Innovative ways to identify and communicate erosion hot-spots, Scotland - UK

1. Policy Objective & Theme

- ADAPTATION TO RISK: Managing impacts of climate change and safeguarding resilience of coasts/coastal systems
- SUSTAINABLE USE OF RESOURCES: Preserving coastal environment (its functioning and integrity) to share space

2. Key Approaches

- Participation
- Knowledge-based
- Technical

3. Experiences that can be exchanged

A repeatable methodology has been demonstrated which facilitates the identification of beach and dune areas that are particularly susceptible to the effects of coastal erosion, to determine whether there is erosion or accretion of the soft coast, and to quantify how much gain or loss (+ve or –ve change) has been occurring.

4. Overview of the case

Comparisons have been made using archival pan-chromatic and colour aerial photography taken with a separation of 10-20 years between them. Using photogrammetry and GIS, an easily understandable, 3D visualisation of erosion and accretion was produced showing erosion hot-spots and vulnerable, coastal areas.

5. Context and Objectives

a) Context

One of the potential impacts of climate change, sea level rise and increased storm frequency and intensity, is increasing coastal erosion. Identifying areas of the coast that are the most vulnerable to coastal erosion (both wind and wave dominated), where such changes are occurring, and quantifying this change is becoming increasingly important, particularly along the soft coastlines. In Scotland, Scottish Natural Heritage is particularly interested in developing new ways to monitor and map coastal change in order to identify erosion hotspots. Furthermore, they are keen to find innovative ways to visualise the potential impacts of coastal change as the means to communicate information to a wider audience e.g. local communities about the changes occurring at the coast as a way to raise awareness and educate people about the impacts of climate change at the coast

b) Objectives

The overall goal of the work was to provide a practical means by which it was possible to monitor and map coastal change over time, and to provide a basis for demonstrating the practical role of remote sensing, Geographical Information Systems (GIS), and digital photogrammetry. In addition, the work formed the basis for future monitoring studies using LIDAR data and imagery.

6. Implementation of the ICZM Approach (i.e. management, tools, resources)

a) Management

Aberdeen Institute for Coastal Science and Management (AICSM) at the University of Aberdeen conducted the work on behalf of Scottish Natural Heritage.

b) ICZM tools

Archival pan-chromatic and colour aerial photography was acquired for seven beach areas in the North East and North of Scotland identified by Scottish Natural Heritage (SNH). These areas were deemed to be ones where change was most likely based upon expert knowledge and fieldwork. At least two sets of aerial photography were acquired for each site, with ideally a temporal separation of twenty years between them. In some cases this was not possible and a ten year interval was accepted.

In order to use photogrammetric techniques it is also necessary to obtain ground control. Each site was visited and a network of ground control points was measured using two Global Positioning Systems, a Fugro Omnistar HP Differential system, and a Trimble 5800 Real Time Kinematic system. This is a time consuming process and one that is further complicated by the relative inaccessibility of some sites. Furthermore, although a straightforward process, the photogrammetric derivation of the topographic contours and Digital Terrain Models (DTMs) relies on the tonal quality of the original aerial photographs, easily identifiable ground control points, and the ease with which such points can be found in coastal areas; areas where stable features such as roads, field boundaries, and buildings are often scarce.

Digital photogrammetric techniques were used to derive DTMs for each date of photography and each site. Specialist photogrammetric software (Erdas Imagine and BAE SocetSet) and hardware (stereoscopic glasses and screen) were used to derive and edit the DTMs. The DTMs were input to the ESRI ArcGIS GIS software for further processing and analysis.

By subtracting the two multi-temporal DTM grids from each other for each site it was possible to identify where change in the topographic height of the land had changed from one date to the next, and by how much. It was therefore possible to generate a map of change showing where the beach and dune areas had been eroded (negative or loss of sand), where accretion (positive or gain of sand) had taken place, and areas which had remained stable. Using ArcGIS, maps showing the coastal change for each beach area were created, and colour coded using a traffic light system (green, amber, red) for ease of communication and interpretation. Green areas showed areas of gain, amber no change, and red erosion. The resulting change maps were then superimposed onto a DTM to provide a 3D visualisation of the beach area, as well as the possibility to generate a fly-through of the areas.
These were captured in a video format and used as a visual communication tool for public awareness and education to reveal change at the coast.

7. Cost and resources

The funding for the work was approximately £40,000.

8. Effectiveness (i.e. were the foreseen goals/objectives of the work reached?)

The development of user-friendly visualisations provides a basis with which to communicate information results about what is a relatively complicated and sophisticated process and analytical procedure to a wider audience which is then easier to understand and can be used in the context of raising awareness and education.

9. Success and Fail factors

Some inevitable and recognised limitations to the approach proposed arose because of the different sources of aerial photographs uses, different formats available (paper print, diapositive, digital), different scales flown (although most were around 1:10,000), different quality of the prints (prints vary in their quality and condition, and degradation can occur following scanning of the information content), availability of the camera calibration data, and spatial coverage of the overflights. It must be remembered that many studies based on archival imagery are using photographs that were not flown for the current use.

10. Unforeseen outcomes

None so far.

11. Prepared by

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12. Verified by

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13. Sources

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- Terrain 3D Modelling for the Assessment of Coastal Change in Beach and Dune Systems in Scotland (2009) C. Gomez, A. Taylor, D. Green, W. Ritchie, A. Dawson and R. Wright. Society of Cartographers. Bulletin. No. 42:19-26 [not electronically available]