Chapters 1–4: answer notes

Extension box 1.1 Geographical systems (p. 5)

1 Suggest some correlations that could exist within a beach system, such as between beach slope and particle size.

Correlations that could exist within a beach system are:

- *Beach slope v particle size*
  Do steeper beaches have larger particles? Do more gentle beaches have smaller particle sizes?
- *Beach firmness v particle size*
  Are firmer beaches made up of finer material?
- *Wave type v beach slope*
  Do destructive waves produce steeper beaches?
- *Beach width v beach slope*
  Are wider beaches associated with more gentle beaches?
- *Beach width v particle size*
  Are wider beaches associated with smaller beach material?

All of these provide opportunities for fieldwork.

2 Explain how a river flood could be described as a cascading system.

River floods can be regarded as a cascading system in two ways:

- *Spatially:* Water builds up the channel of a river, increasing the size of the store of water in that channel. However, when the bankfull stage has been reached, a form of threshold, the water overtops its banks and water spills onto the land on either side of the river, thereby entering a new subsystem within the course of the river.
- *Temporally:* Water can be held back, or constrained, within the upper course valley of the river or within artificially raised floodbanks. The latter is the case when a river passes through an urban area such as York or Shrewsbury. However, after this stage, another threshold can be reached and the water overtops the banks, flooding areas downstream of the constrained area.

Extension box 2.1 Water extraction – springs (p. 11)

1 Outline the role of geology in the creation of springs.

Springs occur where a permeable aquifer, such as chalk or oolitic limestone, is underlain by a layer of impermeable rock, such as shale or sandstone. The water table so formed reaches the surface of the ground and forms a spring. In the case of a chalk or limestone escarpment, the water table often reaches the surface of the ground along both the scarp and the dip slope in two parallel spring lines.

2 Outline the role of geology in the amount and quality of water from springs.

Amount: This depends on the size of the channels and/or caverns that have been eroded in the rock. There may be some areas where water is stored in underground lakes, and water flow will depend on these being filled first. Similarly, some springs are created by faulting, where an impermeable rock acts as a dam. Again, this store would need to be 'filled' before spring water could be released.

Quality: In most cases, water has been filtered clean by passing through the permeable rock. In some cases, groundwater can be stained by contact with iron-enriched impermeable rocks on the top of the water table. This is the case in some springs emerging on the western slopes of the Pennines.

Extension box 2.2 Overland flow and runoff generation (pp. 18–19)

1 In what type of areas are you likely to experience each of these types of overland flow?

Infiltration excess overland flow – where soils do not allow rainwater to seep into the ground. This could be where there are clay soils with small pore spaces that cannot match the rate of precipitation. This could also occur where people or animals have compacted the soil, such as around entrances to fields, or on off-road tracks.

Saturation excess overland flow – at the base of slopes (especially steep ones), near the edges of streams and rivers, or where the water table lies close to the surface of the ground.

2 Why does saturation-excess overland flow present major problems for flood managers and house builders alike?

It presents problems because it is very difficult to anticipate and plan the degree to which it might arise. It is dependent on variables such as the intensity of the precipitation, the porosity of the subsurface materials, and the rate of movement of water beneath the surface. There is also a time lag between the rainfall event and the manifestation of the overland flow, which makes planning difficult.

For house builders, there is the added problem that the water comes from underground to flow on the surface, so properties could be flooded from below by rising groundwater. It is both difficult and expensive to try and prevent this. For this reason, houses should not be built on the edges of floodplains... though there are many instances of this.

Number crunchers (p. 19)

You are investigating the relationship between the gradient of a slope and the rate of infiltration of water into it. *The null hypothesis is that there is no relationship between the gradient of a slope and the rate of infiltration.*

1 Copy Table 2.2 and calculate the Spearman's rank correlation coefficient between slope gradient and infiltration rate.

Table 2.2

Location	Rank of slope gradient (steepest ranked 1)	Infiltration rate (millilitres of water per second)	Rank of infiltration rate (highest ranked 1)	Difference in rank (d)	d^2
1	15	1	18	3	9
2	17	12	11	6	36
3	14	21	9	5	25
4	16	18	10	6	36
5	8	9	13	5	25
6	10	4	15	5	25
7	18	31	8	10	100
8	9	63	4	5	25
9	6	3	16	10	100
10	12	5	14	2	4
11	2	38	5.5	3.5	12.25
12	3	38	5.5	2.5	6.25
13	4	11	12	8	64
14	13	125	2	11	121
15	5	33	7	2	4
16	11	2	17	6	36
17	1	167	1	0	0
18	7	83	3	4	16

$\Sigma d^2 = 644.5$

Spearman's rank correlation coefficient (r_s) = $1 - \frac{6 \sum d^2}{n^3 - n}$

= 1 – 3867/5814 = 1 – 0.665 = 0.335

2 When n = 18, r_s values exceeding ± 0.40 are significant at the 0.05 (5%) level and r_s values exceeding ± 0.56 are significant at the 0.01 (1%) level. Using this information, assess the significance of the coefficient you have calculated, and state the outcome of your investigation.

The r_s is not significant at either the 0.05 or the 0.01 level because it does not exceed either of these values. We cannot therefore reject the null hypothesis and must conclude that on the basis of this investigation there is no relationship between the gradient of a slope and the rate of infiltration.

3 Suggest reasons for this outcome.

The relationship between slope and infiltration rates is much more complex than just these two variables taken separately. We must also consider other aspects such as:

- the characteristics of the surface – was it composed of fine-grained soils, or loose scree particles?
- the degree to which the various surfaces (higher and lower) were already saturated;
- the nature of the land cover – was it grassland or forested, or was there some aeration or compaction by human activity?

A broader and more sophisticated investigation is needed.

CASE STUDY A river catchment – sustainable flood alleviation in Pickering, North Yorkshire (pp. 25–27)

1 Describe and comment on the flows of Pickering Beck shown in Figures 2.12 and 2.13.

Figure 2.12 shows a series of high discharge events, especially in the 1990s and early 2000s. There have been four occasions when the discharge has been almost three times the average, and there have been several occasions where it has been more than twice the average. Such high variability of discharge makes it difficult to be confident that flooding will not occur. It also causes challenges in terms of determining the most cost-effective form of flood management.

This flashiness of the river discharge is also reflected in Figure 2.13, where the discharge exceeded 10 cumecs on two occasions. In a systems context, this could mean that the threshold of the drainage basin was exceeded and flooding was likely. Another observation is that the response by Pickering Beck to rainfall events is rapid, both during and after a storm. Water can rise quickly and subside quickly.

2 Identify the main impacts on stores and transfers in the drainage basins of the scheme.

Stores:

- riparian woodland – to hold more water in trees such as alder and willow;
- wood debris dams – to retain water behind these;
- creation of small hollows to store water;
- no-burn zones – allowing more water to be stored in the heather vegetation;
- washlands – water stored on the floodplain immediately above Pickering within small embankments.

Transfers – the main impact is to 'slow the flow' (i.e. all transfers are to be reduced in scale and speed):

- wood debris dams – to release water at 'normal' levels more often;
- washlands – slower release of water during periods of higher river flows.

3 Identify advantages and disadvantages of the Pickering flood management scheme.

Advantages: Low cost; no expensive 'hard engineering' strategies involved; environmentally friendly in that natural flood management materials are being used – woodland, wood debris dams, increased amounts of heather and a natural floodplain. The scheme consists of a set of 'soft' engineering strategies that are not visually unattractive.

Disadvantages: Difficult to know whether the scheme will work for intense periods of rainfall – the one in a 100-year event. On the other hand, can any scheme cope with such events? The scheme is dependent upon key groups (farmers and landowners) fulfilling their roles. Without constant scrutiny, this could be difficult to achieve.

4 Why is it important that local farmers and landowners are involved in flood management approaches?

The obvious reason is that the reduced risk of flooding for the inhabitants of Pickering depends on the cooperation of many farmers and landowners who live and work in areas some distance from the town. Some of these farmers and landowners are unlikely to be affected by the flood risk themselves, and yet they must play their part in the scheme. They are the ones who must plant the trees, accumulate and maintain debris dams etc., in order to protect the homes of people some distance away. This work may not be a priority in an area where hill farming is already challenging. Moreover, a reduction in heather burning will impact on the breeding of grouse. The maintenance of grouse moorlands is an important revenue stream for some landowners (grouse shooting) and hence the small changes may not be in their interest financially. It is important that all aspects of the scheme work in tandem and hence local farmers and landowners need to be involved.

Extension box 3.1 Biogeochemical cycles (pp. 30–31)

1 Why are biogeochemical cycles crucial to life on this planet?

Biogeochemical cycles refer to the circulation of chemical nutrients like carbon, oxygen, nitrogen, phosphorus, calcium and water through the biological and physical world. They determine not only the ways in which these nutrients circulate within and between the biotic and abiotic elements of the planet but also the rate of transfer. They connect the four broad zones of the planet – the atmosphere, the land, the plants and animals, and the oceans. Put simply, without biogeochemical cycles there would not be life on earth.

2 Choose one sedimentary cycle and one gaseous cycle and give an example of their impact on the planet.

Sedimentary – phosphorus: This cycle describes the movement of phosphorus through the lithosphere, hydrosphere and biosphere. The atmosphere does not play a significant role in the movement of phosphorus because it tends to exist as a solid at the typical temperatures and pressures found on earth. On the land, phosphorus gradually becomes less available to plants because it is lost to surface runoff. Low concentration of phosphorus in soils reduces plant growth and slows down microbacterial growth. Human activity has caused major changes to the global phosphorus cycle through the transport of phosphorus minerals and the use of these minerals as fertilisers. Phosphorus is also lost from the land as sewage and through movement within soils and the ground in agricultural areas.

Gaseous – nitrogen: This cycle describes the processes by which nitrogen is converted between various chemical forms. These include ammonification and nitrification. The nitrogen cycle has a particular impact on ecosystems where it can be measured by the accumulation of biomass in an ecosystem (net primary productivity) and its decay (decomposition). Human activities such as fossil fuel combustion, the use of artificial nitrogenous fertilisers and the release of nitrogen in wastewaters have impacted on the global nitrogen cycle.

CASE STUDY The Arctic and climate change (pp. 52–56)

1 Explain why the extent of sea ice is 'critical' in terms of global weather systems.

Sea ice is a critical element in the global weather system. Ice has a high albedo of 80% and this is a major reason why the poles remain cool. Loss of sea ice can have a disproportionate effect because of this albedo. If a small amount of sea ice is lost, the newly exposed ocean absorbs more heat, warms up and is therefore likely to melt more sea ice, opening up more areas of open sea, and so on. The atmosphere above the water surface will be warmed, which will have an impact on pressure systems and wind patterns. This positive feedback process means that a small change in sea ice extent can quickly lead to enormous changes in global climates and an extended period of sea ice reduction. In theory, this could lead to an ice-free Arctic.

2 Explain why the thickness of sea ice is as crucial as its extent to scientists.

The sea ice of the Arctic Ocean has thinned by an average of over 1.3 m since 1960. The decreasing thickness means that every summer, millions of square kilometres of ice melt, refreezing again in the winter. Ice that has existed throughout the year, as a result of being too thick to melt, has different characteristics from ice that is refrozen annually. It has a higher albedo and hence encourages cooling. Thinner ice also breaks up more easily, creating more areas of open water with a lower albedo. Both types of ice create positive feedback cycles: the thicker ice reduces Arctic warming; thinner ice encourages it.

3 Outline the effects of a weakening North Atlantic circulation on climates of the northern hemisphere.

If an ice-free Arctic occurred, then the Arctic Ocean would become less saline and warmer. This would weaken the North Atlantic thermohaline circulation, which brings warm water and air to northwest Europe from the southern North Atlantic Ocean (the North Atlantic Drift, or Gulf Stream), thereby cooling the climate of that area. This is because freshwater (from the melting ice) does not sink to depths as easily as saline water and therefore warm water will not be drawn north. Temperatures which are currently well above their latitudinal equivalents in North America and Asia would be much lower, and the mild winters associated with the region would not occur. Moreover, as depressions would not circulate from west to east across the area as much as they do now, rainfall totals would decrease, but amounts of snowfall may increase.

CASE STUDIES Local responses to climate change (pp. 64–67)

1 Describe the health and environmental issues associated with traditional cooking stoves.

Health: Exposure to smoke is thought to be responsible for 4 million premature deaths (mostly women and children) a year. The risks are to lung and other respiratory tracts (lung cancer). Furthermore, high levels of carbon monoxide can poison, and lower levels can cause brain damage and impaired growth. Many people also suffer burns.

Environment: Emissions of CO_2 are high. Another major impact is the amount of soot that enters the atmosphere, some of which has been seen to settle on snowfields and glaciers in high areas. Inefficient household stoves also add to the smoke produced in areas where deforestation by fire is taking place, as in Indonesia.

2 Outline three benefits of the new ceramic form of cooking stoves.

- They use less fuel, which saves money and time in the collection of timber for burning.
- They produce less smoke, so they are healthier for the people using them.
- They are designed to be produced locally, to adapt to local needs and to provide employment in their manufacture.

3 'When combating climate change, think global, act local.' To what extent do the case studies of the UK and cook stoves support this statement?

UK: It is now widely accepted that much energy is wasted in the UK home and that more energy conservation should take place. Furthermore, recycling has become increasingly the norm in our society. Both of these acts – conservation and recycling – are in the hands of individuals and communities (i.e. local people). Improved home insulation, smart meters, reduced energy use of everyday items, recycling of household waste, using more public transport, etc. are all within the remit of individuals or community groups. By acting locally in this way, a message is being sent to companies and governments about the need to combat global climate change.

Cook stoves: This is another example of how millions of people around the world can have a huge cumulative impact on reducing emissions of carbon into the atmosphere (in this case by using a more efficient cooking stove), thereby addressing a global problem. As the case study illustrates, these are activities at a local scale across Africa and Asia. There is one significant difference, however, in relation to this quotation, namely in terms of the decision making. In the developing world where new cook stoves are being used, it is unlikely that the motive for their use by the local people is to counteract climate change. Their priorities would be towards having less smoke in the home, fewer incidences of burns, and less illness. Global climate change is not at the top of their agenda.

A good answer to this question would therefore recognise the importance of attitudes and values, and circumstance. Is it perhaps selfish of local people in the developed world to impose their views on other local people in the developing world, when it could be argued that the latter actually need to consume more energy to improve their lives?

CASE STUDY A tropical rainforest – what future for the Amazon?

(pp. 67–69)

1 Describe the impact of climate change on the climate of the Amazon.

The predicted impacts of climate change on the climate of the Amazon can be summarised as follows:

- An increase in temperature of 2–3°C by 2050 (since the 1970s) is forecast, which is likely to result in increased rates of evapotranspiration.
- A decrease in precipitation during the dry season is expected; it is also possible that there will be more intense rainfall during the wet season.
- The dry season is likely to lengthen beyond the current average of 4 months.
- The predicted changes in rainfall vary spatially – NE Brazil may experience significantly lower rainfall, whereas the SE is likely to have an increase.

2 Discuss the impact of climate change on the biosphere of the Amazon.

The predicted impacts of climate change on the biosphere of the Amazon can be summarised as follows:

- Up to 40% of plant species may become unviable in the Amazon rainforest by 2080. Large areas of the evergreen tropical rainforest may be succeeded by mixed forest and savanna grassland vegetation.
- As the dry season lengthens, trees will have more time to dry out, so there is likely to be an increased incidence of wild forest fires.
- In coastal areas there will be some impacts on mangrove forests as the sea level rises, but most of the damage will be due to deforestation.
- As well as flora, there will be impacts on the fauna. Some birds and animals will be dislocated south as their natural habitats decline. Furthermore, where the big mammals and birds are hunted out for food, the trees that need these animals to disperse their seeds may continue to fruit year after year but their seedlings will have little chance of being spread.

3 Assess the degree to which humans can modify the impacts of climate change in the Amazon.

This can be examined at two scales:

- *The activities of humans who live around the world to combat global climate change:* Material from those sections of the textbook examining human interventions in the carbon cycle (mitigation and adaptation) is relevant.
- *The activities of people who live in the Amazon:* The main modification is to reduce the degree of deforestation that is taking place. There are some signs that this is occurring, as many people recognise the damaging effect of deforestation. However, others state that the main threat is increasing levels of development as more land is cleared to house people and to farm food and cash crops. A drier forest is more vulnerable to forest fires, which burn out of control. Amazon trees have evolved without fire. They have none of the protective features, such as thick bark or heat-resistant seeds, evolved by their relatives in areas that burn naturally. In order to conserve the Amazon in a changing climate, better ways of living in the region are required, with much less use of fire and much more value accruing to those forest dwellers prepared to protect their land.

The overall response needs some form of assessment of 'the degree to which'.