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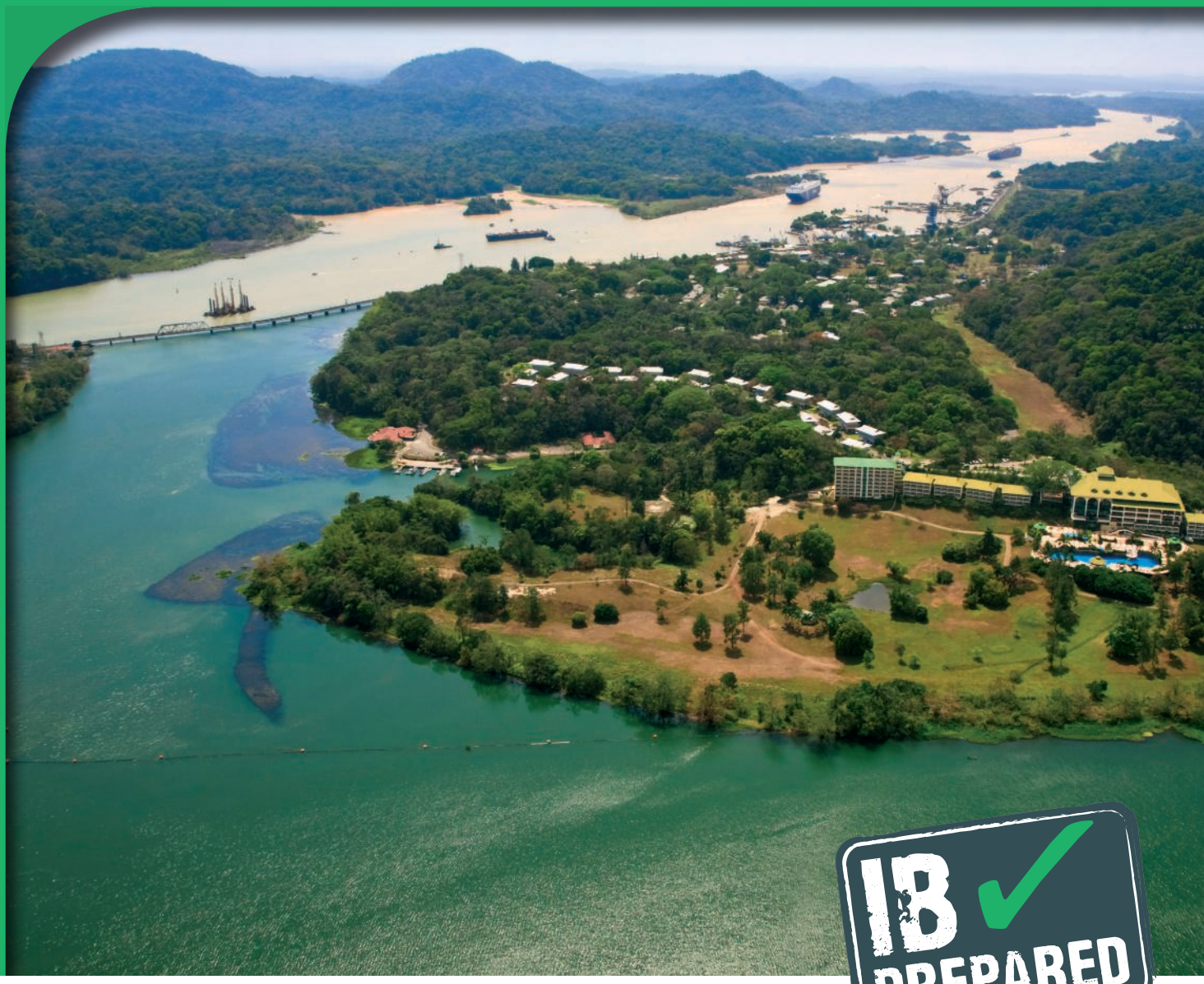
GEOGRAPHY



IB DIPLOMA PROGRAMME

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OXFORD

Contents

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A FRESHWATER

A systems approach is a characteristic of the Geography course, and the Freshwater unit is no exception. A drainage basin is a system, since it has inputs, processes and outputs that shape landscapes and give rise to flooding. As water becomes scarcer due to human and natural factors, careful management of this precious resource is needed at local, national and international scales. As well as examining depletion, the pollution of freshwater is also studied. You should be able to make connections to other parts of the course as you progress through this unit, and you should ensure that you connect with the key concepts of processes, places, power and possibilities.

You should be able to show:

- ✔ how physical **processes** influence drainage basin systems and landforms;
- ✔ how physical and human factors exacerbate and mitigate flood risk for different **places**;
- ✔ the varying **power** of different factors in relation to water management issues;
- ✔ the future **possibilities** for management intervention in drainage basins.

A.1 DRAINAGE BASIN HYDROLOGY AND GEOMORPHOLOGY

- **Drainage basin** – an area of land that is drained by a river and its tributaries.
- **Watershed** – the border of a drainage basin that separates one drainage basin from another.
- **Open system** – when energy can enter and leave a system, such as a drainage basin.
- **Evapotranspiration** – the total amount of evaporation from land and from vegetation (transpiration).
- **Load** – the material transported by the river. The bed load consists of larger material that is transported via processes such as traction and saltation. The suspended load is transported via processes such as suspension and solution.
- **Cryosphere** – water in solid form (e.g. snow, ice).

You should be able to show how physical processes influence drainage basin systems and landforms:

- ✔ The drainage basin as an open system with inputs (precipitation of varying type and intensity), outputs (evaporation and transpiration), flows (infiltration, throughflow, overland flow and base flow) and stores (including vegetation, soil, aquifers and the cryosphere);
- ✔ River discharge and its relationship to stream flow, channel characteristics and hydraulic radius;
- ✔ River processes of erosion, transportation and deposition, and spatial and temporal factors influencing their operation, including channel characteristics and seasonality;
- ✔ The formation of typical river landforms, including waterfalls, floodplains, meanders, levees and deltas.

Assessment tip

This unit includes a wide range of terminology. Terms such as "eutrophication" and "salinization" are often not spelled correctly or are used out of context. Take time to practise spelling these terms, since appropriate use and spelling of terms will increase your mark for knowledge and understanding in your essay responses.

The drainage basin as an open system with inputs, outputs, flows and stores

A drainage basin is an open system since matter can enter and leave the system to join other systems such as a marine system.

After a period of rainfall, the water is then stored and transferred. Some of the transfers take place on the surface, such as overland flow (also known as surface run-off) which occurs when there is limited infiltration due to impermeable rock, for example. Infiltration occurs when water moves underground from the surface. A permeable rock type will allow water to pass through it, and the movement as it percolates downwards via gravity is classified as throughflow. Lakes, reservoirs, ponds, soil, vegetation and ice are all examples of stores where water is held. Clearly, there are a number of physical **processes** taking place in a drainage basin that affect the movement of water.

Concept link

PROCESSES: This section outlines a range of natural processes which create an open system. The dynamic nature of these processes not only shapes landscapes, but it also creates the unique characteristics of places which can be at a range of different scales, from the Nile basin to a basin at a local scale.

Test yourself

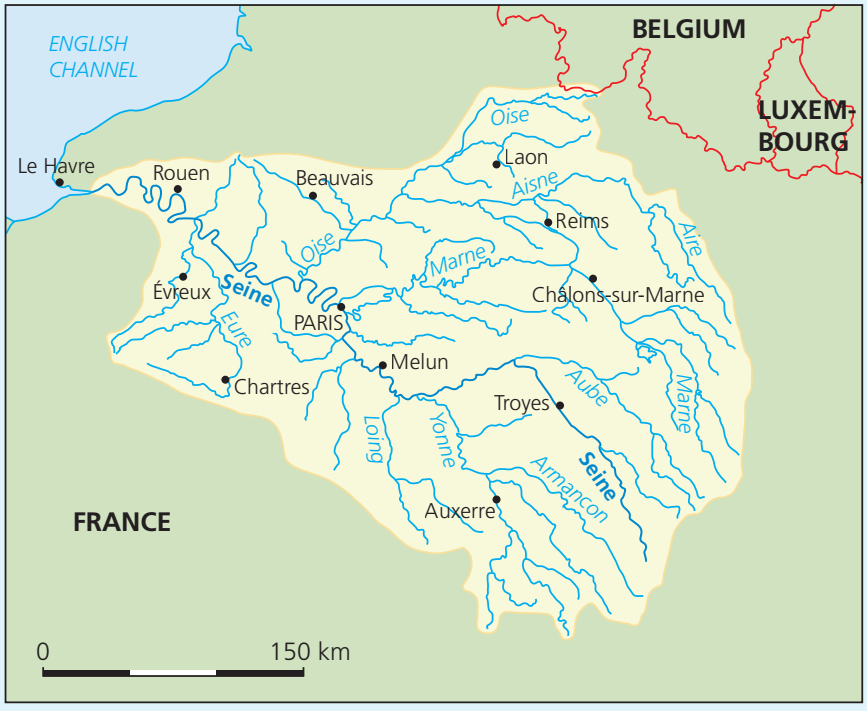
A.1 Distinguish between an open and a closed system. [2]

A.2 Analyse how a drainage basin functions. [3]

A.3 Explain how rock type and vegetation can affect the flow of water in a drainage basin. [2+2]

A.4 Study the map (figure A.1.1).

▼ **Figure A.1.1.** River Seine drainage basin



Describe the physical characteristics of the River Seine and its drainage basin. [3]

Assessment tip

Make sure that you do not include "opposites" or "mirrors" in your answer. This is when you state the opposite compared to the previous part of your answer. You will only get a mark for one side of the "mirror", so do not expect double marks.

Assessment tip

When asked to describe a map, it is important that you utilize your cartographic knowledge by including distances, compass directions, grid references and relief.

River discharge and its relationship to stream flow, channel characteristics and hydraulic radius

The discharge is the volume of water that is flowing at a given point in the river. It is measured in cubic metres per second (cumecs) and theoretically increases downstream. It is calculated by multiplying the velocity by the cross-sectional area at a point in the river. Wider and deeper channels will be able to hold a greater volume of water resulting in a larger hydraulic radius, or in other words, a higher efficiency or ability for water to move downstream.

River processes of erosion, transportation and deposition, and spatial and temporal factors influencing their operation

There are four processes of erosion: hydraulic action, corrasion, corrosion and attrition. Once material has been eroded, it is then transported down the river either as the bed load (material on the riverbed) or as the suspended load (material held in suspension by the flow of the water) or as the dissolved load (soluble material dissolved in the water). Some material may be carried on the surface, such as leaves and branches.

There are four processes for transportation: traction, saltation, suspension and solution.

When material is no longer being transported by a river, it is deposited. For deposition to occur, there must be a reduction in the river's velocity in order that the material can no longer be carried.

The seasonal nature of some rivers can mean an increase or a decrease in processes of erosion, transportation and deposition at different times of the year. For example, ephemeral rivers only contain flow at intermittent periods of the year when there is a rainy season.

Test yourself

A.5 Explain how a river's discharge is related to channel size and shape. [2+2]

A.6 Describe and **explain** the relationship between a river's discharge and suspended load. [2+2]

A.7 Explain how temporal factors will affect a river's ability to transport material. [2+2]

The formation of typical river landforms

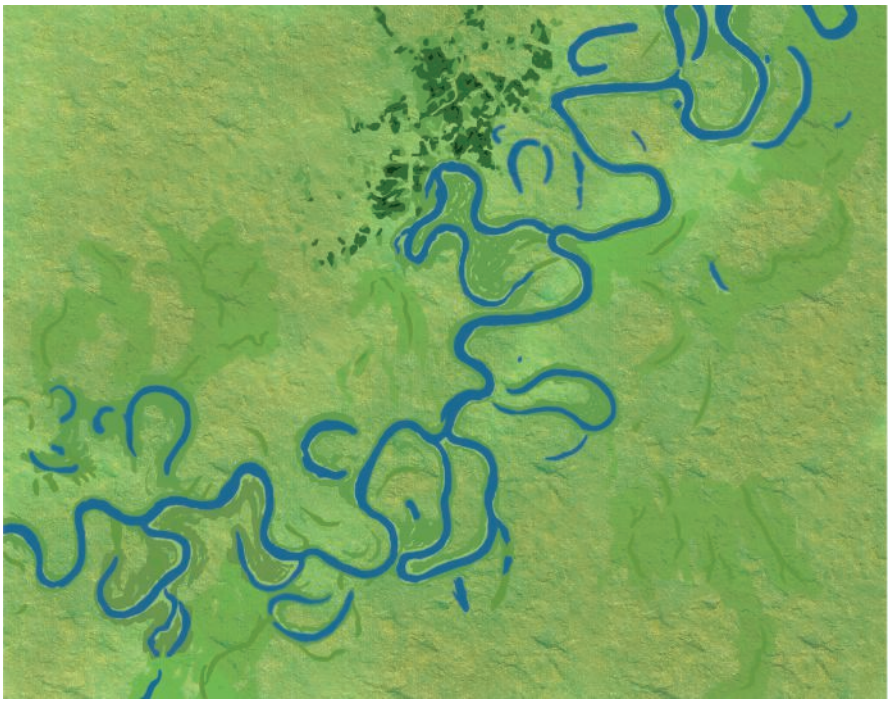
Waterfalls are formed when water flows over two different types of rock. One of the layers is eroded more easily than the other, and due to this the more resistant rock is undercut. Eventually the undercut rock is left without support underneath and it will collapse into the plunge pool below. The process continues, and a gorge is formed. A waterfall is a landform created via erosion.

▼ **Figure A.1.2.** The Goðafoss waterfall in Iceland

Processes of erosion, transportation and deposition are all required for the formation and evolution of meanders. Material is deposited on the inside and lateral erosion occurs on the outside of the meander.

When the sinuosity or "bendiness" of a meander increases, it is possible that the outside bends of two meanders are eroded in order that the meander straightens, creating an oxbow lake. See figure A.1.3 which shows the Juruá River, one of the longest tributaries of the Amazon River. It is a very sinuous river and the image shows a number of oxbow lakes.

▼ **Figure A.1.3.** Oxbow lakes on the Juruá



A floodplain is formed via the deposition of material adjacent to a river. When a river floods on the flat land at the side of the river (normally in the lower course), material is deposited once the water subsides. Layer upon layer of deposited material such as silt or alluvium further develops a floodplain. Levees are created during times of flood when the larger, coarser material is deposited closer to the river channel, as the amount of energy decreases with distance from the channel. Floodplains and levees are depositional landforms although the processes of erosion and transportation are needed to supply the material that is then deposited.

There are different types of deltas: arcuate, bird's foot and cuspate, and each is created via deposition.

Test yourself

A.8 (a) State two landforms found in a drainage basin that are formed solely via processes of erosion. [2]

(b) Explain how the landforms you identified in part (a) are formed. [2+2]

Assessment tip

A clear annotated diagram is an appropriate approach to answering this question.

A.2 FLOODING AND FLOOD MITIGATION

- **Hydrograph** – a graph that shows how a river or stream's discharge changes over time and its relationship with the amount of precipitation that falls during a rainfall event.
- **Antecedent moisture** – the amount of moisture stored underground after a previous period of precipitation.
- **Peak discharge** – the greatest amount of discharge flowing in a river after a rainfall event.
- **Peak rainfall** – the time at which there is the highest amount of rainfall into a drainage basin for a given storm.
- **Afforestation** – the process of planting trees in an area where there were previously none.
- **Reforestation** – replanting trees in an area that was previously deforested.

Concept link

PLACES: The relationship between the human and natural worlds is never more present than when a place experiences a natural disaster such as a flood, which can devastate places. The power of a place, based on experience and/or the economic ability to put in place defences to mitigate the effects of flooding, is able to ensure that the relationship does not bring negative consequences.

You should be able to show how physical and human factors exacerbate and mitigate flood risk for different places:

- ✔ Hydrograph characteristics (lag time, peak discharge, base flow) and natural influences on hydrographs, including geology and seasonality;
- ✔ How urbanization, deforestation and channel modifications affect flood risk within a drainage basin, including its distribution, frequency and magnitude;
- ✔ Attempts at flood prediction, including changes in weather forecasting and uncertainty in climate modelling;
- ✔ Flood mitigation, including structural measures (dams, afforestation, channel modification and levee strengthening) and planning (personal insurance and flood preparation, and flood warning technology);
  - ✔ Two contrasting detailed examples of flood mitigation of drainage basins.

Hydrograph characteristics and natural influences on hydrographs

A hydrograph shows data for two variables on the same chart, e.g. a river's discharge and the amount of rainfall that a drainage basin receives. The amount of rainfall influences the amount of discharge, and this is via overland flow, throughflow and groundwater flow. The lag time—the time between peak rainfall to a river's peak discharge—is an important period. A short lag time means that a river may reach its bank full discharge, which is the maximum amount of discharge a channel can hold, and flood an area quickly. Increasing the lag time and reducing the discharge can reduce the risk of flooding. The monitoring of hydrographs can enable predictions to be made regarding flooding as well as measuring the effectiveness of flood mitigation strategies.

Test yourself

A.9 Discuss how physical factors can influence a hydrograph. [3+3]

Assessment tip

If you are asked to discuss the factors that influence a hydrograph in an extended response, it is important that you evaluate the impact, since this is normally necessary to reach the highest mark bands. For example, human activities can decrease the discharge and increase the lag time via afforestation, whilst urbanization and building on a floodplain will increase discharge and reduce the lag time.

A.10 Suggest how hydrographs can be used to forecast and manage flooding. [2+2]

Assessment tip

When discussing hydrographs in your answer, it is appropriate to include an annotated hydrograph showing the different responses from a river when there are natural differences between two drainage basins or there is change annually in a particular basin.

How urbanization, deforestation and channel modifications affect flood risk within a drainage basin, including its distribution, frequency and magnitude

Human factors such as urbanization will mean that there are more impermeable surfaces, thus increasing overland flow and the time taken to reach a nearby stream or river.

Deforestation reduces interception and exposes soil to erosion whilst increasing the amount of overland flow due to soil capacity being reached.

Increasing the cross-sectional area of a channel reduces the risk of flooding since the channel can hold more volume.

The frequency and magnitude of a flood will depend on the natural and human factors that influence the movement of water. Infrequent flood events tend to have a large magnitude and vice versa. In summary, the characteristics of places via a range of human and physical factors will influence the risk of flooding.

▼ **Figure A.2.1.** Urbanization means an increase in impermeable surfaces and a reduction in infiltration

Attempts at flood prediction

Weather forecasting can predict the timing and the amount of rainfall during a period of low pressure and this data will forewarn authorities and residents in a drainage basin about the impending risk of flooding. Extreme weather events such as cyclones will increase the amount of rainfall and debris reaching a river. Meteorologists are able to detect and track these events days, possibly a week, before they arrive in an area.

Flood mitigation

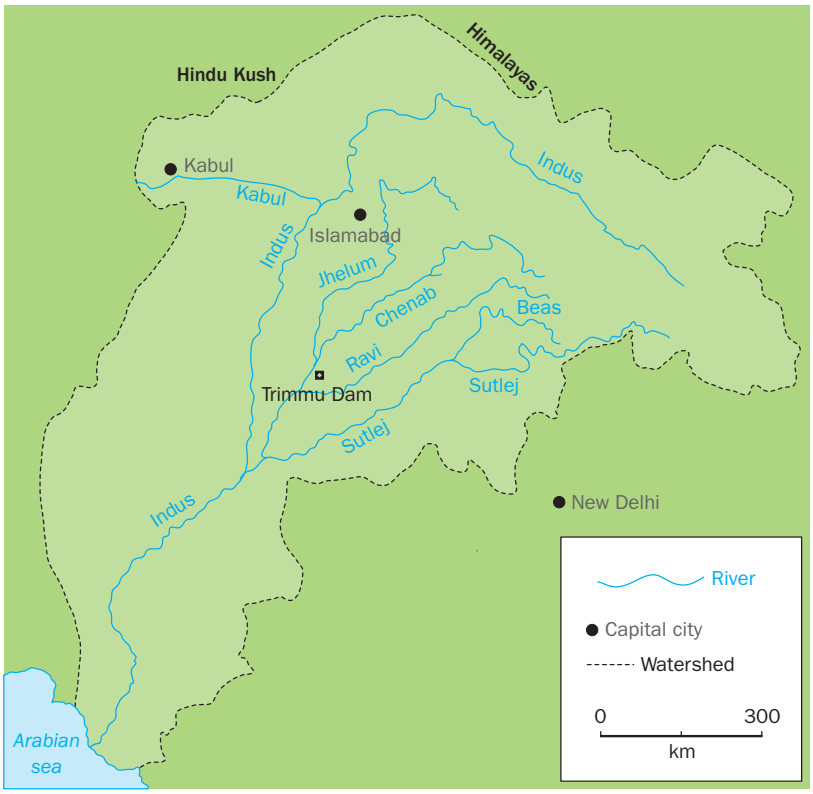
There are a variety of flood mitigation strategies, and they can be classified as "hard" or "soft" engineering. Hard engineering is when the structural measure uses artificial materials with which to alter the landscape. This may involve building a concrete dam in order to control the flow of a river, or construct levees to form channels that will hold more water and protect nearby infrastructure. Soft engineering works with nature, so no concrete or artificial structures are created. Afforestation and reforestation would be examples of this type of flood mitigation strategy. Other strategies such as widening, deepening, lining and straightening a channel (channelization) will also enable a river to hold more discharge and increase its hydraulic radius, thus becoming more efficient.

Two contrasting detailed examples of flood mitigation of drainage basins

The following case studies (Pakistan and Queensland) show that although both places had flood management strategies in place, there was still significant economic damage and the loss of life.

Case study: Flood mitigation in Pakistan

▼ **Figure A.2.2.** The Indus river system



Pakistan has regular floods due to heavy monsoon rainfall, snowmelt from the Himalayas and deforestation.

In September 2014, the rivers Jhelum, Chenab, Ravi and Sutlej started rising above their banks due to monsoon rainfall, and they flooded. Around 2.5 million people were reported to have been affected; 367 people were killed and over 125,000 homes were destroyed. Warnings about the flooding came too late for many people.

Additional dams had been built on rivers further upstream in neighbouring India and some suggested that the release of floodwaters from these dams increased the discharge and amount of flooding further downstream. The Pakistani government denied this. After spending millions on barrages and embankments, the authorities had to allow controlled breaches of the embankments such as on the west bank of the Chenab upstream from a major dam at Trimmu, in order to protect urban areas. This meant that 200 villages were flooded.

Case study: Flood mitigation in Queensland, Australia

In January 2011 there was a major flood in Queensland, Australia due to higher than normal rainfall in a La Niña year and also from Tropical Cyclone Tasha. Rivers such as the Burnett topped their banks and flooded large portions of the state. The economic cost of the disaster was approximately A$10 billion and 35 people died.

Flood management was in place, such as the Wivenhoe Dam which was built to stop Brisbane being flooded (and also to secure water

supplies). Residents argue that insufficient water was released from behind the dam in spite of forecasts of heavy rainfall. When water was eventually released, the Brisbane River already had a high discharge due to rainfall amounts, so the level rose by 10 metres causing widespread damage.

Test yourself

A.11 Using evidence from figure A.2.2, **outline** the potential difficulties for the Pakistani government in relation to mitigating flooding. [3]

A.12 Evaluate the success of flood mitigation strategies in Pakistan from 2010 onwards. [4]

Content link
Flood mitigation in cities is explored in option G.4.

A.3 WATER SCARCITY AND WATER QUALITY

You should be able to show the varying power of different factors in relation to water management issues:

- ✔ Physical and economic water scarcity, and the factors that control these including the causes and impacts of droughts; the distinction between water quantity and water quality;
- ✔ Environmental consequences of agricultural activities on water quality, to include pollution (eutrophication) and irrigation (salinization);
  - ✔ Detailed examples to illustrate the role of different stakeholders;
- ✔ Growing human pressures on lakes and aquifers, including economic growth and population migration;
- ✔ Internationally shared water resources as a source of conflict;
  - ✔ Case study of one internationally shared water resource and the role of different stakeholders in attempting to find a resolution.

- **Physical water scarcity** – where water resource development is approaching or has exceeded unsustainable levels; it relates water availability to water demand and implies that arid areas are not necessarily water scarce.
- **Economic water scarcity** – where water is available locally but not accessible due to human, institutional or financial capital reasons.
- **Drought** – a prolonged period of abnormally low rainfall. Drought is a broad category and can be subdivided into hydrological, meteorological and agricultural drought.
- **Eutrophication** – a process that affects freshwater whereby dense algal and plant growth occurs due to increased concentration of chemical nutrients.
- **Salinization** – a process in which the salt content of surface and/or groundwater increases as overland flow or throughflow transfers crystallized salts left behind after irrigated water has evaporated.

Physical and economic water scarcity—water quality and quantity

Water stress is when annual water supplies drop to less than 1,700 m^3 per person per year, whereas water scarcity is when a person has access to less than 1,000 m^3 annually. The causes of water scarcity can be natural and human, for example a lack of rainfall in an area for a significant period and the unsustainable consumption of water by agriculture.

A decrease in water quality can be caused by a number of different factors. For example, the disposal of plastic in the world's oceans and rivers has led to fibres being present in the food chain and in drinking water. Chemicals from commercial agricultural are another significant source of contamination (see following page), while inadequate sewage and sanitation systems may pollute clean water. Waterborne diseases have caused the deaths of millions, and more than 3 million deaths a year are due to diseases such as cholera, malaria and diarrhoea.

Content link
Water security is examined further in unit 3.2.

Environmental consequences of agricultural activities on water quality

Agriculture can have a negative impact on freshwater. The use of irrigation and the application of chemicals in the form of fertilizer and pesticides can pollute freshwater on the surface and underground. Algae grow on the surface of rivers due to eutrophication which reduces the amount of oxygen available for vegetation and creatures under the water.

A reduction in oxygen results in a reduction of life in a lake or river. A number of different groups and organizations are trying to resolve this problem, including farmers (subsistence or commercial), environmental groups, residents and government departments such as the Environment Agency in the UK.

Content link
The environmental impact of global agribusiness is explored further in unit 6.2.

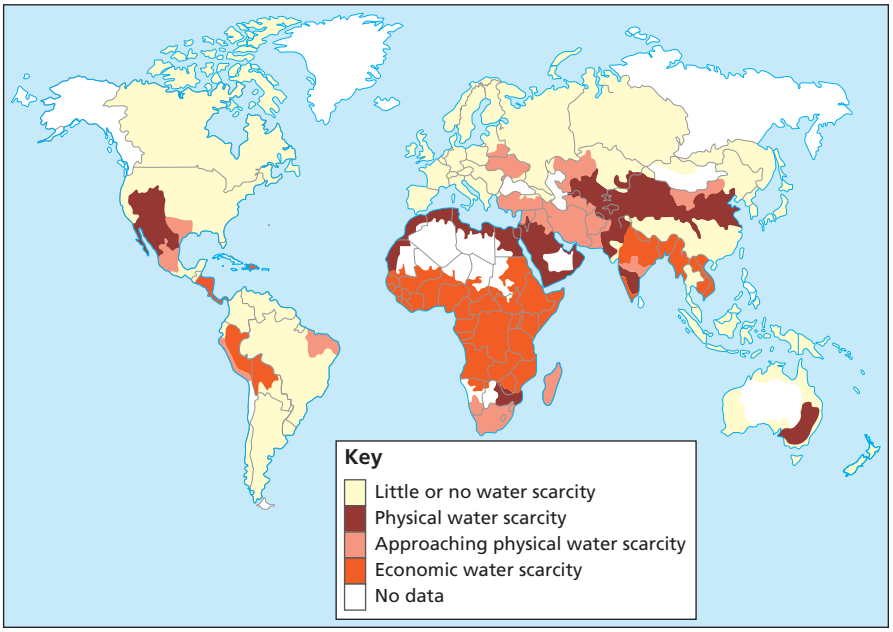
Concept link
POWER: As water becomes more scarce due to the effects of global climate change, population growth and increased consumerism, the opportunity to access water can be decided by the power of a place. The places upstream in a drainage basin have the upper hand in controlling the amount of water to reach places further along the course of a river. In addition, the quality of the water can decrease due to agricultural and industrial processes, which can also negatively affect places.

Case study: The role of different stakeholders in North Carolina, USA

Jordan Lake suffers from eutrophication due to nutrient rich run-off into tributaries that feed into the lake. A number of different stakeholders are involved in this issue, such as the state government which has the power to provide funding for the clean-up of the lake and the national government which is able to put in place rules for industry and agriculture. Here are some of the stakeholders:

- 300,000 people who rely on the lake for drinking water
- The Environmental Protection Agency (EPA), which enforces legislation from the Clean Water Act
- The state government of North Carolina, which provides funding for cleaning the lake
- The Army Corp of engineers who maintain the lake and dam
- Clean Jordan Lake is an environmental organization that organizes volunteers to help clean the lake
- 30 animal-feeding operations
- 12 wastewater treatment facilities.

▼ **Figure A.3.1.** Distribution of water scarcity



Test yourself

A.13 Distinguish between physical and economic water scarcity. [2]

A.14 Study figure A.3.1, which shows the distribution for different types of water scarcity.

Describe the pattern of economic water scarcity. [3]

A.15 Examine how agriculture can have a negative impact on freshwater. [2+2+2]

Growing human pressures on lakes and aquifers, including economic growth and population migration

Aquifers (rocks that contain significant quantities of water) are not subject to evaporation, but they are at risk of significant depletion due to population increase via migration and also from economic growth. Economic growth can create pressure as consumption increases due to industrial processes requiring greater amounts of water as an input. In addition, economic growth may result in an increase in disposable incomes and the growth of a country's middle-class. A person's diet may change, with increased consumption of food, which leads to increased agricultural production and increased stress on water sources.

Groundwater is an important source of freshwater around the world. Aquifers can be either unconfined (they can be recharged via percolation) or confined (the water is enclosed between layers of impermeable rock). For confined aquifers, the recharge has to take place artificially since percolation is not possible.

Internationally shared water resources as a source of conflict

The political borders of countries and the watersheds of drainage basins are never a perfect fit. Many drainage basins straddle two or more countries. The residents of those countries may rely on the same freshwater source, on the surface and/or underground, to fulfill their needs. Agreements are often needed in order that water is shared equitably and consumption by the different stakeholders is environmentally sustainable. This becomes increasingly important as economic development takes place and populations increase.

Case study: Internationally shared water resource

Over recent decades there has been tension between the 11 countries that share the waters of the River Nile. Uganda, Egypt, the Republic of the Sudan, South Sudan, Rwanda, Burundi, Ethiopia, Kenya, Tanzania, Eritrea and the DRC all have a vested interest in the Nile since the drainage basin falls within each country's borders (it covers 10% of Africa's landmass). Egypt has a long-established historic agreement signed in 1929 and amended in 1959, which gives it (and the Republic of the Sudan) full access to water from the Nile, its only source of water, and an ability to veto any plans to restrict water upstream, such as the building of a dam.

Assessment tip

For short-response questions, try to avoid writing a long list of country names when you are asked to describe data shown on a map. As a geographer, you should be skilled at identifying general patterns and anomalies. You will only receive 1 mark at most for a 3-mark question if you provide a list. A 3-mark question will require three distinct patterns when describing a map. A useful strategy would be to comment on the pattern, the extremes and any anomalies.

Assessment tip

Be aware that the syllabus specifically requires you to connect a *human reason* (such as irrigation) with salinization.

In order to generate hydroelectric power for the country and to export it to other countries, Ethiopia decided to build the Grand Ethiopian Renaissance Dam (GERD) on the Blue Nile (the White and Blue Nile join to form the River Nile) and construction began in 2011. Egypt was immediately concerned since it expected a 25% reduction in the water that it would normally receive. At one point, a former Egyptian president proposed military action against Ethiopia.

Despite this past friction, in March 2015, Egypt, the Republic of the Sudan and Ethiopia signed a Declaration of Principles agreement. Part of the agreement was that an independent assessment would take place to evaluate the impact of the dam and ensure that each country would not be affected detrimentally. This independent assessment has never been published due to issues around getting access to accurate information from each country. Therefore, tension remains between the three countries, especially when other issues are considered, such as reduced rainfall and a growing population in Nile basin countries.

Test yourself

A.16 Suggest possible challenges for countries that have to share a source of freshwater. [2+2]

A.4 WATER MANAGEMENT FUTURES

- **Integrated drainage basin management (IDBM)** – a comprehensive approach to the planning and management of a drainage basin involving a variety of different stakeholders in order that there is a balance between economic development and environmental impact.
- **Wetlands** – areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt.

You should be able to show examples of future possibilities for management intervention in drainage basins:

- ✔ The importance of strengthening participation of local communities to improve water management in different economic development contexts, including sustainable water use and efficiency, and ensuring access to clean, safe and affordable water;
- ✔ Increased dam building for multipurpose water schemes, and their costs and benefits;
  - ✔ Case study of contemporary dam building expansion in one major drainage basin;
- ✔ The growing importance of integrated drainage basin management (IDBM) plans, and the costs and benefits they bring;
- ✔ Growing pressures on major wetlands and efforts to protect them, such as the Ramsar Convention;
  - ✔ Case study of the future possibilities for one wetland area.

Concept link

POSSIBILITIES: Possibilities from managing freshwater within a drainage basin can bring benefits and problems at a variety of scales. The implementation of IDBM aims to bring benefits to all stakeholders in a basin, whether they live in different countries or have different priorities.

Strengthening participation of local communities to improve sustainable water use

The sustainable use of water at a national and international level has already been discussed in this chapter. Local communities can also improve the management of their water supplies by recycling water for residential gardens or using more efficient irrigation methods, such as drip irrigation pioneered in Israeli communities, to ensure that no water is wasted when growing crops. Empowering local people is another benefit of community involvement in safeguarding water supplies. The Self-Employed Women's Association (SEWA) in India is just one example of how women are trained to repair hand pumps in order that rural areas can secure clean water without having to walk several miles to an alternative source.

Increased dam building for multipurpose water schemes

Multipurpose dam schemes can provide protection against flooding and an area for recreation and fishing. They can also generate significant amounts of energy in a manner that has fewer emissions than the continual burning of fossil fuels. However, they can be detrimental to the natural environment. The difference in temperature between the water downstream and the water released from the reservoir causes problems for fish, while evaporation and siltation can reduce the amount of water in the reservoir and the potential for generating energy. The construction of dams releases large amounts of carbon dioxide due to the amount of concrete required. The money used to build a dam could also be used instead to significantly improve many aspects of a country, such as health and education.

Case study: Contemporary dam building expansion—the Lesotho Highlands Water Project (LHWP)

▼ **Figure A.4.1.** The Katse Dam in Lesotho

The Lesotho Highlands Water Project (LHWP) is a complex network of pipelines, tunnels and dams which divert water from Lesotho to the Gauteng region in South Africa (cities such as Johannesburg, Pretoria and Vereeniging) and the dams generate hydroelectric power for Lesotho. Lesotho has a surplus of water and the whole country is enclosed within the Orange river drainage basin. Once fully completed, the LHWP will have five dams with 2,000 million cubic metres of water transferred through 200 km of tunnels from Lesotho to South Africa every year. This is a significant engineering project with three phases of construction. The first was completed in 2004 and the second is to be finished in 2025, with no date given for the third phase. For Phase 1, approximately 4,857 hectares of arable land were flooded and 3,400 households were relocated to create the reservoirs necessary behind the Mahole and Katse dams. The Katse Dam was opened in 1998 and then the Mahole Dam in 2004. The Polihali Dam will be completed by 2025 as part of Phase 2.

The benefits for Lesotho were 16,000 jobs created during Phase 1, with 3,000 more jobs in Phase 2, over US$500 million in water sales and US$71 million from the sale of electricity by 2016. South Africa received much cleaner water which did not require treatment. The costs were that 20,000 people were displaced during Phase 1, and 17 more villages will be relocated during Phase 2. Inadequate compensation was provided to the people, and bribery was uncovered involving 12 construction companies during Phase 1 with allegations of malpractice during Phase 2.

The growing importance of integrated drainage basin management (IDBM) plans, and the costs and benefits they bring

As you have already seen a number of times in this chapter, growing populations, economic development and global climate change bring challenges when trying to please different stakeholders economically and socially, while also aiming to achieve environmental sustainability. IDBM tries to achieve all of these with the mutual cooperation of different stakeholders and different countries.

Test yourself

A.17 Suggest reasons why the benefits gained from the construction of large dams may outweigh any costs. [3+3]

A.18 Briefly **outline** what is meant by the term IDBM. [2]

A.19 Describe an IDBM using an example that you have studied. [3]

A.20 Suggest how an IDBM can bring both costs and benefits to different stakeholders. [3+3]

▼ **Figure A.4.2.** Wetlands in a periglacial environment

Growing pressures on major wetlands and efforts to protect them, such as the Ramsar Convention

The Ramsar Convention—the Convention on Wetlands—was signed in Ramsar in Iran in 1971. It is a treaty that was signed by a number of governments in order to protect the unique ecology of wetlands. The UN Environment Programme (UNEP) estimates that about 6% of the world's land surface can be classified as wetlands.

Case study: The future possibilities for one wetland area—the Iraqi Marshes

The Iraqi Marshes are an area of wetlands in the south-east of Iraq. The area is home to the Marsh Arabs, who live on the water in a way that is unique to this part of the Middle East. In recent decades, their life has been made difficult due to Saddam Hussein draining the marshes to punish the Arabs for being disloyal during the Iran–Iraq war in the 1980s and the invasion of nearby Kuwait in 1990. By draining water from the marshes via a series of dams upstream, Hussein forced the Marsh Arabs out of the area, displacing over 200,000 people. By 2003, the wetlands had shrunk by 90%. Livestock perished, revenue decreased, and the unique culture of the Marsh Arabs was devastated.

The UN began a programme to restore the marshes in 2003 and by 2006, 50% of the marshes had been rejuvenated.

In 2016, the area was designated as a UNESCO World Heritage site, and by 2017 some families had returned to the area thanks to further initiatives from the Iraqi government.

Several thousand families now make a living from fishing and buffalo herding, while native birds are present once more. Domestic tourism has been increasing, with groups touring the wetlands and watching the migratory birds such as eagles and pelicans. However, the situation with sectarian conflict in Iraq and the rise of ISIS has meant that few tourists from outside Iraq have visited.

There are positive possibilities, but there are some negative issues too. Turkey is planning to build a series of dams that will starve the rivers Euphrates and Tigris of potentially 40–50% of their normal waters and thus once again decimate the Iraqi wetlands.

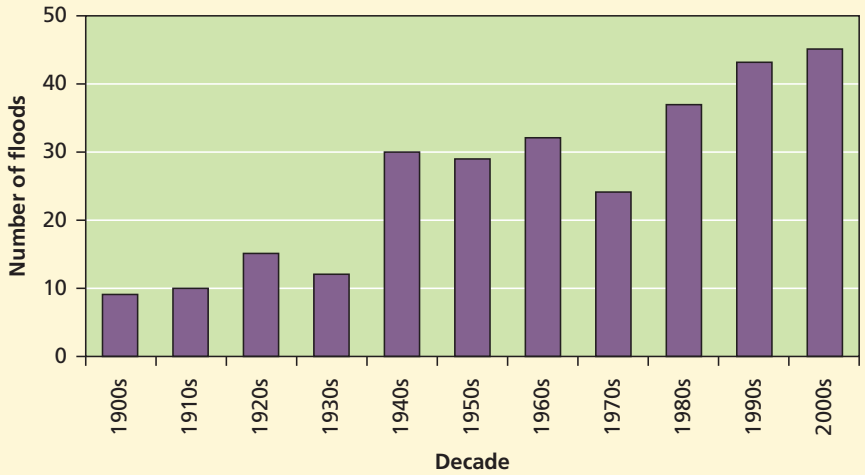
Test yourself

A.21 Define the term "wetlands".

A.22 Outline the value of wetlands.

QUESTION PRACTICE

The graph below shows the number of floods per decade for a river.



Source of data: International Baccalaureate Organization (2016)

a) **Describe** the changes in flood frequency shown on the graph. [2]

b) **Outline** one flood prediction strategy. [2]

c) **Suggest** one physical reason and one human reason why the risk of a river flooding can change over time. [3 + 3]

Essays

Either: **Examine** the role of river deposition in the formation of floodplain landforms. [10]

Or: **Evaluate** the costs and benefits of river flooding. [10]

How do I approach these questions?

a) This 2-mark question will require two distinct points and the inclusion of data. Try to categorize changes that have taken place over time and write one sentence for each time period. Consider the general trend, periods of significant increase or decrease and any anomaly that is not part of the general trend. Do not forget to include data in your answer.

b) A brief account or summary is required for this question; it is worth 2 marks so two or three sentences will be sufficient.

c) For each factor (one natural and one artificial) it will be necessary to clearly state the factor, and then explain in detail how it links to increased or reduced flooding. It would also be appropriate to try and include an example for each of the factors.

First essay choice:

The command term is "examine", and because of this you will need to ensure that the relationships between the river processes and the formation of landforms on a floodplain are discussed. Consider how some landforms are a product of deposition and other landforms require other fluvial processes. Try to ensure that your paragraphs have a focus, and be prepared to draw an annotated sketch that explains how **processes** help to form different landforms on the floodplain.

Second essay choice:

"Evaluate" is the command term for the alternative essay response, and therefore you will need to ensure that you offer a measured response, with both costs and benefits detailed in your answer. In order to provide context and to substantiate the positive and negative effects, you will need to include relevant case studies with detail. Conceptual connections are possible: you can outline how flooding can be beneficial to a **place** in terms of how the land around a river is used.

SAMPLE STUDENT ANSWER

a) The general trend of flood frequency from the 1900s to the 2000s is increasing. Between the 1900s and 1920s is quite a large jump from about 9 floods to approximately 15 floods. There is a decrease between 1920s and 1930s from approx. 15 floods to about 11 floods in the 1930s. Between 1930s and 1940s is the largest increase from 11 floods to 30 floods in 1940s. Relatively staying the same between 1940s to 1960s but a small decrease in 1950s.

▲ General increase a valid point

▲ Significant increase a valid point

This is a comprehensive answer that includes plenty of data and achieves full marks. Given the time constraints in an exam, it would be more appropriate to include less content since two sentences would have been sufficient.

Increasing number of floods = 1 mark

Flood-rich period 1940s–1960s = 1 mark

Marks 2/2

b) Weather forecasting and tracking weather systems is one way that authorities are able to predict floods.

This answer includes a valid strategy, but it requires development in order to link the strategy to flood prediction. For example, the monitoring of any future increases in precipitation can aid authorities in making predictions for potential flooding when also considering river levels and soil moisture. The answer only states or identifies a strategy rather than providing an outline.

Mark 1/2

▲ Increased precipitation

▼ Lacking development/ explanation/examples

▲ Channelization

c) The amount of precipitation received in an area can affect the discharge of a river as additional water will fall in the channel. The human interferences such as flood management, for example channelization, can create negative effects. This is because places further downstream that have not implemented channelization will see an increase in discharge resulting in flood as the size of the channel cannot cope with the excess water.

Increased precipitation, but quite simplistic development = 1 mark

Channelization = 1 mark

Explanation is present via a reduction in capacity for places downstream to cope with an increase in discharge = 1 mark

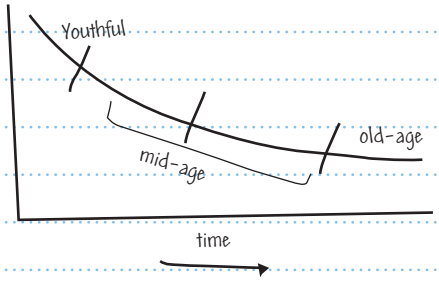
This answer requires more depth. For the physical reason, precipitation could be further developed by explaining that additional volume will be added to the river via overland flow and throughflow. In addition, antecedent moisture could be present from a previous rainfall event, which would further increase overland flow and the risk of flooding. An example would ensure that 3 marks for the physical factor would be credited. The human part of the answer is better since there is more explanation, and an example of where channelization has caused flooding would provide the third mark for this part of the answer.

Marks 3/6

Essay

Either: Examine the role of river deposition in the formation of floodplain landforms.

Floodplain landforms are caused by different river processes the further down or upstream a landform is.



Due to discharge, and velocity upstream and gradient also playing a major role, the landforms may be different due to erosion taking place such as hydraulic action, abrasion and attrition.

▲ Processes

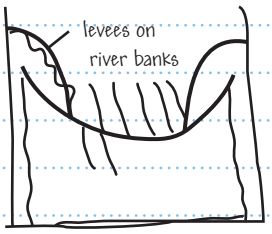
Eroding the large rocks and turning to matter that can be transported downstream and the formation of larger levees begin to form as the velocity of the rivers gets slower the centre of the river will be the fastest as it will be the largest wetted perimeter leaving less friction hence deposition on the sides of the river as less velocity and matter cannot be transported as it's too heavy therefore it is deposited.

▲ Landform

▼ This is a very long sentence and it should be broken down in order to achieve greater clarity

▲ Deposition—link to the question

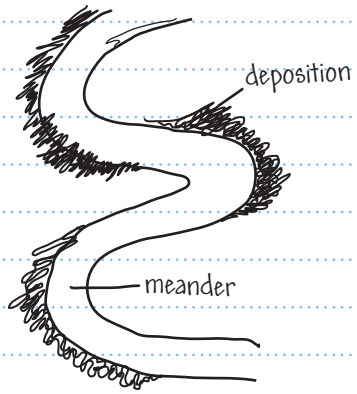
▲ Processes



Just like the formation of oxbow lakes the velocity is higher on the inner side of the river making it deposit on the outer.

▲ Landform

▼ This is incorrect; the velocity is higher on the outer side of the meander, and will deposit on the inner side.



Rivers have different stages such as the upper, the middle and the lower courses and these sections will have different landforms present as the influence of erosion and deposition will differ.

Some sentences are very long, and the essay would benefit from being more structured with clear, focused paragraphs. Some appropriate terminology has been included although more could have been included such as 'slip-off slopes' for the inside of a 'meander'. The drawings do not add much value to the response since they lack annotations and a limited amount of content is provided in the response. Floodplains and deltas could have been discussed, as well as providing a clearer explanation of the formation of a meander.

Marks 4/10

Or: Evaluate the costs and benefits of river flooding.

River flooding tends to occur on an annual basis in most basins due to climatic conditions such as snowmelt in spring, monsoonal rains, and more. The effects of this flooding can be detrimental. However, the relative consistency of these means that communities living within floodplains can adequately prepare in order to avoid detrimental effects and even benefit from flooding. An example of this is Bangladesh, where 30% of the country floods annually due to a combination of its three main rivers – the Brahmaputra, Ganges and Meghna – flooding due to Himalayan snowmelt in the spring paired with heavy monsoonal rains. These floods lead to improved soil fertility (as sediment/alluvium is deposited over the floodplain), which benefits agricultural productivity. This also causes the country's aquifers to be restored, increasing the groundwater supply. This is highly important in a highly densely populated country like Bangladesh, which may be at risk of water scarcity without these floods. Due to the inexistence of sewage treatment plants due to the country's poverty, water cannot always be extracted from the river, and therefore the natural filtration system of aquifers is even more important.

Floods also help to flush away these pollutants, increasing the overall well-being of local ecosystems as well as the aforementioned benefit of eradicating the country's high pollution in its rivers.

As can be seen, the effects of these annual floods can be

▲ Appropriate terminology

▲ Relevant example with detail

▲ Appropriate terminology

▲ Benefit

▲ Benefit

▲ Application to example

▲ Application to example

▲ Benefit

highly beneficial, especially for a nation like Bangladesh that doesn't have very developed urban settlements and relies primarily on agriculture. However, the volatility of global climate on an increasing scale due to climate change means that these floods are not entirely predictable, and can have devastating negative consequences.

▲ Case study knowledge

▼ This final sentence is not aligned with the rest of the paragraph, which discusses the benefits of flooding

Normal floods can destroy settlements, kill livestock and destroy infrastructure, however their unpredictability means their consequences can be mitigated. Intense floods, such as the Bangladesh flood of 2017, can be devastating due to their unexpected nature. This particular case was caused by synchronized discharges of the three rivers due to abnormally intense monsoon rains at the same time as high snowmelt. The effects were consolidated by Himalayan foothill deforestation as well as a high water table due to consistent antecedent rainfall. This led to the largest flood in modern history and devastated the low-lying delta nation. It killed over 100 people and 6 million people were affected. Its effects were consolidated by Bangladesh's poverty, however the flood's negative consequences were immense. Here it can be seen that despite consistent flooding being beneficial, the potential for a large-scale unexpected flood can arise and be highly damaging.

▲ Structure

▲ Negative consequences

▲ Relevant example

▲ Appropriate terminology

▲ Appropriate terminology

▲ Negative impacts, case study detail

In conclusion, I disagree with the statement that the negative consequences always outweigh benefits, given that it is often the benefits of flooding that maintain the survival of these river/delta communities. However, climatic volatility can lead to large floods which communities aren't prepared for, which can often be devastating enough to make the benefits of flooding appear meagre in comparison.

▲ Effective summary with no new information included, aligned with the rest of the essay

Detailed explanation of the problems and benefits with an evaluation.

Marks 10/10