Dynamic systems: Modelling the coastal environment

Coasts provide us with a wide variety of vital resources and services. They support our fisheries and tourism industries, and play an important role in the cycles that affect the climate and environment. They have also historically served as our links to other parts of the globe, allowing us to trade and interact with those previously beyond our reach, which has shaped our societies into those we live in today.

The coastline is dynamic and ever-changing. It is governed and shaped by a wide range of physical processes and forces. Therefore, while these areas provide great support to a nation’s society and economy, there are great risks associated with coastal development that should be considered heavily during investment and planning.

Modelling is a significant method of visualising the processes at play in the coastal environment. Dr Andres Payo of the British Geological Survey is currently working on developing such models and tools to help stakeholders anticipate coastal change so that they can make informed decisions during development and allow us to continue using the vital resources the coasts provide in a sustainable manner.

ENERGETIC ENVIRONMENTS

Energy levels can vary widely at different parts of the coast, from relatively calm beaches encased in bays to rocky cliffs exposed to the harsh conditions of the open sea. It is this energy that moulds the landscape — coasts facing high levels of energy endure high levels of erosion from powerful waves, while low-energy coasts experience low-power waves and thus face little erosion. Landforms such as wave-cut platforms and headlands can be common on high-energy coasts, forming through wave action and the geology of the area. Cliffs are rarely uniform in terms of their geology, typically constituting layers of different types of rock that erode with varying levels of ease. Softer types of rock may be eaten away by wave action, leaving protrusions of harder rock extending into the sea.

The numerous processes that shape the land of the coastal environment take place at a range of time-scales that ultimately change the morphology of the coastline at different rates. Waves and tides move sediment instantaneously, while large-scale morphological change may not be notable for decades or centuries. Despite their dynamic and ever-changing nature, humans have settled near coasts for millennia owing to the resources and services they provide, including the easy transport of goods across the seas and the bountiful produce that supports easy transport of goods across the seas and the bountiful produce that supports.

The development of infrastructure is at risk against them. Developers and stakeholders are likely to focus on protecting and maintaining their existing assets, which hinders expansion into more sustainable methods. Therefore, they will face the ever-increasing cost of continually responding to the extreme events that are expected to occur as the climate changes, instead of developing a resilient community that can adapt to the challenges of the future environment. This has already been observed in the use of “hard” approaches to erosion, which are short-term and, as stated above, are likely to delay or relocate the problems they were implemented to solve. These methods are expensive to implement and maintain, which, along with the environmental issues they contribute...
The team observed and simulated 16 years (1999 to 2015) of erosion at Happisburgh.

MODELLING THE FUTURE

Models are extremely useful tools for examining processes and systems which occur over large spatial and temporal scales that we cannot directly observe. They can be used to simulate future scenarios and ultimately inform decision makers and stakeholders during investment, planning and construction; models are vital for sustainable development. Dr Payo’s work focuses on coastal system models which simulate and predict processes such as waves, tides, hydraulics and sediment conservation. He uses these models to inform investors of likely geomorphological change over the upcoming decades so that it may be considered during the development of coastal infrastructure.

Four main types of models are applied to coastal systems, which include conceptual, physical, numerical and statistical methods. Each of these modelling methods has its own advantages and disadvantages when they are applied to a coastal system, yet all four are vital in research. Conceptual models represent a system based on its key components, and while they are useful for visualising the processes that occur in their respective system, they cannot predict the changes caused by these processes within a location or time-scale. Physical models are recreations of processes and systems at an observable scale (for example, they may include small scale-versions of large-scale systems), and allow the observation of events that cannot be modelled in other manners. However, differences between the scale of the modelled and actual systems may affect the results. Numerical models can easily and cheaply simulate changes in a coastal system due to storm events. However, they are less adept at modelling slow changes under non-storm conditions. Finally, statistical models build on data from the past to identify and assume trends and cycles that can then be used to forecast future conditions. However, the coastal system is dynamic and ever-changing, and the future may not necessarily follow the patterns of the past.

Combining different types of modelling approaches may be a more prudent method of forecasting system-wide coastal change which is vital for informing developers exploring sustainable development and intervention strategies. Dr Payo’s modelling tool, CoastalME, can simulate the geomorphological change of a coastline over several decades while considering interactions between different landforms and human activity. This work is fundamental if we are to continue sustainably using the resources that coastal environments offer us.

This work is fundamental if we are to continue sustainably using the resources that coastal environments offer us.