



EDEXCEL INTERNATIONAL GCSE (9–1)

GEOGRAPHY

Student Book

Michael Witherick



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GCSE (9–1)

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ACKNOWLEDGEMENTS	II, 278
COURSE STRUCTURE	IV
ABOUT THIS BOOK	VI
ASSESSMENT OVERVIEW	VIII
SECTION A: PHYSICAL ENVIRONMENTS	
CHAPTER 1: RIVER ENVIRONMENTS	2
CHAPTER 2: COASTAL ENVIRONMENTS	32
CHAPTER 3: HAZARDOUS ENVIRONMENTS	64
SECTION B: HUMAN ENVIRONMENTS	
CHAPTER 4: ECONOMIC ACTIVITY AND ENERGY	96
CHAPTER 5: RURAL ENVIRONMENTS	128
CHAPTER 6: URBAN ENVIRONMENTS	156
SECTION C: GLOBAL ISSUES	
CHAPTER 7: FRAGILE ENVIRONMENTS AND CLIMATE CHANGE	182
CHAPTER 8: GLOBALISATION AND MIGRATION	212
CHAPTER 9: DEVELOPMENT AND HUMAN WELFARE	240
GLOSSARY	270
INDEX	275

SECTION A: PHYSICAL ENVIRONMENTS

CHAPTER 1: RIVER ENVIRONMENTS 2

- 1.1 THE HYDROLOGICAL CYCLE – A CLOSED SYSTEM 4
- 1.2 DRAINAGE BASINS AND THEIR FEATURES 5
- 1.3 RIVER REGIMES AND HYDROGRAPHS 7
- 1.4 FLUVIAL PROCESSES 9
- 1.5 DOWNSTREAM CHANGES IN RIVER CHARACTERISTICS 11
- 1.6 DOWNSTREAM CHANGES IN RIVER LANDSCAPES 12
- 📦 THE RIVER TAY (UK) AND ITS VALLEY 15
- 1.7 WATER USES, DEMAND AND SUPPLY 17
- 1.8 WATER QUALITY AND SUPPLY 20
- 📦 RIVER MANAGEMENT LESSONS FROM SPAIN/
RIVER MANAGEMENT LESSONS FROM CHINA/
PLANS TO MANAGE THE BLUE NILE, ETHIOPIA 24–27
- 1.9 FLOODING – CAUSES AND CONTROL 27
- CHAPTER QUESTIONS 31

CHAPTER 2: COASTAL ENVIRONMENTS 32

- 2.1 COASTAL PROCESSES 34
- 2.2 COASTAL LANDFORMS 35
- 2.3 FACTORS AFFECTING COASTAL ENVIRONMENTS 40
- 2.4 COASTAL ECOSYSTEMS OF THE WORLD 42
- 2.5 COASTAL ECOSYSTEM CHARACTERISTICS 47
- 2.6 COASTAL ECOSYSTEMS UNDER THREAT 49
- 📦 MANAGEMENT OF THE MANGROVE 51
- 2.7 COASTAL CONFLICTS 52
- 2.8 COASTAL FLOODING 55
- 2.9 COASTAL MANAGEMENT STRATEGIES 56
- 📦 COASTAL MANAGEMENT IN THE GAMBIA/
COASTAL MANAGEMENT IN SRI LANKA/
COASTAL MANAGEMENT IN THE UK 58–62
- CHAPTER QUESTIONS 63

CHAPTER 3: HAZARDOUS ENVIRONMENTS 64

- 3.1 DIFFERENT TYPES OF HAZARD 66
- 3.2 TROPICAL CYCLONES 67
- 3.3 VOLCANIC ERUPTIONS AND EARTHQUAKES 69
- 3.4 THE SCALE OF TECTONIC HAZARDS 74
- 3.5 IMPACTS OF TECTONIC HAZARDS 75
- 📦 EARTHQUAKES IN NEPAL/EARTHQUAKES IN
CENTRAL ITALY/MOUNT MERAPI ERUPTION/
MOUNT ONTAKE ERUPTION 76–79

- 3.6 REASONS FOR LIVING IN HIGH-RISK AREAS 80
- 3.7 TROPICAL CYCLONES AND THEIR IMPACTS 82
- 📦 HURRICANE KATRINA HITS THE USA/
TYPHOON HAIYAN HITS THE PHILIPPINES 84–86
- 3.8 PREDICTING AND PREPARING FOR EARTHQUAKES 87
- 3.9 RESPONDING TO HAZARDS 92
- 📦 PREPARING FOR EARTHQUAKES IN INDIA 94
- CHAPTER QUESTIONS 95

SECTION B: HUMAN ENVIRONMENTS

CHAPTER 4: ECONOMIC ACTIVITY AND ENERGY 96

- 4.1 ECONOMIC SECTORS AND EMPLOYMENT 98
- 4.2 FACTORS AFFECTING THE LOCATION OF ECONOMIC ACTIVITIES 102
- 4.3 CHANGES IN SECTOR EMPLOYMENT 104
- 4.4 SECTOR SHIFTS IN THREE COUNTRIES 107
- 📦 ETHIOPIA (PRE-INDUSTRIAL)/CHINA (RAPIDLY EMERGING)/THE UK (POST-INDUSTRIAL) 108–110
- 4.5 INFORMAL EMPLOYMENT 110
- 📦 4.5 DHAKA, BANGLADESH 112
- 4.6 POPULATION AND RESOURCES 112
- 4.7 RISING ENERGY DEMAND 114
- 4.8 RENEWABLE VERSUS NON-RENEWABLE ENERGY 118
- 4.9 SUSTAINABLE ENERGY 122
- 📦 ENERGY RESOURCE MANAGEMENT IN QATAR/
ENERGY RESOURCE MANAGEMENT IN INDIA/
ENERGY RESOURCE MANAGEMENT IN NEPAL 123–126
- CHAPTER QUESTIONS 127

CHAPTER 5: RURAL ENVIRONMENTS 128

- 5.1 BIOMES AND THEIR GLOBAL DISTRIBUTIONS 130
- 5.2 THE GOODS AND SERVICES OF ECOSYSTEMS 132
- 5.3 THE IMPACTS OF ECOSYSTEM EXPLOITATION 134
- 📦 TROPICAL RAINFOREST IN BRAZIL 134
- 5.4 CHARACTERISTICS OF RURAL ENVIRONMENTS 138
- 5.5 RURAL CHANGE IN THE UK 140
- 📦 CHANGING RURAL AREAS OF THE UK 140
- 5.6 RURAL CHANGE IN CHINA AND KENYA 143
- 📦 RURAL CHANGE IN CHINA/
RURAL CHANGE IN KENYA 144–145
- 5.7 THE DIVERSIFICATION OF FARMING AND FARMS 146
- 📦 FARM DIVERSIFICATION IN THE UK 146

■ 5.8 SUSTAINABLE RURAL LIVING	148
📦 MAKING RURAL LIVING SUSTAINABLE IN CHINA/ MAKING RURAL LIVING SUSTAINABLE IN KENYA	148–151
■ 5.9 MANAGING RURAL CHALLENGES	152
■ CHAPTER QUESTIONS	155

CHAPTER 6: URBAN ENVIRONMENTS 156

■ 6.1 URBANISATION AND ITS PROCESSES	158
■ 6.2 URBANISATION AND THE RISE OF MEGACITIES	162
■ 6.3 THE PROBLEMS OF RAPID URBANISATION	164
■ 6.4 THE URBAN LAND-USE PATTERN	166
■ 6.5 URBAN CHALLENGES IN THE DEVELOPED WORLD	168
📦 HONG KONG	168
■ 6.6 URBAN CHALLENGES IN THE DEVELOPING AND EMERGING WORLDS	170
■ 6.7 DEVELOPMENTS ON THE URBAN FRINGE	173
■ 6.8 MAKING URBAN LIVING MORE SUSTAINABLE	175
📦 MASDAR CITY, ABU DHABI (UAE)/CURITIBA, BRAZIL/ URBAN GARDENS, AFGHANISTAN	176–178
■ 6.9 MANAGING URBAN CHALLENGES	178
■ CHAPTER QUESTIONS	181

SECTION C: GLOBAL ISSUES

CHAPTER 7: FRAGILE ENVIRONMENTS AND CLIMATE CHANGE 182

■ 7.1 FRAGILE ENVIRONMENTS	184
■ 7.2 CAUSES OF DESERTIFICATION AND DEFORESTATION	188
📦 DESERTIFICATION OF THE SAHEL	189
■ 7.3 THE CAUSES OF CLIMATE CHANGE	192
■ 7.4 THE IMPACTS OF DESERTIFICATION	195
■ 7.5 THE IMPACTS OF DEFORESTATION	196
■ 7.6 THE IMPACTS OF CLIMATE CHANGE	198
■ 7.7 DEALING WITH DESERTIFICATION	203
■ 7.8 MANAGING RAINFORESTS IN A SUSTAINABLE WAY	204
📦 BRAZIL'S SEARCH FOR WAYS TO CONSERVE ITS RAINFOREST	206
■ 7.9 RESPONSES TO GLOBAL WARMING AND CLIMATE CHANGE	207
📦 THE UK'S RESPONSE/CHINA'S RESPONSE/ SOLOMON ISLANDS' RESPONSE	208–210
■ CHAPTER QUESTIONS	211

CHAPTER 8: GLOBALISATION AND MIGRATION 212

■ 8.1 THE RISE OF THE GLOBAL ECONOMY	214
■ 8.2 THE ROLES OF GLOBAL INSTITUTIONS	216
■ 8.3 THE GROWING VOLUME OF MIGRATION	218
■ 8.4 THE IMPACTS OF GLOBALISATION	222
■ 8.5 THE IMPACTS OF MIGRATION	223
📦 SIX MIGRATION EXAMPLES	224–225
■ 8.6 THE IMPACTS OF GLOBAL TOURISM	226
📦 SPAIN'S COSTA BLANCA	229
■ 8.7 GEOPOLITICAL RELATIONSHIPS	230
■ 8.8 MANAGING MIGRATION	234
📦 THE UK'S MANAGEMENT OF IMMIGRATION	234
■ 8.9 MAKING TOURISM MORE SUSTAINABLE	235
📦 THE GAMBIA/BHUTAN ECOTOURISM/CYPRUS	236–238
■ CHAPTER QUESTIONS	239

CHAPTER 9: DEVELOPMENT AND HUMAN WELFARE 240

■ 9.1 DEFINING DEVELOPMENT AND HUMAN WELFARE	242
■ 9.2 CONTRIBUTORS TO DEVELOPMENT AND HUMAN WELFARE	245
■ 9.3 MEASURING DEVELOPMENT AND QUALITY OF LIFE	246
■ 9.4 UNEVEN DEVELOPMENT	252
■ 9.5 THE IMPACTS OF UNEVEN DEVELOPMENT	256
📦 ITALY – A DIVIDED COUNTRY	256
■ 9.6 DEMOGRAPHIC CHARACTERISTICS OF COUNTRIES AT DIFFERENT LEVELS OF DEVELOPMENT	258
■ 9.7 STRATEGIES TO REDUCE UNEVEN DEVELOPMENT	261
■ 9.8 CLOSING THE DEVELOPMENT GAP	263
■ 9.9 CONTRASTING APPROACHES TO THE PROMOTION OF DEVELOPMENT	264
📦 NIGERIA'S COASTAL RAILWAY/THE UK'S HS2 PROJECT/WATERAID PROJECTS IN KENYA/SOUTH AFRICA'S AGRICULTURAL CO-OPERATIVES	265–268
■ CHAPTER QUESTIONS	269

GLOSSARY 270

INDEX 275

ACKNOWLEDGEMENTS II, 278

ABOUT THIS BOOK

This book is written for students following the Pearson Edexcel International GCSE (9–1) Geography specification.

This book has been structured so that it can be used in order, both in the classroom and for independent learning. It explains and illustrates all the subject content of the specification; it is on the knowledge and understanding of this content that the student will be examined.

Each chapter has a short introduction to help students start thinking about the topic. It also sets out the learning objectives which will be covered by the end of the chapter.

Throughout the book there are margin boxes setting a range of different tasks. All of them are aimed at helping master the content and skills required.

In their study of the nine topics, students have to include at least two countries as case studies. One should be a developed country; the other either an emerging or a

developing country. In this book, all options are covered so that in each chapter there are at least three national case studies that cover the three main levels of economic development. An important aspect of these country case studies is comparison. Those comparisons should be between the developed country and either the emerging or developing country selected.

The boxes in the margins and text do one of several things:

- 1 Ask short questions to check knowledge and understanding (**Check your understanding**)
- 2 Suggest a range of activities that build on what has been read in the chapter, from issues for discussion to exercises based on a figure or table (**Activity and Skills**).
- 3 Give you extra information or help (**Did you know?**).

There are also prompt boxes in Sections A and B with advice on making use of fieldwork. Fieldwork can be found on the ActiveBook.

184 GLOBAL ISSUES 7 FRAGILE ENVIRONMENTS AND CLIMATE CHANGE

7.1 FRAGILE ENVIRONMENTS

CHARACTERISTICS

The well-being of the Earth's physical environments is of vital importance to us all. Our living standards and our health depend on the quality of those environments. However, natural environments are very fragile. There is a delicate balance between non-living parts (climate, rocks, soils) and living parts (plants, animals). Natural hazards, such as fires, high winds and volcanic eruptions, have always disturbed environments and made them more fragile (Figure 7.1). However, in most cases, environments have recovered. For thousands of years, people have been making use of environmental resources to provide food, fuel and building materials. They have done so without causing too much environmental damage. Early people lived in harmony with the environment.

▶ Figure 7.1: Fire is a natural environmental hazard



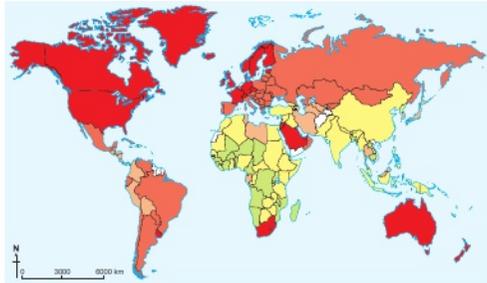
DID YOU KNOW?
Many environments are 'fragile' because of the delicate nature of most ecosystems. Look at Part 5.2 (page 032) to help you to understand why.

CHECK YOUR UNDERSTANDING
In what ways do people threaten ecosystems?

DISTRIBUTIONS

The fragility of environments is closely related to the pressure that is put on them. The ecological footprint is a measure of the mark that humans make on the natural world. It considers how much land and sea are required to provide us with the water, energy and food we need to support our lifestyles. If the Earth's resources were shared equally, it is believed that a 'fair share' for everyone would be a little less than 2 hectares of the globe. The UK has an ecological footprint of about 5.5 global hectares per person. This means that if everyone in the world consumed resources at the rate of people in the UK, we would need two more planets to sustain the world's present population. Figure 7.2 shows how the ecological footprint varies around the world. It gives us an impression of where we might expect environments to be made fragile by people.

GLOBAL ISSUES 7 FRAGILE ENVIRONMENTS AND CLIMATE CHANGE 185



Ecological footprint by country
Area units per person, 1996

- 5.0 and over Unsustainable
- 1.0-5.0 Global average 2.89
- 1.0-1.9 Sustainable
- Less than 1.0
- No data

Land needed for:

- water
- food
- energy
- raw materials
- waste disposal

Influencing factors:

- rate of population growth
- level of consumption of resources per person
- type of technology

Source: Living Planet Report. Reproduced with permission from WWF.

▶ Figure 7.2: Global variations in the ecological footprint

ACTIVITY

Identify the six countries on the southern half of the map that have unsustainable ecological footprints.

DESERTIFICATION

Desertification is the term used to describe how once-productive land gradually changes into a desert-like landscape. The process is not necessarily irreversible and, as Figure 7.3 shows, it usually takes place in semi-arid land on the edges of existing hot deserts. The worrying message illustrated by Figure 7.3 is that large areas of the world are at risk from desertification. The most conspicuous includes much of southern Asia, the Middle East and North Africa.

Did you know?
Interesting facts to encourage wider thought and understanding

Check your understanding Short questions to check your knowledge and understanding

Activity In this case an opportunity for the skill of interpreting geographical information

Glossary definitions help support understanding of academic and difficult words.

END OF CHAPTER QUESTIONS

There are three items here:

- a checklist of integrated skills recommended in the specification for the topic
- review questions using approved exam command words
- short and longer exam-style practice questions.

PHYSICAL ENVIRONMENTS 1 RIVER ENVIRONMENTS 31

CHAPTER QUESTIONS

END OF CHAPTER CHECKOUT

During your work on the content of this chapter, you are expected to have practised in class the following:

INTEGRATED SKILLS

- drawing and interpreting storm hydrographs
- using geological maps to understand drainage characteristics
- using GIS to map river systems
- using different maps to investigate the impacts of human intervention
- using and interpreting weather and climate data.

SHORT RESPONSE

- 1 Identify **one** input and **one** output of the drainage basin cycle. [2]
- 2 Suggest **two** reasons why flood plains are valuable to people. [2]
- 3 State how **one** named river channel characteristic changes downstream. [1]
- 4 Describe how a waterfall is formed. [3]

LONGER RESPONSE

- 5 Describe how a river transports its load. [4]
- 6 Examine the value of hydrographs. [6]
- 7 For a named country, analyse the sources of river pollution. [8]
- 8 Compare soft-engineering and hard-engineering approaches to the management of floods. [8]

EXAM-STYLE PRACTICE

- 1 Identify the meaning of the term 'watershed'. [1]
 - A The edge of a drainage basin
 - B The top of a waterfall
 - C The mouth of a river
 - D The soaking of water into the ground
- 2 a) Identify **one** store in the hydrological cycle. [1]
 b) State **one** flow in the hydrological cycle. [1]
 c) Explain **one** process of river erosion. [2]
- 3 Study Figure 1.24 (on page 20). Suggest **two** reasons why agriculture is such a large user of water. [4]
- 4 Explain the formation of an oxbow lake. [3]
- 5 Study Figure 1.8 (on page 8). Identify the month when the discharge of the Thames is greatest. [1]
- 6 Explain **two** ways in which people increase the flood risk. [4]
- 7 Study Figure 1.9 (on page 9). Analyse the factors affecting the distribution of high water deficits. [8]

[Exam-style practice total 25 marks]

Review questions are divided into 'short' and 'longer'. They provide quick, effective feedback on your progress.

Progression icons show the level of difficulty according to the 12 steps of the Pearson International GCSE Geography Progression Scale. Icons are provided for questions with a tariff of four marks or more.

A checklist of topic-specific **Integrated skills** recommended in the specification

For all chapter questions, an appropriate mark is given. In the case of the *Exam-style practice* section, the tariff indicates the length and depth of the answer required.

THE ACTIVEBOOK

The ActiveBook contains not only exam-type questions, but also:

- advice about the fieldwork required; questions about fieldwork will be set in Section B of both examination papers
- extra case studies for the following chapters: Chapter 1, Chapter 2 (x2), Chapter 6 (x2), Chapter 7 (x2), Chapter 8 (x4) and Chapter 9.

ASSESSMENT OVERVIEW

The following tables give an overview of the assessment for the Pearson Edexcel International GCSE (9–1) in Geography.

We recommend that you study this information closely to help ensure that you are fully prepared for this course and know exactly what to expect in the assessment.

PAPER 1	PERCENTAGE	MARK	TIME	AVAILABILITY
Physical geography Written examination paper Paper code 4GE1/01 Externally set and assessed by Edexcel	40%	70	1 hour and 10 minutes	June examination series First assessment June 2019
PAPER 2	PERCENTAGE	MARK	TIME	AVAILABILITY
Human geography Written examination paper Paper code 4GE1/02 Externally set and assessed by Edexcel	60%	105	1 hour and 45 minutes	June examination series First assessment June 2019

ASSESSMENT OBJECTIVES AND WEIGHTINGS

ASSESSMENT OBJECTIVE	DESCRIPTION	% IN INTERNATIONAL GCSE
AO1	Demonstrate knowledge of locations, places, processes, environments and different scales.	15–16
AO2	Demonstrate geographical understanding of: <ul style="list-style-type: none"> • concepts and how they are used in relation to places, environments and processes • the interrelationships between places, environments and processes. 	25–26
AO3	Apply knowledge and understanding to interpret, analyse and evaluate geographical information and issues and to make judgements.	34–35 (approx. 13% applied to fieldwork context/s)
AO4	Select, adapt and use a variety of skills and techniques to investigate questions and issues and communicate findings.	24–25 (approx. 10% used to respond to fieldwork data and context/s)

RELATIONSHIP OF ASSESSMENT OBJECTIVES TO UNITS

UNIT NUMBER	ASSESSMENT OBJECTIVE			
	AO1	AO2	AO3	AO4
Paper 1	7.1%	12.9%	17.9%	12.1%
Paper 2	8.5%	12.9%	16.2%	12.4%
Total for International GCSE	15–16%	25–26%	34–35%	24–25%

PAPER 1	DESCRIPTION	MARKS
Physical geography Paper code 4GE1/01	<p>Structure</p> <p>Paper 1 assesses 40% of the total Geography qualification. There will be two sections on the paper.</p>	Total number of marks available: 70
	<p>Section A</p> <p>This section consists of multiple-choice, short-answer, data-response, and open-ended questions.</p> <p>Students choose two out of three questions on: river environments, coastal environments, and hazardous environments.</p>	50
	<p>Section B</p> <p>This section requires students to use knowledge and understanding from research and fieldwork that they have carried out. Students are not allowed to take materials into the examination.</p> <p>Students choose one out of three fieldwork-related questions on: river environments, coastal environments, and hazardous environments.</p>	20
PAPER 2	DESCRIPTION	MARKS
Physical geography Paper code 4GE1/02	<p>Structure</p> <p>Paper 2 assesses 60% of the total Geography qualification. There will be three sections on the paper.</p>	Total number of marks available: 105
	<p>Section A</p> <p>This section consists of multiple-choice, short-answer, data-response, and open-ended questions.</p> <p>Students choose two out of three questions on: economic activity and energy, rural environments, and urban environments.</p>	50

	<p>Section B</p> <p>This section requires students to use knowledge and understanding from research and fieldwork that they have carried out. Students are not allowed to take materials into the examination.</p> <p>Students choose one out of three fieldwork-related questions on: economic activity and energy, rural environments, and urban environments.</p>	20
	<p>Section C</p> <p>This section consists of multiple-choice, short-answer, data-response, and open-ended questions.</p> <p>Students choose one out of three questions on: fragile environments and climate change, globalisation and migration, and development and human welfare.</p>	35

EXAM COMMAND WORD DEFINITIONS

This table lists the command words that may be used in the examinations for this qualification and their definitions. It is important that you understand what the question is asking, in order to answer and receive full marks.

COMMAND WORD	DEFINITION
Identify/state/name	Recall or select one or more pieces of information.
Define	State the meaning of a term.
Calculate	Produce a numerical answer, showing relevant working.
Label	Add a label/labels to a given resource, graphic or image.
Draw/plot	Create a graphical representation of geographical information.
Compare	Find the similarities and differences between two elements given in a question. Each response must relate to both elements, and must include a statement of their similarity/difference.
Describe	Give an account of the main characteristics of something or the steps in a process. Statements in the response should be developed but do not need to include a justification or reason.
Explain	Provide a reasoned explanation of how or why something occurs. An explanation requires a justification/exemplification of a point. Some questions will require the use of annotated diagrams to support explanation.
Suggest	Apply understanding to provide a reasoned explanation of how or why something may occur. A suggested explanation requires a justification/exemplification of a point.

Examine	Break something down into individual components/processes; say how each one individually contributes to the question's theme/topic and how the components/processes work together and interrelate.
Assess	Use evidence to determine the relative significance of something. Give consideration to all factors and identify which are the most important.
Analyse	Investigate an issue by breaking it down into individual components; make logical, evidence-based connections about the causes and effects or interrelationships between the components.
Evaluate	Measure the value or success of something and ultimately provide a substantiated judgement/conclusion. Review information and then bring it together to form a conclusion, drawing on evidence such as strengths, weaknesses, alternatives and relevant data.
Discuss	Explore the strengths and weaknesses of different sides of an issue/question. Investigate the issue by reasoning or argument.



1 RIVER ENVIRONMENTS

LEARNING OBJECTIVES

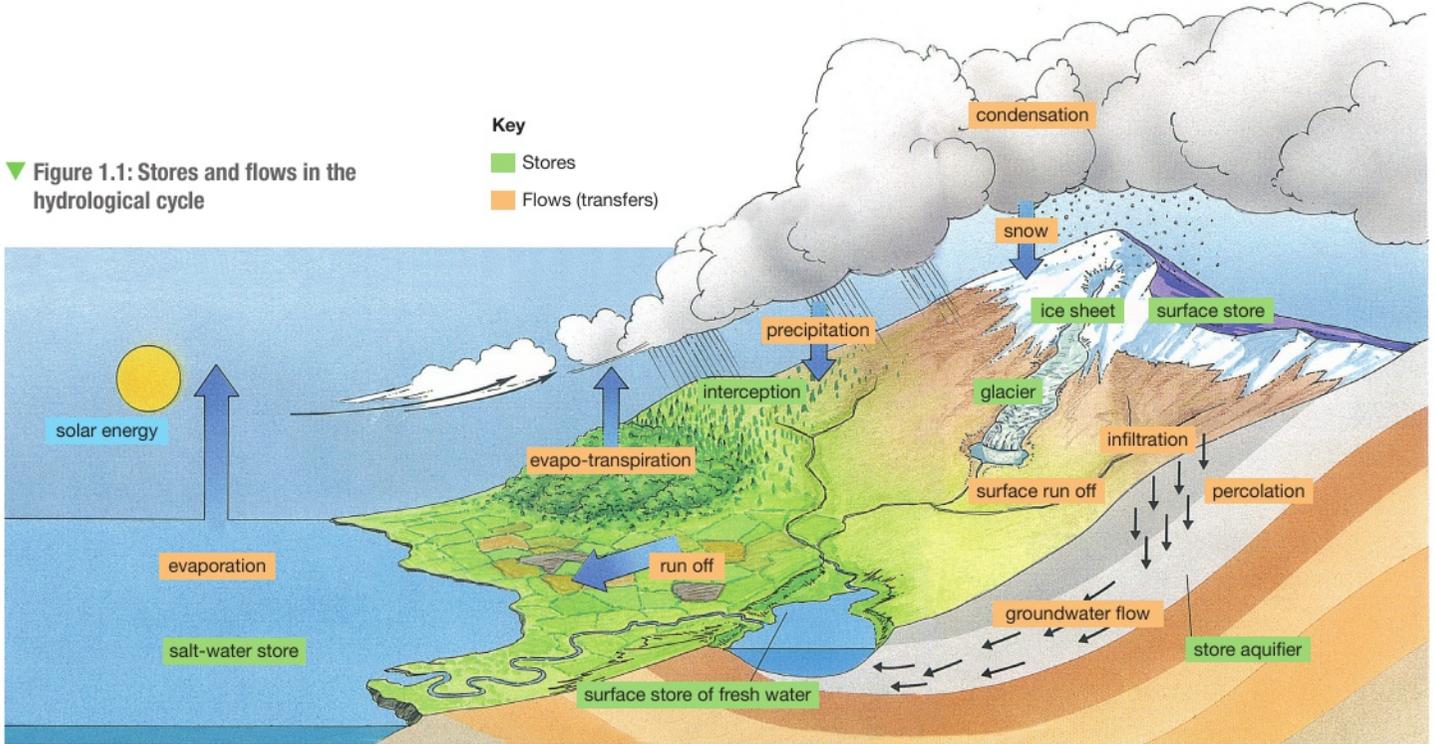
By the end of this chapter, you should know:

- How water moves through the **hydrological cycle**
- The main features of a drainage basin
- The factors affecting river regimes
- The fluvial processes involved in the formation of river channels and valleys
- How the characteristics of river channels and valleys change along the course of a named river
- The difference between upland and lowland river landscapes
- The rising demand for water and the creation of areas of water shortage and water surplus
- The importance of water quality; the storage and supply of clean water
- The causes of river flooding, and how to predict and prevent it

This chapter is about rivers. They are a vital part of the global circulation of water. Rivers are responsible for the creation of landforms found throughout the world. They are valuable to us because they supply much of the water we use in our everyday lives. At times, because of the risk of flooding, they can become hazards that threaten people and their settlements.

1.1 THE HYDROLOGICAL CYCLE – A CLOSED SYSTEM

Fresh water is essential for life on Earth. This water is constantly being recycled as it moves through what is called the hydrological cycle. This is a global circulation of water and it is a giant **closed system** (Figure 1.1). This means that there is a fixed amount of water because water neither enters nor leaves the Earth and its atmosphere.



STORES

During the hydrological cycle, water is held in a number of **stores** and then moves between them by means of a series of flows, also called **transfers**. The stores in the cycle are as follows.

CHECK YOUR UNDERSTANDING

Which store do you think holds the largest amount of water?

- The atmosphere – where the water exists either as water vapour or as minute droplets in clouds.
- The land – where water is stored on the surface in rivers, lakes and **reservoirs**. Water is taken in by plants and stored in vegetation for short periods of time. It is also stored below ground in the bedrock. This is known as the **groundwater** store (see **aquifer**). Water mostly exists in these stores in a liquid form. However, it can also exist in a solid form as snow and ice, for example in ice sheets, glaciers and snowfields.
- The sea – it is estimated that over 95 per cent of the Earth’s water is stored in the sea. This is mostly held in liquid form, but also as ice, for example the icebergs in high-latitude seas.

SKILLS REASONING

ACTIVITY

List the possible physical consequences of melting ice sheets and glaciers.

While the amount of water in the global hydrological cycle cannot change, the proportion held in the different stores can. These variations are caused by changes in the Sun’s energy. For example, an increase in the Sun’s energy will lead to more evaporation and possibly to the melting of ice sheets and glaciers.

FLOWS (TRANSFERS)

The transfers of water that take place between stores do so through a variety of **flows** as listed below.

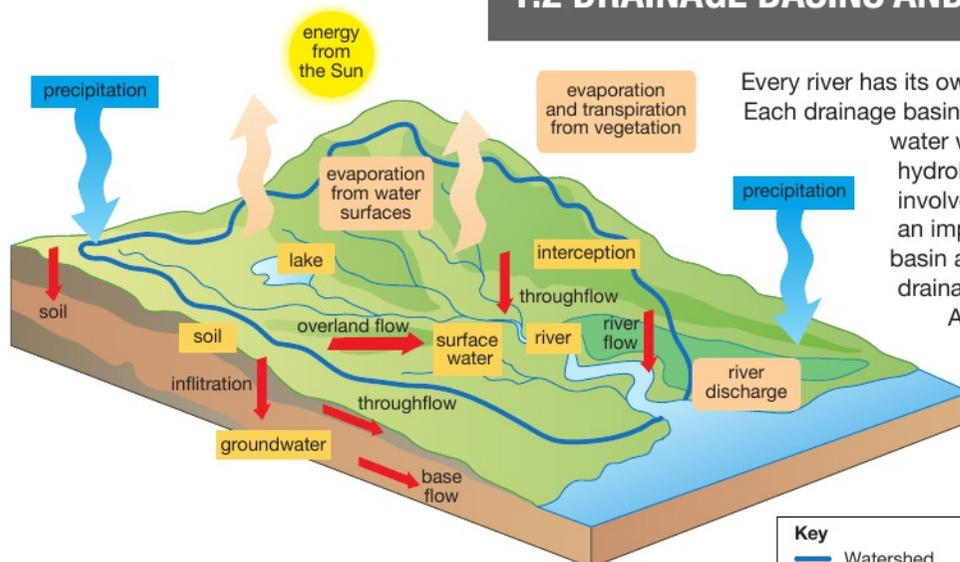
- Evaporation – the hydrological cycle starts with evaporation due to the heat of the Sun. Water is converted from a liquid into a gas (called water vapour). This takes place from the surface of the sea and from water surfaces (ponds and lakes) on land. Evaporation is particularly important in the transfer of water from the sea store into the atmosphere.
- Transpiration – plants take up liquid water from the soil and ‘breathe’ it into atmosphere as water vapour.
- **Evapotranspiration** – the loss of moisture from the ground by direct evaporation from water bodies and the soil, plus transpiration from plants.
- Condensation – the change in the atmosphere when water vapour cools and becomes liquid. The liquid takes the form of water droplets that appear in the atmosphere as clouds.
- Precipitation – the transfer of water in any form (rain, hail or snow) from the atmosphere to the land or sea surface.
- Overland flow – most precipitation that hits the ground moves due to gravity and eventually enters a stream, river or lake. This is known as run off.
- Infiltration and percolation – the transfer of water downwards through the soil and rock into the aquifer or groundwater store.
- Throughflow – this takes place between the ground surface and the top of the groundwater store. As a result of gravity, water moves slowly through the soil until it reaches a stream or river.
- Groundwater flow – this happens in the rocks of the aquifer and is the underground transfer of water to rivers, lakes and the sea.

CHECK YOUR UNDERSTANDING

What is the difference between a store and a flow?

All these transfers come together to form a circle involving the three major stores (the atmosphere, the land and the sea). We might imagine that the cycle starts and finishes in the sea. However, some of the water that falls as rain on the land may never reach the sea. Instead, it is returned directly back to the atmosphere from the land by the transpiration of plants and evaporation from both soil and water bodies

1.2 DRAINAGE BASINS AND THEIR FEATURES

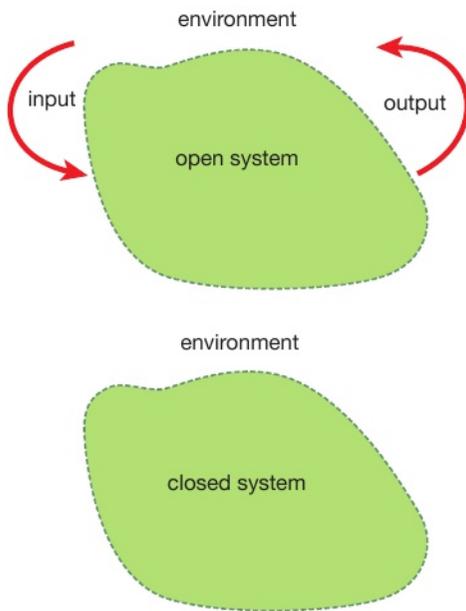


Every river has its own drainage basin or catchment area. Each drainage basin is a system. There is a movement of water within it that is rather like a small-scale hydrological cycle. The drainage basin cycle involves stores and flows (Figure 1.2). However, an important difference between the drainage basin and the hydrological cycle is that the drainage basin is an **open system** (Figure 1.3).

A drainage basin has external inputs and outputs. The amount of water in the basin system varies over time. In the hydrological cycle the amount of water remains exactly the same.



▲ Figure 1.2: The drainage basin cycle



▲ Figure 1.3: Open and closed systems

CHECK YOUR UNDERSTANDING

Why is the hydrological cycle a closed system and the drainage basin cycle an open system?

CHECK YOUR UNDERSTANDING

Is there an inland sea in the country where you live?

The inputs of a drainage basin are:

- energy from the Sun
- precipitation formed from moisture picked up outside the basin
- possibly water from tributary drainage basins – this is not shown in Figure 1.2; an explanation is given below.

The outputs are:

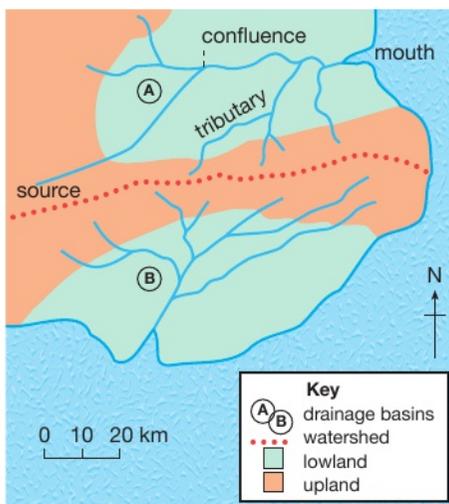
- the river's **discharge**
- the water in its basin from which evaporation and transpiration take place; this water eventually falls as precipitation in another drainage basin.

As Figure 1.4 shows, we can draw a dividing line between neighbouring drainage basins. It follows the tops of the hills and is called the **watershed**. The main river has its source in the higher parts of the basin close to the watershed. This is where most precipitation falls. Smaller streams, or tributaries, enter the main river channel at locations known as confluences. The mouth or **estuary** of the river is where it flows out into the sea.

Drainage basins can be of at least three broad types as follows.

- Those that simply collect and deliver water directly to the sea.
- Those that are parts of much larger drainage basins. For example, the basin of the River Negro in Brazil is a tributary or part of the huge drainage basin of the River Amazon. The water it collects is conveyed to the Amazon and then eventually to the sea.
- Some drainage basins do not lead, either directly or indirectly, to the open sea. Rather they lead to 'inland' seas or lakes such as the Caspian Sea located between Europe and Asia, the Aral Sea to the east of it, or Lake Victoria in East Africa.

The **channel** (or drainage) **network** is the system of surface and underground channels that collects and transports the precipitation falling on the drainage basin.



▲ Figure 1.4: Basic features of the drainage basin

Figure 1.4 shows the channel networks of two drainage basins, A and B. Basin A's network is slightly less dense (has fewer channels) than B's, though the main channel of B is shorter. Channel networks can be mapped and their lengths and densities (number of channels per unit area) measured. The network can change over short periods of time. For example, during flooding drainage basins often have many more and longer channels than they do in periods of low or normal rainfall.

Each drainage basin is unique in its combination of features. These features include size, shape, rock type, relief and land use. They determine how quickly or slowly water moves through the basin.

Figure 1.5 shows how some of these features can affect overland flow or run off. Rock type and relief are physical factors over which people have little control. But land use can be easily changed by people. Woodland holds water and slows overland flow. However, once it is cleared for cultivation, run off will speed up. The built-up areas of towns and cities can speed up run off even more. Rainwater hits solid surfaces such as roofs, pavements and roads. It is then quickly channelled into drains which speed its delivery into a stream or river.

► Figure 1.5: Factors affecting run off

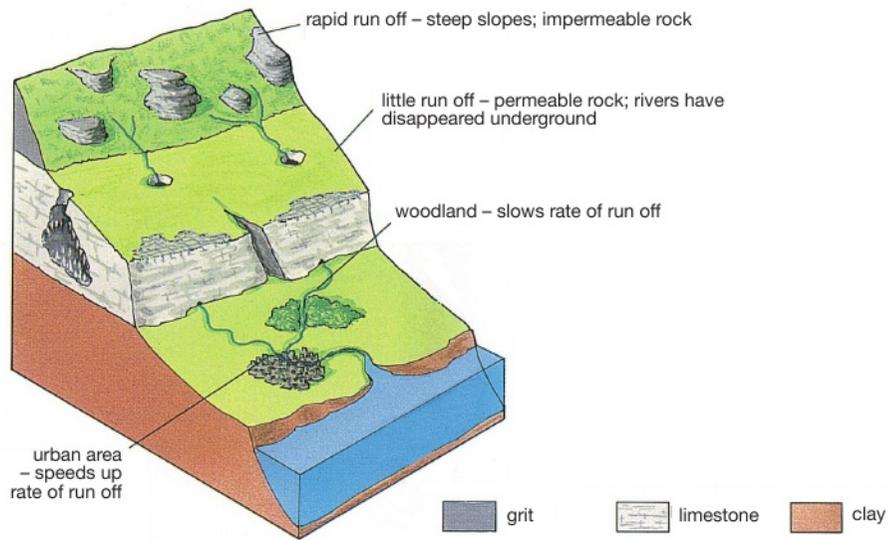
SKILLS REASONING

ACTIVITY

Suggest **two** reasons why drainage basins close to one another might have different drainage densities.

CHECK YOUR UNDERSTANDING

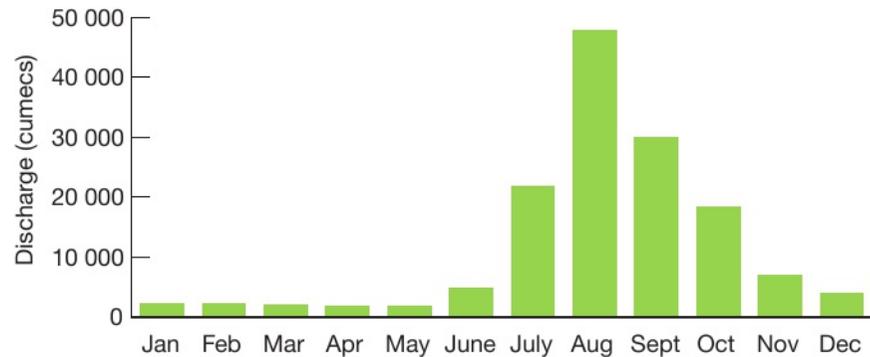
Be sure you know the difference between permeable and impermeable rocks.



1.3 RIVER REGIMES AND HYDROGRAPHS

We need to know how quickly any rain falling in a drainage basin will reach the drainage network. It is also important to know how much a river's channel can hold. If rainwater reaches the river quickly, the channel may not cope and flooding will occur. The amount of water carried by a river at any one time is known as its discharge. This is measured in cumecs – that is, in cubic metres of water per second moving past a particular point along the river's course.

► Figure 1.6: A hydrograph of the River Ganges in Bangladesh. Average monthly discharge is shown in cubic metres per second.



RIVER DISCHARGES

River discharges vary throughout the year, from month to month, from day to day. These variations make up what is termed the **river regime**. In most rivers, the regime closely reflects local climatic conditions, particularly the rainfall. Figure 1.6 shows the average monthly discharge of the River Ganges as it passes through Bangladesh. This diagram is a **hydrograph**. Clearly, mean (average) discharge is high between June and October. This period of high discharge coincides with the monsoon season, during which total rainfall can exceed 2750 mm.

► Figure 1.7: Hydrograph of the River Thames at Reading, 2001–02

SKILLS INTERPRETATION (NUMERICAL)

ACTIVITY

Compare the hydrograph of the Ganges with that of the Thames as shown by Figures 1.6 and 1.7. Try to explain the differences.

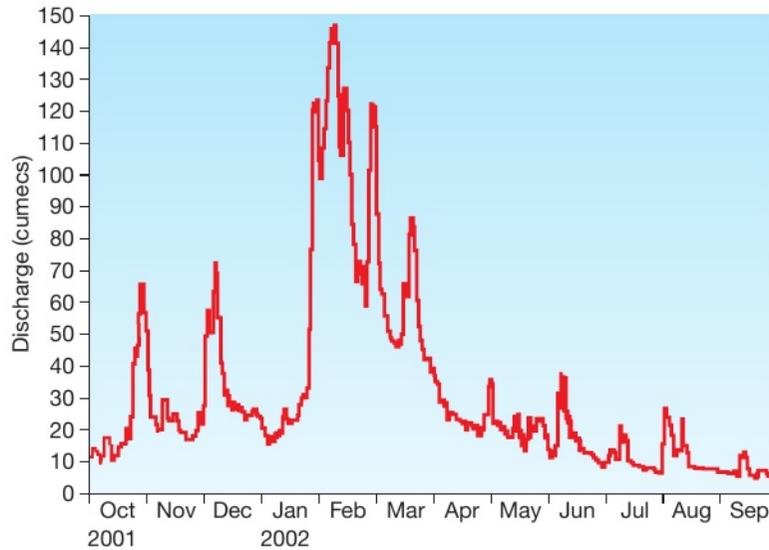


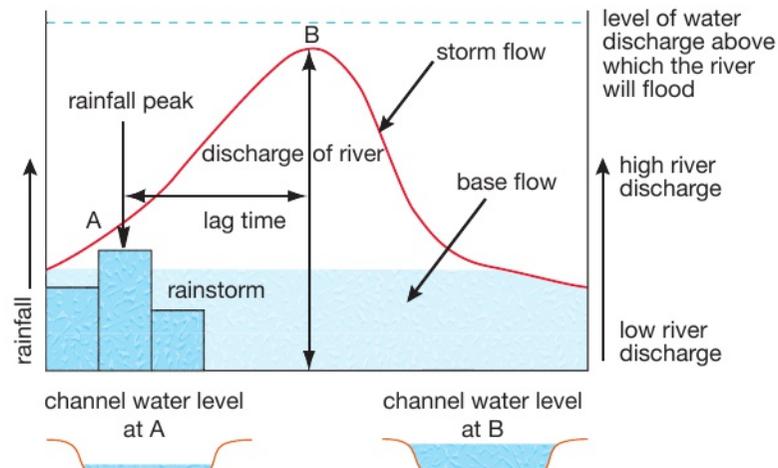
Figure 1.7 shows the regime of the River Thames (England) during one year. Unlike the Ganges, the highest discharges generally occur in winter, in February and March. Another feature of the hydrograph is its 'jaggedness'. Discharge varies from day to day. The peaks indicate the impact of passing showers and short periods of heavy rainfall.

The majority of the world's drainage basins are home to many people. The big attractions of such areas are their fertile soils and the ability to grow food. Today much money is invested in drainage basins, not just in farmland, but also in homes, businesses and transport. It is therefore important to know how rivers will behave following heavy rainfall. This data allows people to work out the risk of flooding, and over what area. This is where a storm hydrograph is useful.

STORM HYDROGRAPHS

A storm hydrograph records the changing discharge of a river after a rainstorm. The bars in the left-hand corner of Figure 1.8 show the input of rain. After rain hits the ground, it takes time for rainwater to reach the river and cause river levels to rise. This delay between peak rainfall and peak discharge is called the lag time. The shorter the lag time, the quicker the water reaches the river channel. A short lag time causes the river discharge to rise steeply. The steeper the rise in discharge, the greater the chances of flooding. It is possible to mark on the storm hydrograph the level of discharge above which the river will flood. Once the storm and its peak discharge have passed, the amount of water in the river starts to decrease.

► Figure 1.8: A storm hydrograph



SKILLS REASONING

CHECK YOUR UNDERSTANDING

Explain why lag time is so important.

The storm hydrograph shows discharge of the river as being made up of two flows:

- the **base flow** – the ‘normal’ discharge of the river
- the **storm flow** – the additional discharge of the river as a result of the rainstorm.

FACTORS AFFECTING RIVER REGIMES

Six factors affect river regimes in general and storm hydrographs in particular.

- The amount and the intensity of the rain. Heavy rain will not sink into the ground. Instead, it will become overland flow or run off and quickly reach the river.
- Temperatures affect the form of precipitation. For example, if temperatures are below freezing, precipitation will be in the form of snow. This can take weeks to melt. If the ground remains frozen, melting snow on the surface can reach the river quickly.
- Steep slopes will cause rapid surface run off, so water will reach the river more quickly. Flat and gently sloping land may lead to water sinking into the soil. This will delay it reaching the river.
- Rock type – impermeable rocks will not allow rainwater to sink into it, so will speed up run off. Permeable rock allows infiltration and percolation of water into the bedrock. This in turn slows delivery of water to the river.
- Vegetation and land use – trees and other plants intercept and delay the rain reaching the ground. Bare soil and rock speed up run off and reduce the time lag. So, too, will urban areas under tarmac and concrete.
- Human intervention – **dams** and reservoirs are an obvious form of intervention in river regimes. By holding back discharge, dams reduce the risk of flooding downstream. The flow of water out of reservoirs can also be controlled by opening and closing sluice gates. The increasing **abstraction** of water from rivers for a range of growing human needs (see Part 1.7) impacts on the regimes of many rivers, not just on their storm hydrographs.

SKILLS EXECUTIVE FUNCTION

ACTIVITY

Draw an annotated diagram showing impacts of the six factors on river regimes.

1.4 FLUVIAL PROCESSES

WEATHERING AND MASS MOVEMENT



▲ Figure 1.9: A landslide in Sri Lanka

Rivers play a major part in shaping landforms. Three processes are at work here – **erosion**, **transport** and **deposition**. These river processes partner two other processes – **weathering** and **mass movement**. Let us first look at weathering and mass movement and then examine more closely the work that rivers do.

Weathering involves elements of the weather, particularly rainfall and temperatures (Table 1.1).

PHYSICAL WEATHERING	This breaks rocks down into smaller and smaller pieces. It is done by changes in temperatures and by rainfall freezing and thawing in rock cracks.
CHEMICAL WEATHERING	This causes rocks to decay and disintegrate. It is largely done by slightly acidic rain seeping into porous rocks.
BIOLOGICAL WEATHERING	The roots of plants, especially trees, growing into cracks in the rocks gradually split the rock apart.

► Table 1.1: Different types of weathering

All this destructive activity takes place where rocks are found above the surface of the surrounding land. Once rocks are really broken down, the weathered material starts to move down the slope under the influence of gravity. This is mass movement. It takes several forms. In river valleys, there are two main types of mass movement as follows.

CHECK YOUR UNDERSTANDING

What made the landslide in Figure 1.9 into a serious hazard and natural disaster?

- Slumping – this occurs when the bottom of a valley side slope is cut away by the river flowing at its base. It makes the slope unstable and weathered material slumps down towards the river. Slumping is also helped when the weathered material on the slope is saturated by heavy rain. The water does two things. It makes the weathered material heavier and acts as a lubricant. Figure 1.9 is an example of sudden slumping leading to a major landslide.
- Soil creep – weathered material moves slowly down slope under the influence of gravity. It collects at the bottom of the valley side and is eroded by the river.

EROSION

There are several different ways in which rivers erode their channels and valleys (Table 1.2).

HYDRAULIC ACTION	Water hits the river bed and banks with such force that material is dislodged and carried away. This is most likely to happen during periods when the river’s discharge is high.
ABRASION	The material being carried by a river is rubbed against the sides and floor of the channel. This ‘sandpaper’ action widens and deepens the channel.
CORROSION (SOLUTION)	Minerals in the rocks forming the sides of the river channel are dissolved by the water flowing past them.

▲ Table 1.2: The processes of river erosion

CHECK YOUR UNDERSTANDING

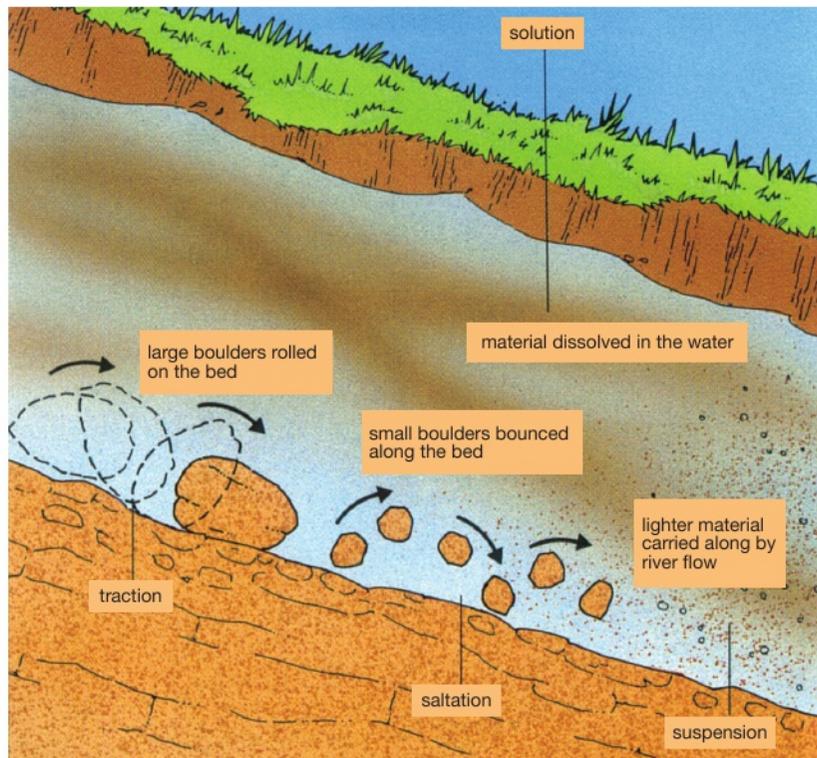
Check that you know the difference between weathering and erosion.

Attrition is another river process. It involves particles of material being carried by a river, and becoming rounder and smaller as they collide with each other. This process does not cause erosion of river channels and valleys.

TRANSPORT

This is the movement of material (known as the **load**) by the river. The load is material that has been washed or fallen into the river. It also contains materials eroded by the river from the sides of the channel. The load can be transported in a number of different ways (Figure 1.10).

► Figure 1.10: Ways in which rivers transport their load



SKILLS REASONING

ACTIVITY

Explain why the size of load material affects the way it is transported by a river.

DEPOSITION

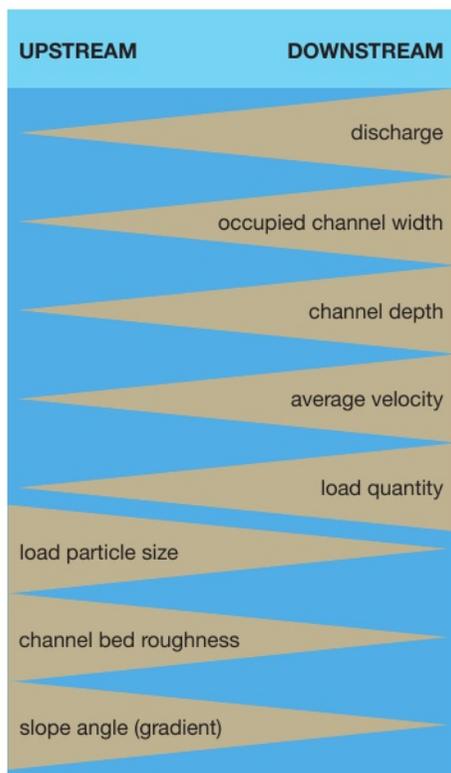
Deposition is the laying down of material transported by the river. This occurs when there is a decrease in the energy, speed and discharge of the river. Deposition is most likely to happen when a river enters a lake or the sea. It also happens wherever there is a decrease in the gradient of the river's channel.

CHECK YOUR UNDERSTANDING

What sort of material is transported and deposited by rivers?

Erosion, transport and deposition are affected by a number of factors. A wetter climate means more discharge and therefore more erosion and transport. Softer rocks are more easily eroded and transported. Gentle slopes encourage deposition.

1.5 DOWNSTREAM CHANGES IN RIVER CHARACTERISTICS



▲ Figure 1.11: Long-profile changes in channel characteristics

The **long profile** of a river runs from its source to the point where it enters the sea, a lake or joins another and larger river. The character of the long profile changes downstream. Overall, it has a smooth concave shape. It is steep and in places irregular where the river is flowing well above sea level in upland country. The irregularities occur where outcrops of hard rock run across the valley. Natural lakes and reservoirs can disrupt the smoothness of the long profile. However, the profile becomes much gentler and smoother as the river runs through lowland country and reaches its destination.

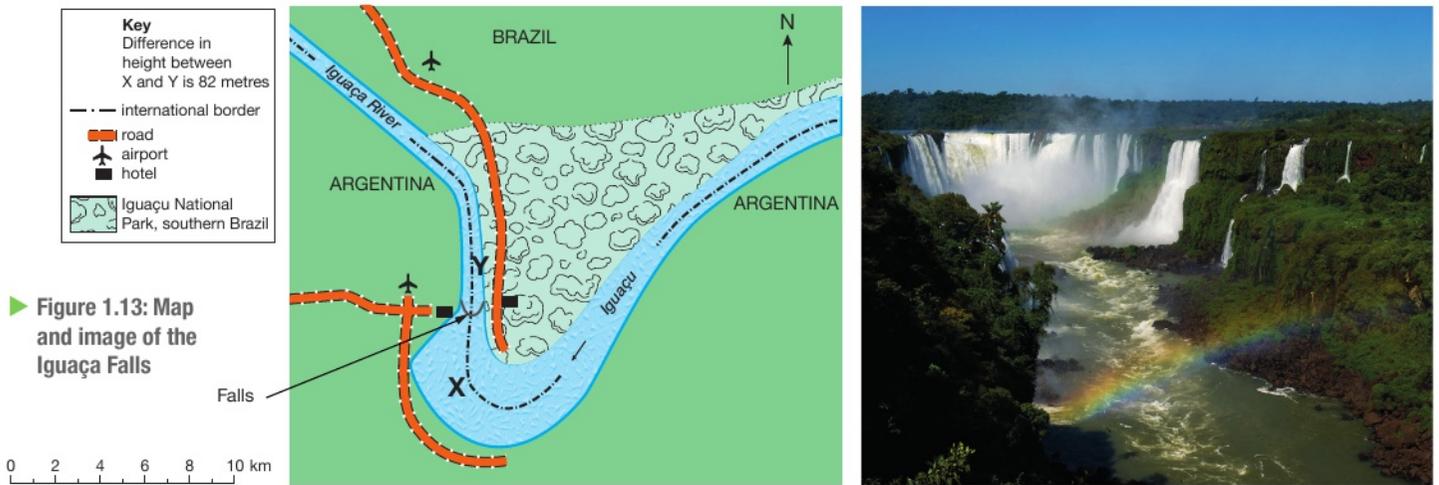
Of the many changes that take place along the long profile, changes to the river channel are particularly striking. The channel starts narrow and shallow (it is V-shaped) with rough edges. It gradually becomes wider, deeper and smoother. Figure 1.11 shows also that discharge and average velocity increase downstream, as does the amount of load being transported. At the same time, the size of sediment in the load becomes progressively finer and more rounded.

SKILLS REASONING

ACTIVITY

Explain the downstream changes, as shown in Figure 1.11, to each of the following:

- load particle size
- load quantity
- channel bed roughness
- channel depth.



► Figure 1.13: Map and image of the Iguaza Falls

SKILLS SELF DIRECTION

ACTIVITY

Can you name a waterfall located in your country?

Waterfalls occur where a band of hard rock is much more resistant to erosion than the softer rock below it (Figures 1.12C and D). This softer rock is readily eroded by the force of the water as it falls over the hard cap rock. Gradually, the falling water excavates a plunge pool at the bottom of the falls. Slowly, the hard rock is eroded back by the river and so the waterfall gradually retreats upstream leaving a gorge below it. The gorge is protected from being widened by its capping of hard rock. The Iguaza Falls in South America are a spectacular example and attract many tourists (Figure 1.13).

LOWLAND LANDFORMS

ACTIVITY

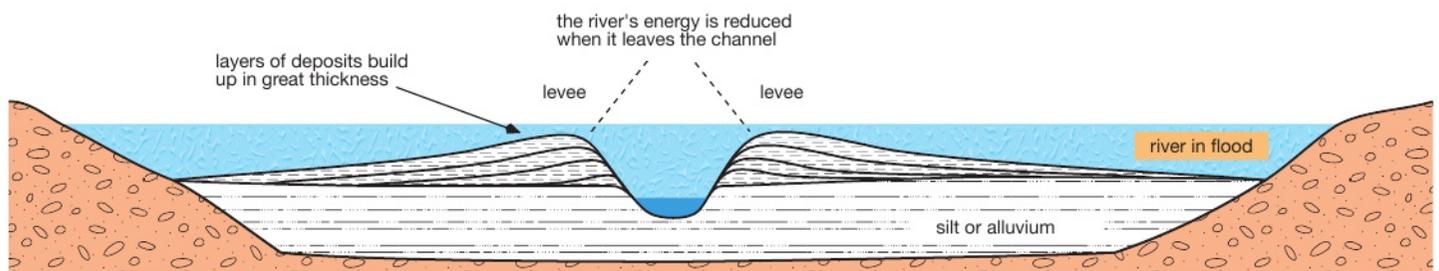
Describe how river erosion changes downstream.

The river and its landforms change when the river leaves the uplands and flows across lowlands. The river channel and its valley become wider, deeper and smoother. Because of this, both the **river velocity** (speed) and the discharge of the river continue to increase, despite the gentler gradient. The river course in plan (map) view becomes less straight.

The valley cross-section is wider and flatter. The floor is occupied by a **flood plain**. Near the end of its course, the flood plain spreads out to become either a **delta** or an estuary.

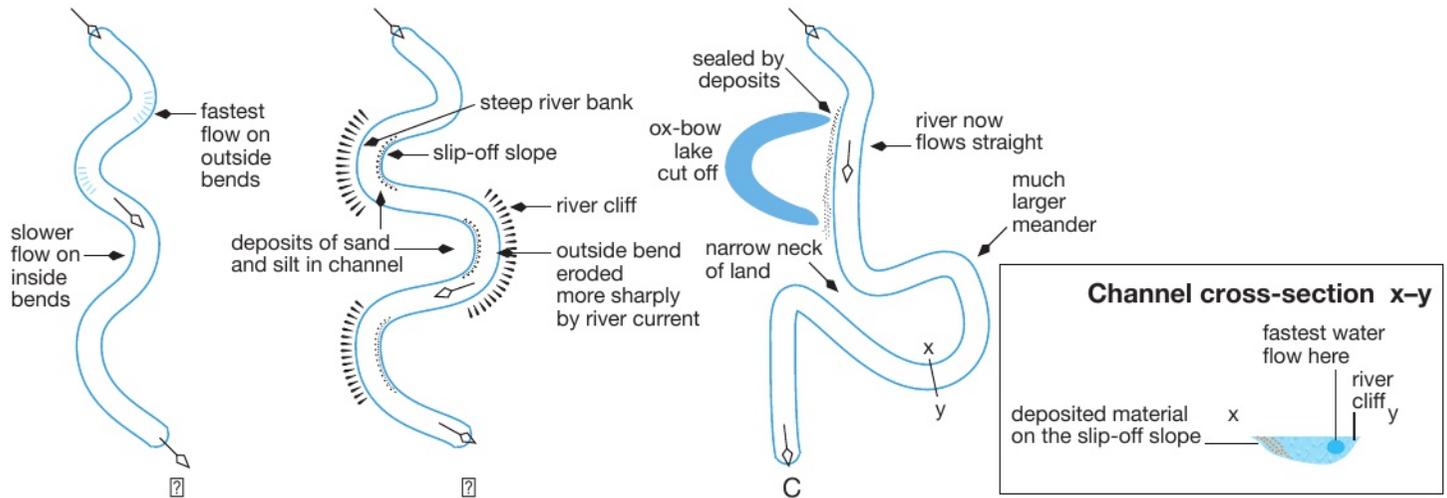
During its lowland course, the river is still actively eroding. However, vertical erosion is less important because the river is too close to sea level. More important is lateral erosion where the river wears away the sides of the channel, especially on the outside of **meanders**. The river becomes an agent of deposition as well. Such a large load of material has been picked up that, once the river loses energy, it drops some of that load on the flood plain. This is usually mud, stones and other organic matter. Every time the river leaves its channel, its velocity decreases. Once this happens, sediment is deposited across the valley floor. A great thickness of sediment builds up. The largest amount of deposition is always on the banks of the channel, which builds up to a greater height than the rest of the flood plain to form **levees** (Figure 1.14).

▼ Figure 1.14: The formation of a flood plain and levees



A study of the formation of meanders and **ox-bow lakes** shows how the river both deposits and erodes laterally (Figure 1.15). The force of the water undercuts the bank on the outside of a bend to form a steep bank to the channel, called a river cliff or bluff. An underwater current with a spiral flow carries the eroded material to the inside of the bend where the flow of water is slower. Here the material is deposited to form a gentle bank, called a slip-off slope or point bar.

▼ Figure 1.15: Formation of meanders and ox-bows



▲ Figure 1.16: Mississippi meanders and ox-bows

As lateral erosion continues, the bend of a meander becomes even more pronounced (Figure 1.15). Especially in times of flood, when the river's energy is much greater, the narrow neck of the meander may be breached (broken and crossed) so that the river flows straight again. The redundant meander loop keeps some water and becomes an ox-bow lake. Deposition during flooding seals off the edges and ends of the lake. Figure 1.16 shows a small part of the complicated meander pattern of the Mississippi River (USA).

SKILLS SELF DIRECTION

ACTIVITY

Find out this information about the Mississippi River:

- the actual length of the river from its source to the sea
- using a map, work out the straight-line distance from its source to the sea.

What do these **two** pieces of information tell you about the amount of meandering the river does?

► Figure 1.17: Satellite image of part of the Ganges-Brahmaputra delta. It also shows huge amounts of silt being deposited in the waters of the Bay of Bengal.



SKILLS INTERPRETATION

ACTIVITY

Describe the physical features of the delta shown in Figure 1.17.

DID YOU KNOW?

Not all rivers build up deltas as they enter the sea. Many have open mouths or estuaries. Can you name **two** such examples, one in your own country and one elsewhere?

The delta is the final landform of the river's journey from its source to the sea or lake. Deltas are vast areas of **alluvium** at the mouths of rivers. The Ganges–Brahmaputra delta is one of the largest in the world (Figure 1.17). It is located at the head of the Bay of Bengal. The rivers that have built it up carry huge quantities of sediment, mainly from the Himalayas, down to the delta. It is estimated that they deliver about 1.7 billion tonnes of sediment each year. The flows of the combined rivers are slowed as they meet the denser sea water in the bay. The result is that much of the load is dropped. In fact, the load is deposited faster than the tides can remove it out to sea. The river flow is blocked by deposition so that the rivers split up into smaller channels known as **distributaries**. These distributaries deposit sediment over a wide area, creating new land where there was once sea.

CASE STUDY: THE RIVER TAY (UK) AND ITS VALLEY

IN THE UPLANDS

The River Tay is fed by streams which drain the slopes of the Grampian Mountains in the Highlands of Scotland. Precipitation in the upland parts of the drainage basin is high (well over 1000 mm a year) and slopes are steep.

SKILLS SELF DIRECTION

ACTIVITY

Look at an atlas of the British Isles to locate the drainage basin of the River Tay.

► Figure 1.18: Part of the upland course of the River Tay



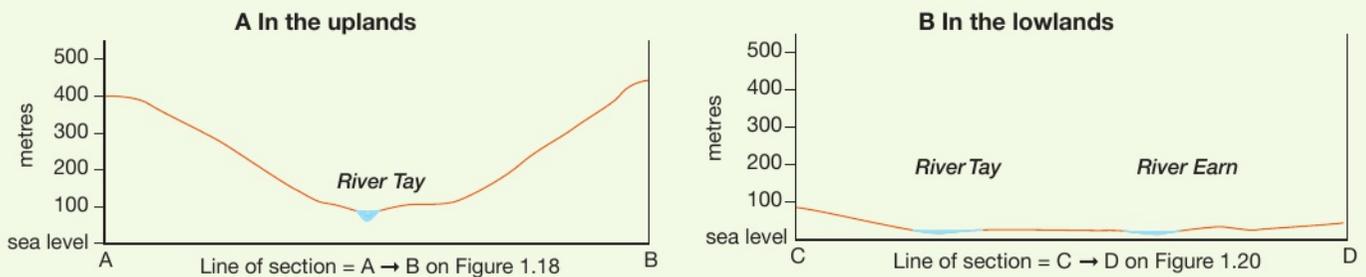
The height of the drainage basin and the steep slopes result in large amounts of run off. The Tay is already about 100 metres across in that part of its course, as shown on the Ordnance Survey map extract (Figure 1.18). The curving river course suggests that it is flowing between interlocking spurs.

The valley cross-section is shown in Figure 1.19A. It is V-shaped and steep-sided. The river fills the valley floor. The cross-section shows that the river is still flowing at some height above sea level. Erosion by the river appears to be vertical rather than lateral.

IN THE LOWLANDS

Figure 1.19B shows the valley cross-section near the sea. The flat and low-lying land is the flood plain. It is 600m wide where the tributary River Earn meets the main River Tay. Notice the big meander loop on the tributary through grid squares 1718 and 1717 (Figure 1.20). The black dashes marked around its banks show the levees.

▼ Figure 1.19: Cross-sections across the Tay valley



▲ Figure 1.20: Part of the flood plain and estuary of the River Tay

The River Tay shows many of the typical estuary features that can be found at the mouths of rivers (Figure 1.20). They include:

- a wide channel – up to 2 km
- sand and mud banks (such as Abernethy Bank)
- some areas of marsh (in grid square 2119)
- channels of deeper water (such as North Deep).

SKILLS EXECUTIVE FUNCTION

ACTIVITY

Using Figure 1.20, draw a sketch map of the River Tay estuary to the east of easting 20.

SKILLS INTERPRETATION

ACTIVITY

What are the advantages and disadvantages of the Tay estuary for shipping?

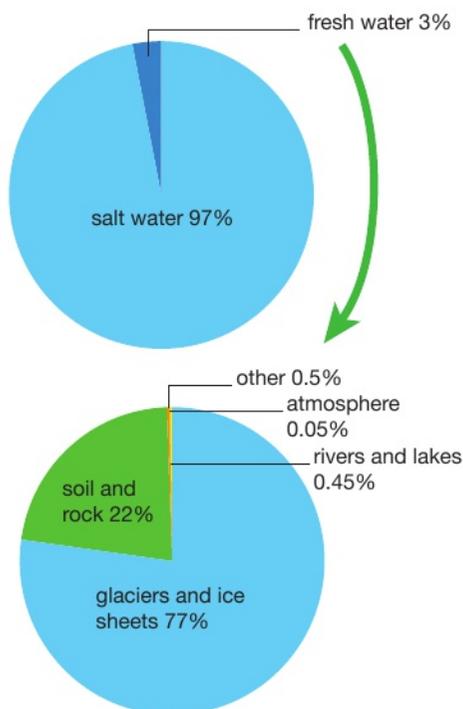
1.7 WATER USES, DEMAND AND SUPPLY

USES

Only 3 per cent of all water on Earth is freshwater; the rest is salt water in the seas (Figure 1.21). Over 75 per cent of the fresh water is locked up in glaciers and ice sheets, and 20 per cent is groundwater. The world's remarkably small amount of fresh water is:

- essential to all life
- vital to economic development
- unevenly distributed, with some areas 'water-rich' and others 'water-poor'.

SKILLS DECISION MAKING



▲ Figure 1.21: The world's water

ACTIVITY

Discuss, in groups, how global warming might change Figure 1.21. Compare the conclusions from different groups.

Fresh water is needed for:

- domestic use – bathing and showering; flushing toilets; drinking and cooking; washing clothes and dishes; watering the garden
- industrial use – producing a wide range of goods from beer to steel; generating electricity
- agricultural use – irrigating crops; providing drinking water for livestock
- leisure use – sport fishing on rivers; sailing on lakes and ponds; watering golf courses.

All forms of water use revolve around two key elements:

- demand – this is the need for water for a range of uses; it is also often referred to as **consumption**, and the amount of water consumed reflects the level of demand
- supply – meeting the demand for water by tapping various sources, such as groundwater, lakes and rivers.