Landscape Systems

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New A Level Subject Content Overview

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Introduction

There is a long history of Geomorphology as a key component of physical geography at A level so that the landscape systems core content in the new A-levels is in many ways familiar[1]. Understanding the key landforms and processes of glacial, dryland, or coastal landscapes is central to several previous specifications. Key erosional and depositional landforms and processes in these environments are well covered in existing text books and volumes providing more detailed process understanding are identified in the further reading section of this summary. So what is new in the content to be taught from 2016? The changes relate primarily to conceptual approaches to the understanding of geomorphology which are emphasised more strongly in the new content, which provide clear progression from GCSE and which link to the way Geomorphology is taught in higher education. This introduction to the Landscape Systems content therefore focusses on these key concepts which are applicable to each of the three optional landscape types.

The geomorphological content is specifically framed within a systems context so that students should understand that the physical landscape can be imagined as a series of linked components through which energy and material are cycled. Material is moved by geomorphological processes (e.g. mass movement or transport by ice) between stores. In geomorphological systems these stores are typically landforms (for example a sand dune or a beach deposit). The rates and types of processes controlling movement of material through the landscape vary in time and space creating distinctive sets of landforms. Critically, change in one part of the system can impact on other parts of the system so that landscapes need to be understood as complex interlinked systems. Human management of landscape systems requires an understanding of the linkages and feedbacks within the geomorphological system. Many of the general points about systems and systems theory made in the RGS-IBG 'water and carbon cycle' A Level overview also apply to the landscape content. Excellent introductions to geomorphological systems can be found in Huggett, 2003; Smithson *et al*., 2008; and Gregory and Lewin, 2014.

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[1] Geography GCE AS and A Level Subject Content. Department for Education 2014

Approaches to Landscape Systems

Systems framework and sediment budgets

One common way to conceptualise the geomorphological system is through the idea of a sediment budget represented as:

$$O = I + \Delta S$$

Where O is output of sediment from a system, I is input of sediment to the system and ΔS is change in storage within a system.

We could apply these ideas to a single landform such as a sand dune. Inputs would be windblown sediment deposited on the stoss slope (upwind) of the dune and outputs would be material eroded from the lee slope. The change in storage is the difference between the input and output. Where it is positive there is net deposition of material and the dune grows. A negative change in storage represents erosion of material from the dune. The sediment budget approach can be expanded from a single landform to look at larger landscape components. For example we could consider a beach system which has multiple inputs and outputs (e.g. figure 1). What the sediment budget approach does is focus on identifying and quantifying the main stores and flows (processes) within the system. In doing so it not only identifies locations in space with net erosion or deposition but develops understanding of why this is the case which is critical for attempts to manage the system.

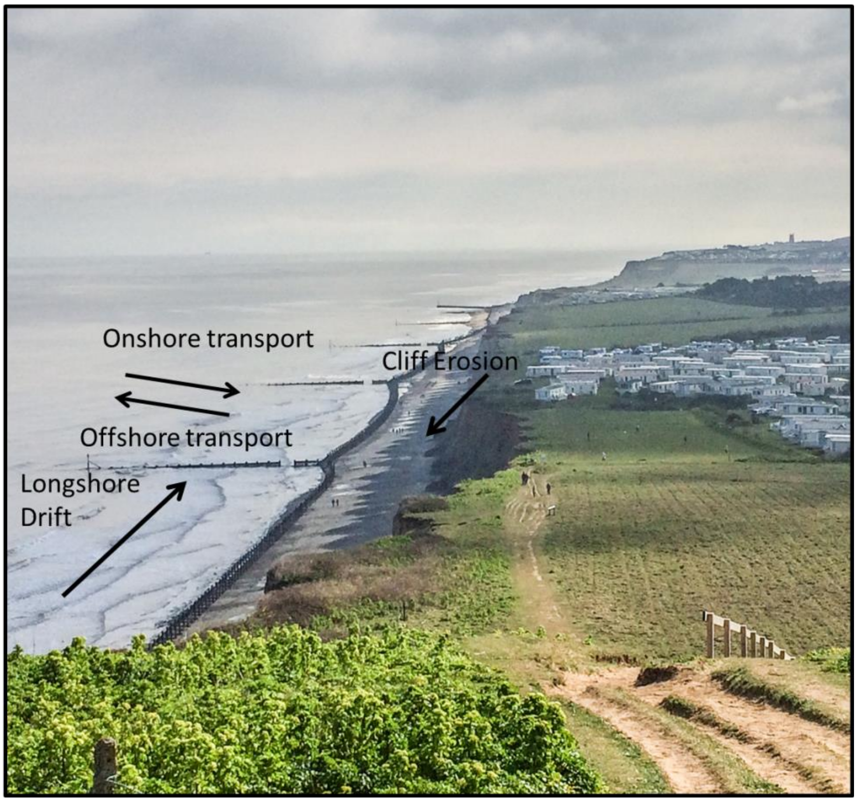


Figure 1*: The sediment budget for this beach would have three input terms (longhore drift, cliff erosion, onshore transport) and two output terms (Longshore drift and offshore transport). The groynes built on this eroding stretch of coast aim to minimise losses to longshore drift so that the local sediment budget is positive and the beach accumulates to protect the cliffs. Note that in protecting the cliffs the input from cliff erosion will also reduce (negative feedback) but the overall aim is to produce a positive sediment budget for the beach.*

Coastal management zones around the coast of the UK explicitly consider the sediment budget. Littoral cells are identified as zones where it is assumed that there is no longshore loss of sediment (because of the arrangement of headlands and bays) so that the cell is a discrete source or sink of sediment (figure 2).

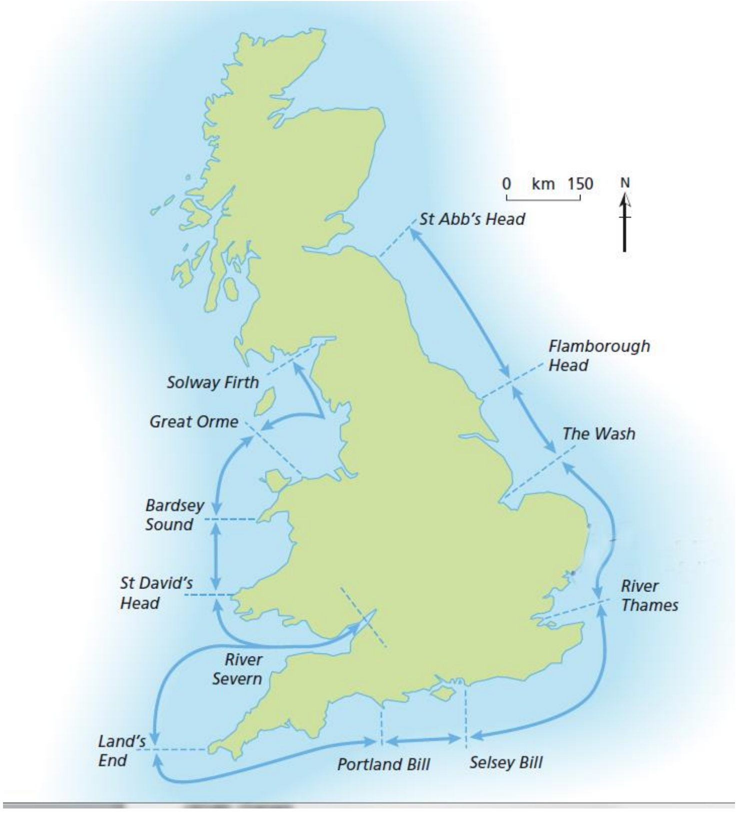


Figure 2: *Coastal sediment cells around the coast of the England and Wales which are used to define the spatial extent of Shoreline Management Plans. Reproduced with permission from Geography Review magazine*

Processes, Landforms, and Landscapes

The landscapes content emphasises understanding of the range of geomorphological processes which operate within a particular environment and the way in which these combine to create specific landforms. Within a given landscape landforms can be inter-related. Erosion in one location typically leads to deposition in another. The physical controls on an environment such as climate, rock type and tectonic setting vary in space so that characteristic suites of landforms create distinctive landscapes (landform assemblages) which vary across the globe. The optional areas of study for this unit; coasts, glaciated landscapes, and drylands are environments with distinctive process regimes and landform assemblages. However we can also recognise categories of landscape type within these broad groups. A common distinction is between erosional and depositional landscapes. These are spatially defined parts of the landscape system where the sediment budget is dominantly positive (depositional) or negative (erosional). In glaciated systems we recognise the difference between the upland valleys dominated by features such as cirques, and arêtes which are predominantly erosional (Figure 3) and landscapes where depositional forms such as drumlins and moraine are widespread (Figure 4).(See also, Glaciated Landscapes overview available at: http://www.rgs.org/NR/rdonlyres/841D9F95-3E42-4A9F-AB1A-01E44B75B95A/0/SCO_ALevelOverview_GlaciatedLandscapes.pdf)

Figure 3: *A landscape of glacial erosion, Chamonix, France © Professor Martin Evans*

Figure 4: *A landscape of glacial deposition, Wensleydale, Yorkshire, UK © Professor Martin Evans*

Similar distinctions between rocky coasts (erosional) and sandy or muddy coasts (predominantly depositional) and between desert systems dominated by yardang type features (erosional) and dune systems (depositional) apply in other environments (See also, RGS-IBG forthcoming overview on Deserts). Rates of erosion are determined by available energy (wind, wave, or iceflow) and the resistance of the eroding materials (hard or soft rocks). Depositional environments tend to be lower energy but a further critical control is sediment supply, where the production and delivery of sediment exceeds rates of removal deposition occurs. This fact emphasises the geographical linkages between areas of erosion (upwind, upglacier or cliff and river inputs to the coastal zone) and areas of deposition to which eroded sediments are transported. These create natural geographical associations between landscape types so that for example areas of glacial deposition occur down-glacier from areas of upland glacial erosion.

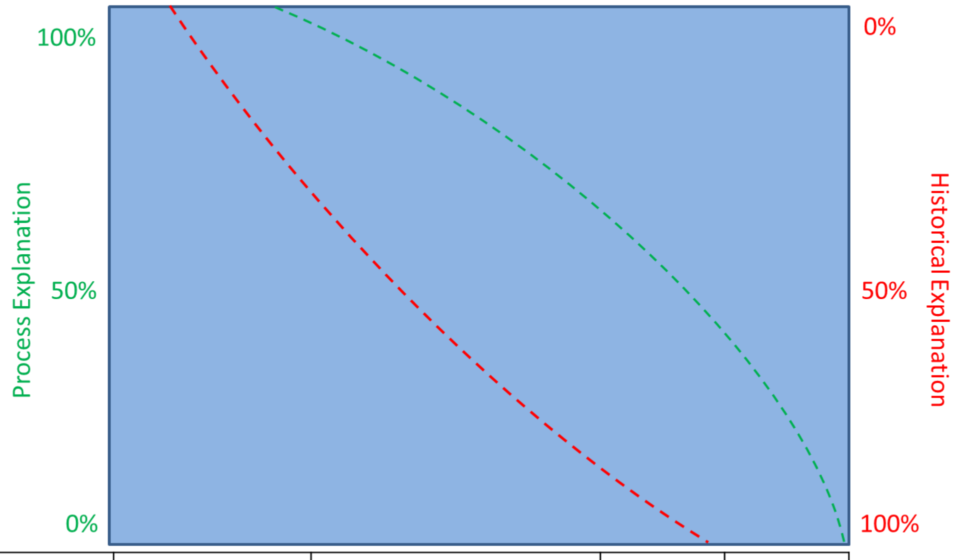
The most detailed applications of these notions of characteristic landform assemblages have been in glacial landscapes. Here the idea of the 'landsystem' a characteristic suite of landforms which occur together in space and which have formed under a specific process regime (past of present) has been particularly well developed (see Evans, D.J.A. 2013 further reading). In this scheme suites of landforms associated with particular contexts have been identified. For example, the glacial valley 'land system' includes lateral and supraglacial moraine as well as subglacial till and mass movement features associated with bare deglaciated terrain.

Conceptually what is important in this theme is that students understand that particular landform assemblages are characteristic of environments with particular process regimes (past of present). This understanding allows us to both answer the question 'why does this physical landscape look like this?' but also in cases where inherited forms are important answer questions about what the environment was like at this site in the past.

Timescales

As well as understanding the main processes of erosion and deposition in each of the environments, it is important to understand the timescale over which they operate. These can vary from seconds to millennia or longer. In any landscape there are processes which operate at high frequency but low magnitude such as the slow movement of material onshore by small constructive waves occurring on most days. Higher magnitude processes occur less frequently but have a greater instantaneous effect, for example cliff collapse during a storm event.

Because landforms and landscapes are affected by processes operating at a variety of timescales, a complete explanation of a physical system will normally require consideration not just of contemporary processes but also of the history of the system. For example, the ice carved valleys of the Lake District cannot be explained only in terms of current fluvial processes, and the landslide deposits of many Peak District valleys relate to a period of enhanced landslide activity shortly after deglaciation.



Erosional Forms	Ventifacts	Yardangs		Mesas	Major Desert Systems
Depositional forms	Ripples	Dunes	Dune Fields	Sand Seas	

Figure 5: *The relationship between landscape scale and the relative importance of historical and process explanations of the landscape system. After a conceptual diagram first published by Schumm (1985) modified with reference to dryland systems*

Figure 5 is a version of a famous diagram proposed by Schumm (1985) to suggest that smaller and younger features are more significantly controlled by contemporary processes whilst landscape scale explanation increasingly has to consider historical controls on the observed system. This conceptual diagram attempts to reconcile the study of landscapes driven by contemporary processes with the study of landscape history. In order to understand most landforms we need to study both but the relative importance of historical and contemporary influences will vary. In this diagram the red line indicates a potential maximum proportion of historical explanation for features of a given scale and the green line a potential maximum for process explanation. The diagram suggests that the relative importance of the two modes of explanation varies consistently with scale of landform. Large, long lived features have a greater historical component so that for example the existence of major desert systems is a function of the distribution of land masses and global climate circulation and is significantly controlled by long term plate movement whereas the pattern of ripples on a dune is a function of contemporary windspeed and direction interacting with the sand. There may be a small historical component of explanation even here though since the density and calibre of the sand at a point may be related to the geological and geomorphological history of the site.

Landscape evolution

It is important that students understand that landscapes evolve over long timescales so that relief can be significantly modified by erosional processes and by tectonic activity. Over these timescales landscapes are also impacted by climate change leading to changes in characteristic process regime and changes in sea level which impact particularly on coastal systems.

Larger features require more work to modify or remove and so are longer term features in the landscape. When we study formerly glaciated landscapes the large-scale glacial landforms we study derive from the historical glaciation of the landscape only slightly modified by post glacial activity so that an understanding of glacial history is required to explain the contemporary physical geography.

Because large features persist in the landscape some landforms or landform assemblages can be relict features whose formation has been dominantly influenced by past processes. The most straightforward examples of this are formerly glaciated landscapes. The hanging valleys, cirques and arêtes of upland Britain are explained largely with reference to a previous climatic regime with characteristic weathering and erosion processes during the Quaternary ice ages. Figure 6 shows a similar example from a dryland system. Some landforms can be a result of combinations of process regimes in time to yield unique features. The Tors of upland Britain are usually thought to be a result both of deep weathering of jointed granite in sub-tropical conditions during the Eocene (55-35 mya) and subsequent removal of weathered material by running water and by periglacial activity during the Quaternary period (2mya-present.)

(See also: http://www.dartmoor.gov.uk/learningabout/lab-printableresources/lab-factsheetshome/lab-torformation)

Figure 6: *shows an example of a sand sea in south eastern Libya. In the North-east corner is a relict river bed. This was dammed by volcanic activity circa 5 mya creating a lake/ Climate change led to desiccation of the lake which became a sediment source for the sand sea http://earthobservatory.nasa.gov/IOTD/view.php?id=76652. Image credit Nasa Earth Observatory*

Human Impacts

In 2001 Douglas and Lawson estimated that the magnitude of sediment movement by human agency (through construction, landscaping, mining etc.) was circa 57 billion tons, a figure which significantly exceeds the 22 billion tonnes estimated to be moved by all the world's rivers. More recently it has been argued that human beings are now a dominant geomorphological agent on the earth surface (Price *et al*. 2011).

Human modification of the landscape takes many forms, there are direct impacts on the earth surface through construction related fill and excavation and large amounts of sediment are moved through mining operations. This includes deep mining but also exploitation of surface resources which are in themselves landforms such as the mining of eskers and fluvioglacial deposits for gravel. As technological ability advances various large scale land forming activities have begun in coastal areas. These range from island formation driven by property development in Dubai (figure 7) to construction of islands in the south China sea as part of geopolitical claims (see http://www.nytimes.com/interactive/2015/07/30/world/asia/what-china-has-been-building-in-the-south-china-sea.html?_r=0)

Figure 7: *Extensive construction of artificial islands off the coast of Dubai Public domain image – Tobias Karlhuber*

Manipulation of coastal sediment budgets is also a key management approach in terms of coastal defence ranging from groynes to limit sediment loss by longshore drift to active reconstruction of beach defences by replenishment of beach and bar gravels after major storm events (see Holiday, 2014). Human impact on landforms and landscapes also occur indirectly. Human modification of vegetation cover can lead to dramatic erosion (see, UNESCO, http://www.unesco.org/mab/doc/ekocd/chapter11.html and RGS-IBG Water and Carbon Cycle A Level overview).

Because the landform assemblages that make up our landscapes are influenced by both contemporary and historical processes there are very few landscapes remaining where there is no significant human impact. There has been a dramatic acceleration of human impact on sediments and landforms in the industrial age so that the magnitude of contemporary processes is such that it may dominate in some locations. In some large urban areas anthropogenic landforms such as canals, cuttings, embankments, and reclaimed land may be the dominant surface features creating a land system where human action is the dominant geomorphological process. For an excellent discussion of human impact on geomorphology see Goudie (2013).

Fieldwork and Skills

The new A level content specifies that skills and fieldwork should be embedded in content. The Landscape unit is particularly well suited to developing some of these. A key field skill for geomorphologists is observation. So much of geomorphological investigation seeks to answer the question 'why is this landscape like that?' The ability to observe landforms in the field, to systematically record those observations and then apply classroom knowledge of the environment and process to explain the genesis of the forms you observe is central. Producing annotated field sketches is a great way to formalise this process, annotating photographs in the field using appropriate apps is another option (see Holmes, 2013).

Of course, in addition to observation fieldwork in physical Geography is a great opportunity to collect data, whether this is till fabric data from drumlins, gravel size data from coastal spits, or sand transport data from sand traps on coastal dunes. The landscape unit therefore offer the opportunity to work with that data practising skills such as unit conversion and statistical description of data. Often such data is collected at various points in space so that approaches to mapping data, such as perhaps proportional circles for mean grain size along the spit can be introduced here. Data that is geo-located as it is collected using GPS can be imported into Google earth or simple GIS packages to explore digital approaches to handling geospatial data.

Many schools have well established fieldwork that relates to coastal and/or glacial systems. Drylands fieldwork could be more problematic however, the content specifically allows for dryland fieldwork looking at Aeolian processes in this country. So studies of dune form in relation to prevailing winds, or sand transport on coastal dune systems are all possibilities. If you are lucky enough to be able to offer overseas fieldwork there is potential for drylands fieldwork in relatively accessible areas of southern Europe.

Ideas for Case Studies

Provision of detailed case studies is beyond the scope of this introduction; however three examples below draw on the three core landscape types to illustrate some ways in which empirical material can be drawn upon to develop the themes identified in this article.

Sediment Sources

Sand dune systems in dryland landscapes require a sufficient source of sandy sediment to maintain the dune field. Without an input of sediment from upwind the dunes will erode away. Common sediment sources are river sands from dryland river systems (e.g. figure 8) or from dried up lake beds. The latter are also an example of the importance of historical processes since lake sediments have been deposited under a previous wetter climate. Useful examples from the Mojave Desert can be found here: http://pubs.usgs.gov/of/2004/1007/dunes.html.

Figure 8: *Sand dunes at Great Sand Dune National Park in Colorado, U.S.A. Rivers draining from the mountains deposit sandy alluvium that is the sediment source for the dunes.*

Coastal sediment budgets

Constructing accurate sediment budgets is a time consuming process which involves measurement and monitoring of the rates all the major sediment transport processes and storage zones. Complete sediment budgets are therefore relatively unusual; however this example of a sediment budget approach to coastal erosion in South Carolina usefully exemplifies the application of the approach in a coastal management context: http://pubs.usgs.gov/of/2008/1206/html/processes1.html

Glacial land systems

Ice streams are areas of rapid ice flow within ice sheets (figure 9). These are well studied features since they play a significant role in ice sheet mass balance and so in our understanding of the dynamics of past, present and future ice sheets. Ice streams are high energy environments which are able to carry out significant geomorphological work and create distinctive suites of landforms. The short article linked here www.geos.ed.ac.uk/homes/s0350775/everestetal2005.pdf describes a suite of landforms in the valley of the River Tweed, Scotland and provides an excellent example of the way in which an understanding of this ice stream land system has allowed interpretation of the dynamics of glacial ice over this region in the last ice age.

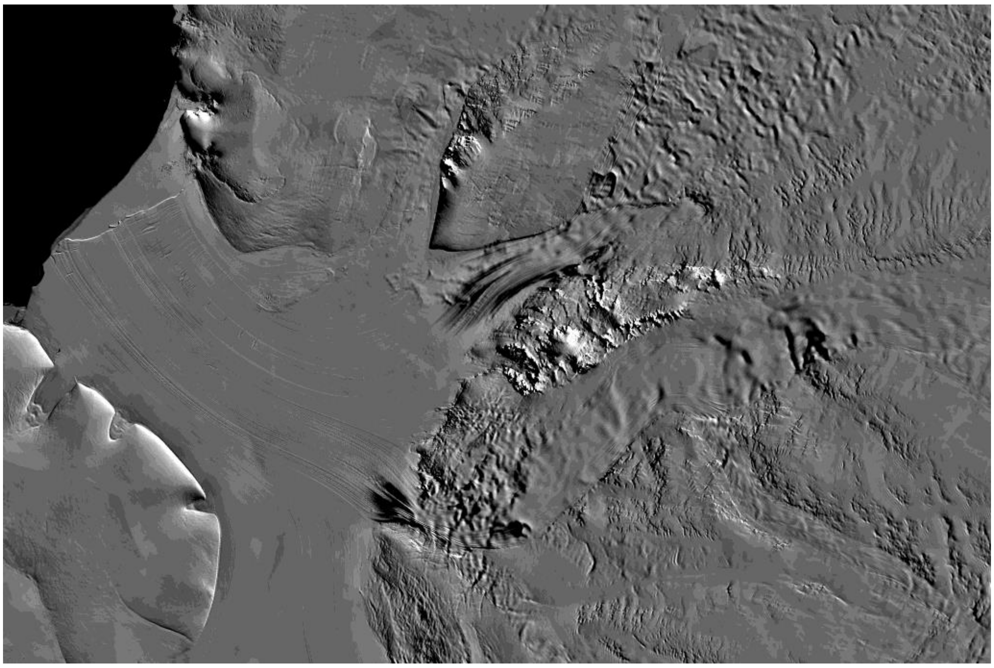


Figure 9*: The dark coloured streamlined ice just above the centre of the image is the Recovery ice stream flowing onto the Fisher ice shelf in East Antarctica Imagery from NASA earth observatory* http://earthobservatory.nasa.gov/IOTD/view.php?id=7620

Reading List and references

References

Douglas, I. & Lawson, N. (2001) The human dimensions of geomorphological work in Britain. *Journal of Industrial Ecology* 4, 9–33.

Evans, D.J.A. (2013) Glacial Landsystems. Routledge: Abingdon.
[Chapter one of this volume has a useful introduction to glacial land systems]

Goudie, A.S. (2013) The Human Impact on the Natural Environment: Past, Present and Future. Wiley-Blackwell, Oxford.
[Includes an excellent chapter on human impact on geomorphology and landscape change]

Gregory. K.J. and Lewin, J. (2014) *The Basics of Geomorphology.* Sage: London.

Holiday, A. (2014) Storm damage and coastal protection *Geography Review* 28(1) 38-41

Holmes, D. (2013) Fieldwork of the future. *Geography Review* 26(4) 25-27

Price, S.J., Ford, J.R., Cooper, A.H. and Neal, C. (2011) Humans as major geological and geomorphological agents in the Anthropocene: the significance of artificial ground in Great Britain *Phil. Trans. R. Soc. A* 369, 1056–1084.

Schumm, S.A. (1985) Patterns of alluvial rivers. *Annual review of Earth and Planetary Sciences.* 13 5-27

Good general Geomorphology Texts

The following all include conceptual material on geomorphological systems and useful chapters on the three environments specified in the content:

Holden, J. (2012) *An Introduction to Physical Geography and the Environment* 3rd edition Pearson, Harlow. p904

Huggett, R. (2011) *Fundamentals of Geomorphology* 3rd edition Routledge, London. p383.

Smithson, P. Addison, K. and Atkinson, K. (2008) *Fundamentals of the Physical Environment* 4th edition Routledge, London. p626.

More detailed coverage on the three environments in these volumes

Benn, D. and Evans, D.J.A. (2010) *Glaciers and Glaciation 2nd Edition* Routledge, London. p816.

Masselink, G. and Hughes, M.G. (2003) *Introduction to Coastal Processes and Geomorphology* Hodder, London. p368

Thomas, D.S.G. (2011) *Arid Zone Geomorphology3rd edition.* Wiley-Blackwell, Oxford. p648.