Climate Change and geomorphology:- implications for the Sefton Coast

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What is Climate Change?

The term “climate change” refers to the variation in the Earth's global climate or regional climates over time. It describes changes in the variability or average state of the atmosphere - or average weather - over time scales ranging from decades to millions of years. These changes may come from natural processes, be driven by external forces or, more recently, be caused by human activities (Wikipedia, 2006). It is commonly incorrectly used interchangeably with "global warming" and "the greenhouse effect". The greenhouse effect is the process by which an atmosphere warms a planet while global warming refers to the increase in the temperature of the atmosphere of the earths oceans, contributed to by the greenhouse effect. These changes have occurred through natural processes in the past and are still occurring as a result of natural processes but mans activities have now contributed to these changes leading to concern over the future implications. The future effects of climate change include changes in rainfall patterns, sea level rise, potential droughts, habitat loss, and heat stress.

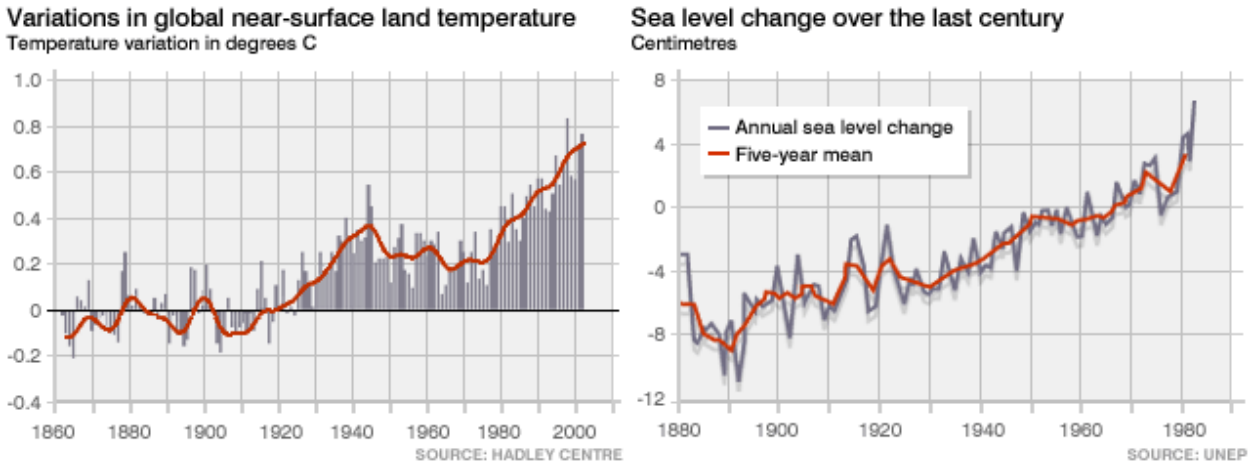
Evidence of human influenced climate change

The earth’s climate is constantly changing, however, some of the changes seen during the latter part of the twentieth century cannot be explained by natural variations alone. Reducing global greenhouse-gas emissions could play an important role in mitigating climate change in the second half of the century. However, the time delay inherent in the atmosphere and oceans means that action needs to be taken now to achieve that.

Evidence of climate change

- The average rate of sea level rise during the last century around the UK coastline, after adjustment for natural land movements, has been approximately 1 mm per year. The global average for the past century is believed to be between 10-20cm.
- Global temperature has risen by about 0.6ºC since 1900 with 0.4ºC of this since the 1970s.
- Central England’s average temperature rose by almost 1ºC through the twentieth century.
- The last decade has seen an increase in gale frequency in the UK, this increase is not unprecedented in the historic record.
- Hot summer days with daytime temperature in central England exceeding 25ºC have become more common.
- The UK’s thermal growing season for plants is now longer than at any time since the start of the record in 1772 by about one month.
- Over the last half-century, night-time temperatures have increased over many land areas at about twice the rate of day-time temperatures.
- Winters across the UK have been getting wetter, with a larger proportion of the precipitation falling in the heaviest downpours, while summers have been getting slightly drier.

(Hulme *et al*, 2002)



Images taken from www.bbc.co.uk

The UK Government set up in April 1997 the UK Climate Impacts Programme (UKCIP). UKCIP works with stakeholders and co-ordinates research on how climate change will have an impact at regional and national levels. UKCIP provides support and guidance throughout the process for both stakeholders and researchers, and provides a bridge between researchers and decision-makers in government organisations and business.

Climate change scenarios

The UKCIP (www.ukcip.org.uk) has produced a series of potential climate change scenarios, which run until 2080, based on four different global emission rates. Low; Medium low; Medium high and High. However, there are a large number of uncertainties associated with predicting the outcomes of the scenarios. The two main uncertainties relate to the emissions and scientific understanding. It is unknown how the global emission patterns will continue into the next century and scientific knowledge and modelling about the sensitivity of how the global climate will continue to react and change is limited.

Predicted Climate Changes

- Average annual temperatures across the UK may rise by between 2ºC and 3.5ºC by the 2080s, depending on the scenario.
- In general, there will be greater warming in the south east than in the northwest of the UK.
- There may be more warming in summer and autumn than in winter and spring.
- The temperature of UK coastal waters will increase, although not as rapidly as over land, with again the greatest warming in the south.
- By the 2050s, typical spring temperatures may occur between one and three weeks earlier than at present and the onset of present winter temperatures may be delayed by between one and three weeks.
- Global-average sea level may rise by between 7 and 36 cm by the 2050s, and by between 9 and 69 cm by the 2080s.
- Relative sea level (including the effect of land movements) will continue to rise around most of the UK shoreline, the rate depending on region and scenario.
- Extreme sea levels, occurring through combinations of high tides, sea-level rise and changes in winds, will be experienced more frequently in many coastal locations.
- Sea level rise may also lead to deeper water in the near-shore zone allowing waves with greater energy to reach the shoreline.
- By altering the shape of many estuaries, rising tides will interfere with the marine processes that cycle sediment and maintain salt marshes.
- Rising sea levels will cause widespread erosion of coastal habitats such as salt marshes, sand dunes and vegetated shingle, especially where hard defences are maintained behind these coastal habitats (commonly termed coastal squeeze).
- Winter precipitation will increase for all periods and for all scenarios. For summer, the pattern is reversed and almost the whole of the UK may become drier.

(Hulme *et al*, 2002)

What is geomorphology?

Geomorphology is the branch of geology that is concerned with the structure, origin and development of the topographical features of the earth's crust. In simple terms for the coast: how do sand-dunes, beaches, salt marshes, estuaries etc form and develop?

Natural coastal geomorphological processes

This is a collective term covering the action of natural forces on the shoreline, and the nearshore seabed. The natural processes that shape the coast are those forces such as wind, waves, tides and currents. Coastal processes are important because they can determine the past and future evolution of a coastline (Green and King, 2003). By understanding the processes and how the coast has evolved under those processes we can begin to predict how the coast might evolve under these processes. However, the interaction of these processes with the coast forms a very complex system and in constant flux so predicting coastline evolution is difficult. The coast is continually changing, and the process of erosion and accretion are part of the natural tendency of the coast to find an equilibrium with the processes. Understanding the system is further hampered by human interaction, directly or indirectly, with the coastal processes.

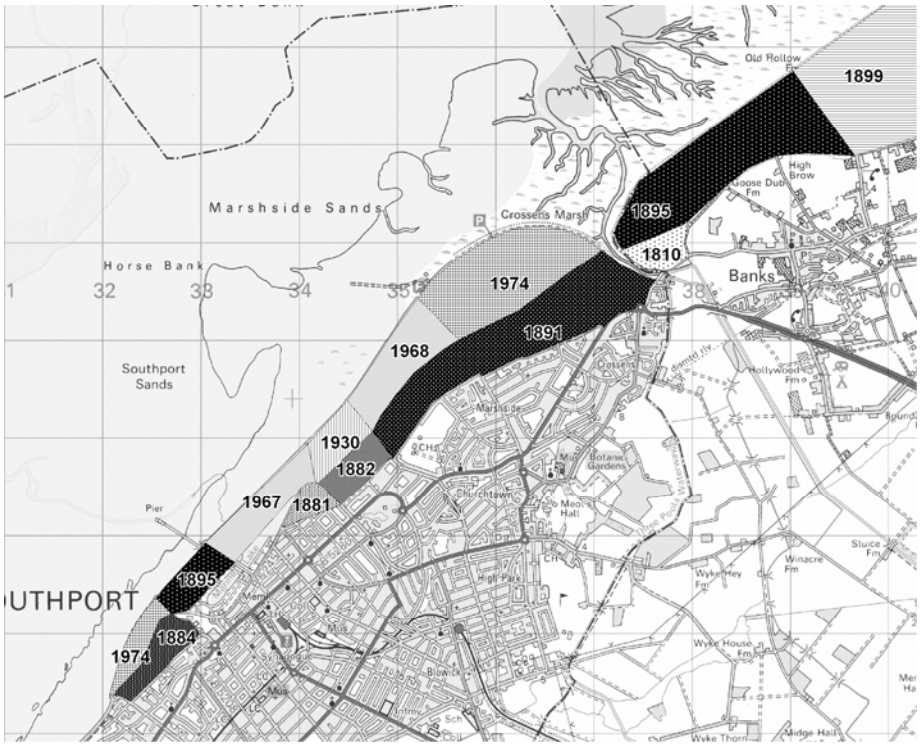
Natural processes	**Man-made influences**
Wind	Oil and gas
Tides	Wind farms
Waves	Channel training
Currents	Dredging and dumping
Biogenic	Aggregate extraction
Estuarine	Climate change
Vegetation succession	Land reclamation
Other biogenic	Sand extraction
Precipitation	Farming
Sunshine	Recreation
	Waste tipping
	Urbanisation
	Coastal defences
	Forestation

Natural Processes do not follow strict rules and are difficult to predict. They do demonstrate some seasonal cycles and long term trends. As a result of this their impacts can be episodic with periods of little or no change followed by times of intense activity, most obviously during storms (Coates *et al*, 2000).

Recent evolution of the Sefton Coast

Southport

The evolution of the coast at Southport has been dominated by the development of the town and the influence of the Ribble Estuary. Southport was built on reclaimed land that was once within the Ribble estuary. “South Port” was developed as a bathing resort in the early nineteenth century. Hotels were built close to the sea and in 1835 a promenade and sea wall were built to protect property. As the sea receded further it was relatively easy to excavate the first Marine Lake and later, in 1895, to enclose its seaward edge with a Marine Drive. The Drive was below the level of spring tides, so the Lake was refilled by high tides and over-flowed naturally onto the shore when full.



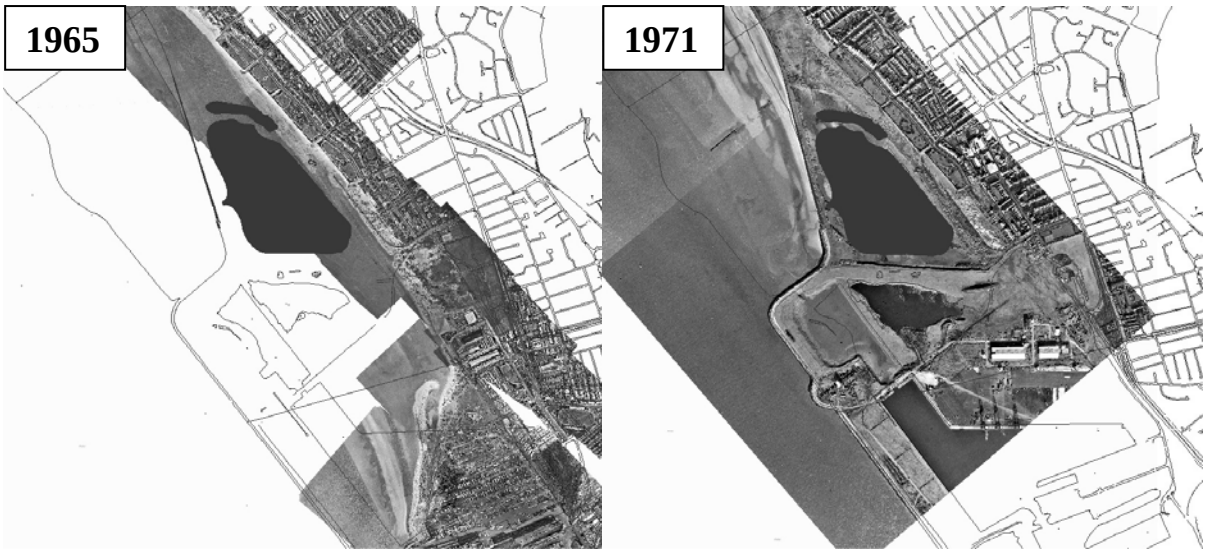
Plan of Southport’s reclamation.

The Marine Lake of 1887 did not extend beyond the Pier (1860) but was such a success that a further lake and park were joined in 1895. In the 1960s the lake was again extended north to Fairway. Until 1998, the central part of Marine Drive was still at its original low level and was frequently closed during periods of high tides. A new sea wall and promenade, completed in 1998, removed the need for road closures and facilitated the re-development of the seafront.

Crosby

The foreshore at Crosby was originally a natural foreshore with sand dunes on the northeast side of the Mersey Estuary. In the early 19th Century terraces of seafront villas were built at Waterloo (Marine Terrace) and Brighton-le-Sands (Mersey Road). In the 1930’s public gardens were built between Great Georges Road and Harbord Road. Gladstone Dock (1912), Royal Seaforth Dock (1972) and Crosby Marine Park (1973) occupy land reclaimed from the shore and protected by sea walls.

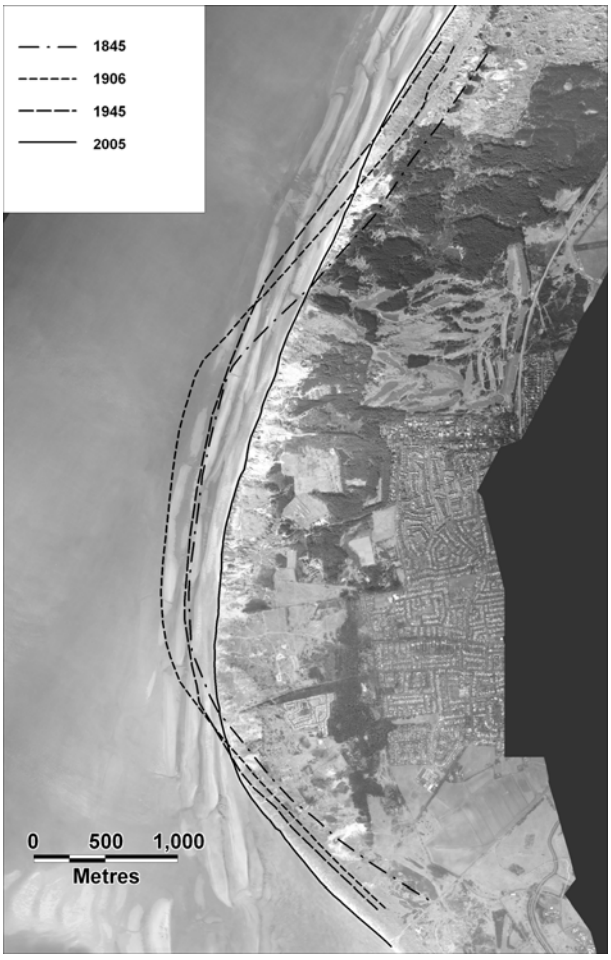
North of Mariners Road, the foreshore was very much under the influence of the River Alt. Severe erosion became a problem at Blundellsands from about 1910 as the River Alt migrated southwards along the coastline and all the houses on the seaward side of Burbo Bank Road were abandoned. The erosion was finally brought under control after the completion in 1937 of the River Alt training wall.



Crosby Marine Lake development: left image 1965 pre development, right image 1971 during development. Shown with 2004 OS1:1250 base map

Formby Point

Dunes are a dynamic, but fragile coastal landform. The changes brought about by the natural processes are rarely gradual or predictable, rather they are episodic, with periods of little or no change followed by times of intense activity, most obviously during storms (Coates *et al*, 2000).



The present sand dune system dates from between 1400 AD and 1600 AD, previous dune systems having been destroyed during periods of coastal instability.

During the 1800's there was a period of accretion especially around Formby Point. After 1900, erosion began to set in near Victoria Road. However, the erosion was progressive over a widening front and continued throughout the 20th century. At present the shoreline is eroding between Lifeboat Road and the Freshfield / Ainsdale boundary.

The geographic limits of erosion at any time vary according to the ever-changing influence of wind, waves and tides. Accretion generally occurs along the Rifle Range dune front and from Ainsdale north into the Ribble Estuary. Since the turn of the 20th century the action of coastal erosion in this section has blunted the northern apex of Formby Point. Thus a straighter coastline replaced the more angular form that existed in the early part of the 20th century. By the end of the 20th century the change between accretion and erosion fluctuated between Fisherman's Path and the Freshfield/Ainsdale boundary.

The following distances taken at Victoria Road give an indication of the amount of change.

- 1845 to 1906: 235 metres accretion
- 1906 to 1945: 190 metres loss
- 1945 to 2005: 310 metres loss
- 2005 to urban area: 900 metres

The implications of Climate Change

There are a large number of uncertainties associated with predicting the outcomes of the scenarios. The first of these uncertainties can be thought of as a consequence of the many possible paths that future society may follow, or emissions uncertainty; the second can be thought of as uncertainty about our understanding of how the climate system works, or scientific uncertainty.

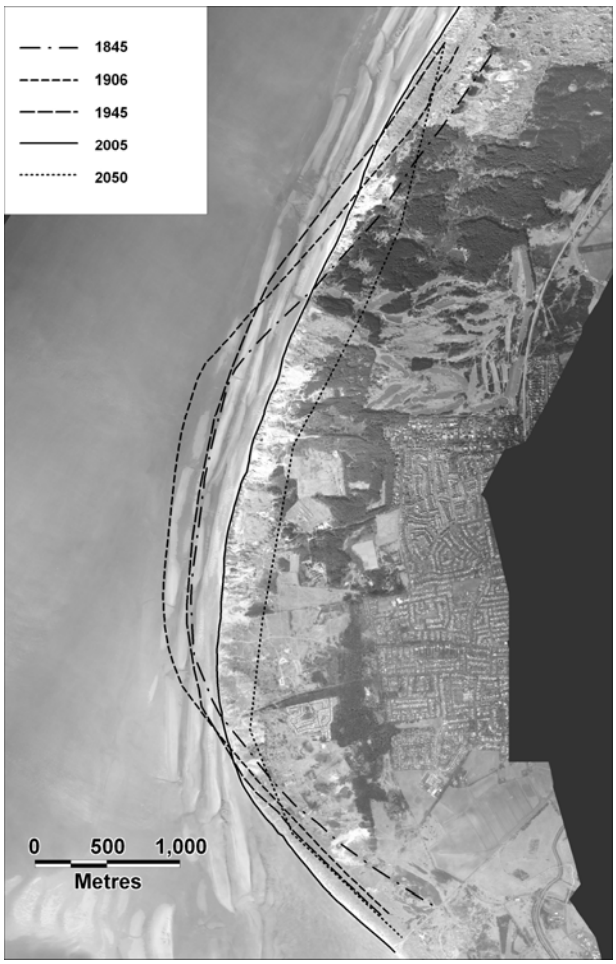
Salt marsh

Salt marsh is currently accreting at Southport and in the Ribble Estuary. The salt marsh provides an important coastal defence by absorbing wave energy and helping elevate the foreshore by trapping sediment. The majority of the salt marsh in the estuary has a fixed rear boundary of man made defences.

The predicted changes in climate and physical processes suggest that salt marshes will be sensitive to these changes and will especially be under threat from erosion due to the increased sea level and likelihood of more storms (UKCIP, 2006). The marshes could further suffer as the fixed rear boundary will prevent the natural realignment of the vegetation community taking place. In the long term this could lead to large losses of salt marsh and more overtopping of the current man made defence.

Sand Dunes

A section of sand dunes around Formby Point are currently eroding, whilst those to the north and south are stable or accreting. The extent and rate of erosion is likely to increase due to the impacts of climate change.



Using the high emissions scenario developed by UKCIP and looking at long term trends in the position of the dune toe a prediction for the position of the dune toe in 2050 has been calculated. It is predicted by 2050 that the coastline will be approximately 585 metres from the urban area at Victoria Road.

Measurements taken at Victoria Road

- 1845 to 1906: 235 metres accretion
- 1906 to 1945: 190 metres loss
- 1945 to 2005: 310 metres loss
- 2005 to 2050: 315 metres loss

- 2050 to urban area: 585 metres

This prediction doesn't include all of the potential impacts of climate change. The most notable missing impact is the increased frequency of storms which could significant alter the prediction. Other impacts relating to changes in precipitation could be influential in the evolution of the dunes. There are other limitations with this prediction as it is based on a simple model and further work will be required to refine it.

Sea Walls

Any man made construction on the foreshore will have an impact on the natural processes. The initial construction of a sea wall will significantly alter the shape of the foreshore and unbalance the equilibrium that was in effect. There is normally a time lag until the foreshore reaches a new equilibrium. The other main impact sea walls have is to fix the position of the coastline preventing the natural processes of realignment and vegetation succession that would normally take place.

The implication of sea level rise and increased storminess could see a reduction in the standard of service provided by the sea wall. In practise that will mean more overtopping of the sea wall. Under current conditions at Southport we might expect serious overtopping 2 or 3 times in a fifty year period, this will increase. By 2080 it is possible that overtopping might occur once every 2 years or even every year.

Summary

The coastal geomorphology of Sefton is very complicated being influenced by a wide range of factors. This makes the prediction of coastal evolution very difficult and hampered with much uncertainty. The scenarios for climate change add more complications and limitations to the predictions.

The soft areas of the coast, salt marsh and sand dunes, are likely to realign further back (landward) than at their current position, though the exact extent is hard to predict accurately. The areas that are protected with a sea wall are likely to experience more overtopping of those defences. As a result of these changes there will be an overall reduction in the extent of coastal habitats.

The Way forward

Reducing uncertainty through research

By carrying out research at a local level and participating in and making use of research at a regional, national and international level we can address some of the uncertainties currently present. An improved understanding of the implications of future climate change will inform decisions that we need to take to adapt to this change.

Work with and respect Natural Processes

It is too expensive to do otherwise and can also increase the assets at risk if we build in inappropriate locations and tie ourselves in to constructing unsustainable defences in the future.

Plan for change

Having identified how things might change we need to build this into plans that look at least 50 if not a 100 years hence. This knowledge should inform our decisions and be sustainable; we shouldn't burden future generations with our mistakes

A final thought

The coast will change…

…we will have to adapt to that change.

Further information

UK Climate Change Programme www.ukcip.org.uk

BBC www.bbc.co.uk/climate/

Defra www.derfa.gov.uk/environment/climatechange/

Sustainability North West www.snw.org.uk

Intergovernmental Panel on Climate Change www.ipcc.ch/

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