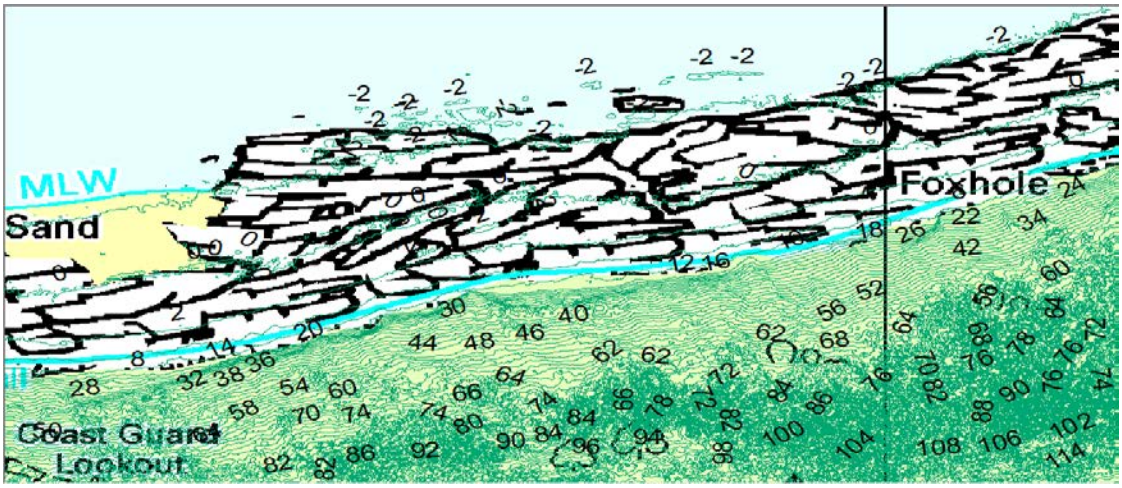

Fig. 2.3.4 2012 LIDAR

3.0 DISCUSSION OF RESULTS

This study shows that it is very possible to generate and monitor tide-coordinated shorelines. This is necessary without actual marks on the ground especially in terrains were there are severe environmental problems. This technique is not limited to length or size of the maritime zone only that it requires excellent geospatial techniques. Here, the LIDAR was used to generate contours, but contemporary studies have even suggested that DTM's can as well be gotten from other imageries not limited to satellite or aerial. Locally, DTM's can even be generated from drones making this technique cheap and realistic. This will be discussed in our future presentations. According to (Boak and Turner, 2005) "the remaining challenge is to improve the quantitative and process-based understanding of those shoreline indicator features and their spatial relationship relative to the physical land water boundary". This statement is correct as there can never be any meaningful evaluation of shoreline changes without **indicators.** The indicators here are the control points whose coordinates are fixed. The relevance of the Digital-tide indicators and the need for GPS controls along the shoreline is also reiterated by Elkoushy and Tolba, 2004. Even without ground thruthing or ground surveys, this study also carefully evaluates the reliability of the respective water surface used as base line for determining changes along this shoreline. Results therefore obtained are described as reliable and the conclusions herein are therefore viable.

Digital images not only provide for an accurate measurements and delineation of the shoreline, it is also very vital for visual inventorying and interpretation of the shoreline (Niu et al, 2003). Apart from the resolution propensities of the LIDAR, it is also better in combating with weather conditions. This again makes it better and easier to extract changes using the manual digitizing. Other advantages over the conventional field survey methods is that it saves time, irrespective of any physical challenge and the ability to periodically monitor tidal changes with high accuracy and precision.

4.0 CONCLUSION

From the above discussion and analysis carried out in this study, the following conclusion can be deduced:

- Tide coordinated shorelines are capable of delineating between legal boundaries along the shoreline.
- Tide coordinated shorelines are most appropriate for shoreline data management
- Manual digitizing of shoreline gives good results but it is very hectic, time consuming and needs plenty of carefulness when digitizing
- With fixed reference system and XYZ coordinates, any tidal surface which delineates between two or more maritime zones can be successfully monitored.
- Digital tide coordinated shorelines are irrespective of length and size.
- Over the four years of this study, the MLW remained almost constant. This is an indication that the MLW hardly changes along the dune shorelines.

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