Questions matter

Teaching guide: Skills in Geography

Introduction

As geographical skills are fundamental to succeed in A-level Geography, we've created this geographical skills guide to support and equip teachers and students.

Complete with key information about each specific skill listed in the geographical skills checklist – our guide is designed for you to use with students. Examples illustrate what they may look like in an assessment setting and how to incorporate them into fieldwork.

It covers the specification in the order listed and in some cases some skills are grouped together. The order is by no means prescriptive and geographical skills should be taught embedded into subject content and covered in different contexts.

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Section 1: Core skills

1.1 Base maps

What is a base map?

A base map is a reference map on which geographical information is displayed. A wide variety of maps can be used, and at different scales.

The example in **Figure 1** shows a base map with the track of a hurricane overlaid. A useful source of base maps for A-level students is the Ordnance Survey (OS), the national mapping agency for Great Britain. The OS produces digital and paper maps at various scales, which can be used for displaying geographical information.

Useful weblinks

- Ordnance Survey YouTube video channel: *Learn how to map read with Steve Backshall and Ordnance Survey*
- Street Map website: This allows free access to view sections of OS maps at 1:50 000 and 1:25 000 scales Streetmap - Maps and directions for the whole of Great Britain
- Basic map skills revision website: Mapping tools; Maps and symbols; Direction, scale, distance and height; Grid references. Mapping tools - OS map skills - KS3 Geography (Environment and society) Revision - BBC Bitesize

Example

As part of A-level Paper 1, Section C, 2020, a question used **Figure 1,** the track of Hurricane Michael, and data related to the intensity and timescale of the event.

How to comment on the Figure 1 data relating to the base map.

1. Use points of the compass (north, south, east and west).
2. Refer to the map underlying the geographical information, for example is the data over ocean or land?
3. Use the scale line.
4. Comment on latitude and longitude. Latitude means degrees north or south of the equator. Longitude means degrees east or west of the Prime Meridian.

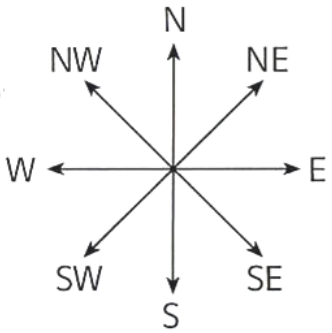
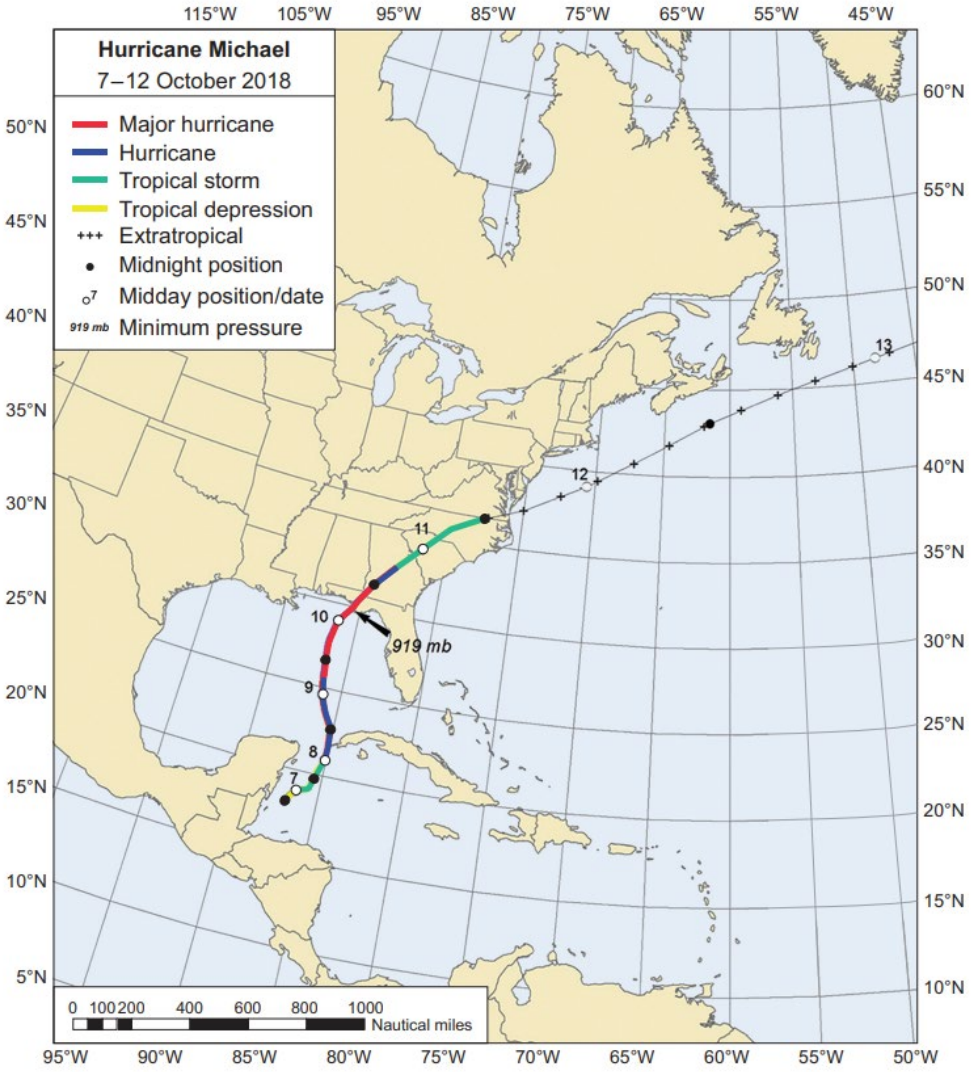


Figure 1: The track of Hurricane Michael, and data related to the intensity and timescale of the event.



Example commentary

Hurricane Michael starts as a tropical depression, shown on the base map in the west of the Caribbean Sea on October 7. The depression becomes a tropical storm which moves north past the 20 degrees north line of latitude.

The tropical storm becomes a hurricane on October 8 as it passes to the west of Cuba and into the Gulf of Mexico. The hurricane becomes a “major hurricane” as its track continues to move north past the 25 degrees north line of latitude.

The track of the major hurricane continues over the ocean until it makes landfall in southern USA (in the north of the state of Florida) after midday on October 10.

The hurricane’s track then moves in a north-west direction over five states of mainland USA as it gradually loses energy. Using the scale line, Hurricane Michael is a “major hurricane” (red line) on the base map over a distance of about 400 nautical miles.

1.2 Sketch maps

What is a sketch map?

A sketch map is a simple drawing of a study area which shows only key details. Sketch maps can be produced by hand or with mobile phone apps such as Skitch. It's important to add the following:

- Scale: Roughly how big is the area shown?
- Notes: Use annotations (with detail - more than single words).
- Orientation: Add a north arrow.
- Time: Note the time (and date).

Example

As part of the Geography fieldwork investigation and geographical skills questions in AS Paper 2, 2022, the following sketch maps appeared.

Figure 2: Student's sketch map of the fieldwork site.

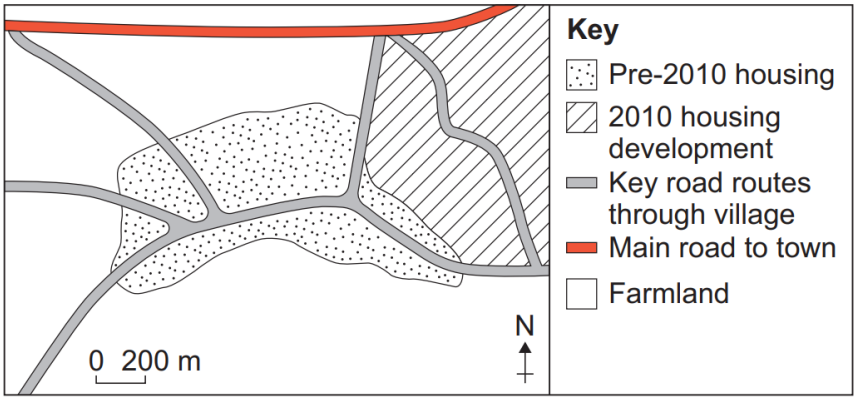
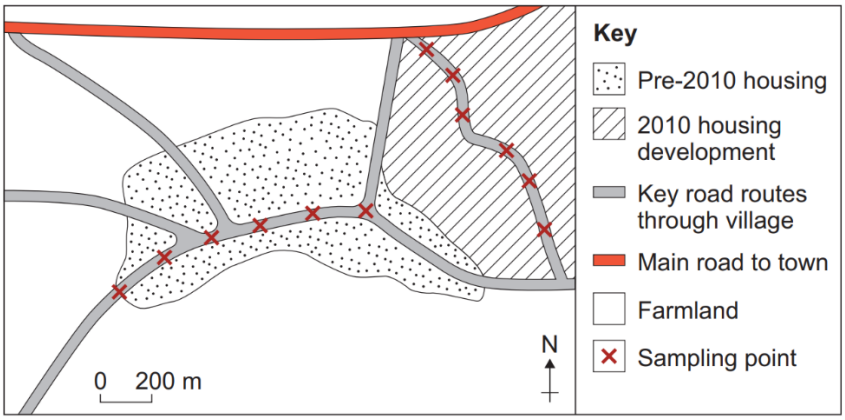


Figure 3: Student's sketch map of planned sampling points.



The student was undertaking fieldwork to investigate whether a housing development had altered the place character of a village. The housing development had been built in 2010 on the edge of the village. The student's hypothesis for the investigation was: "The place character of the 2010 housing development is significantly different to the rest of the village."

Strengths of the sketch maps in Figure 2 and 3

- The sketch maps are effective because they have only the key details required, such as the road layout, the pre-2010 housing, and the 2010 housing development.
- The sketch maps include a north arrow and scale.
- The data sampling points are also located, showing that student had a clear fieldwork plan to collect valid primary data.
- The sampling points are also shown to be spaced out at intervals of approximately 200 metres.
- The **Figure 2** sampling point sketch map, combined with the **Figure 3** survey tool, will enable quantitative and qualitative analysis.

Suggestions to improve this fieldwork using sketch maps

The student could increase the number of sampling points and carry out a wider range of other methods (e.g. questionnaires or an environmental quality survey) to enhance the validity of the results.

Figure 4: Student's sketch map of the fieldwork site.

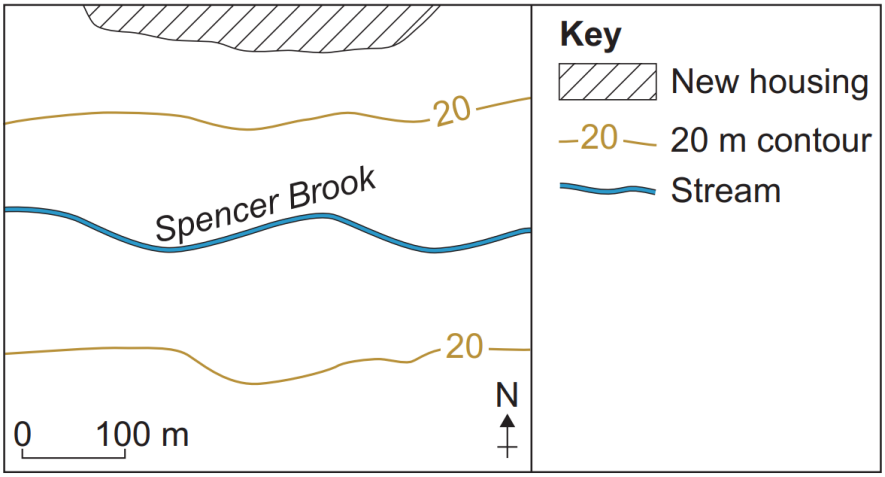
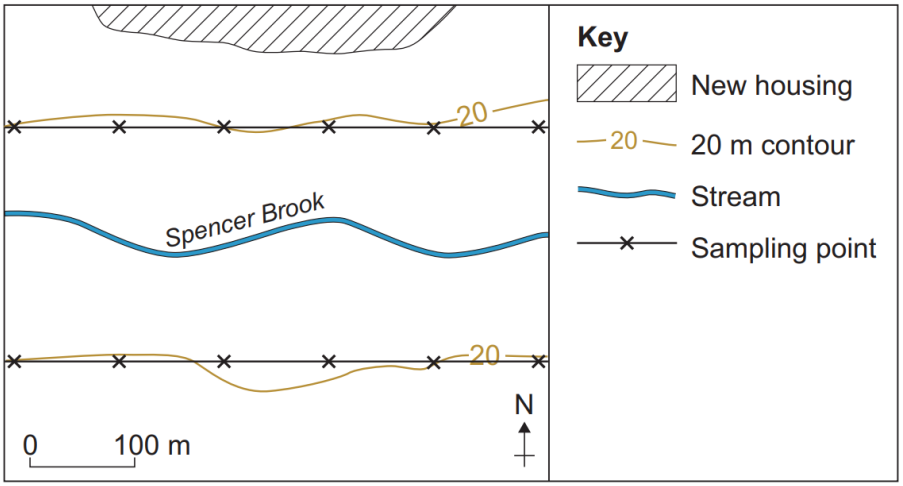


Figure 5: Student's sketch map of planned sampling points.



This student was considering the theory that impermeable surfaces associated with the housing development will lead to more overland flow on the north side of the Spencer Brook (stream). This would then lead to more saturated soil between the housing development and the stream, which would cause more rapid increase in stream discharge after a storm event. The student's hypothesis for the investigation was: "Rates of overland flow are higher on land north of the stream where new housing has taken place."

Strengths of the sketch maps in Figure 4 and 5

- The sketch maps are effective because they are simple to understand and show only the key details required, such as the Spencer Brook, the 20 metre contour line and the area of new housing.
- The sketch maps include a north arrow and scale.
- The data sampling points are also located, showing that the student had a clear fieldwork plan to collect valid primary data.
- The sampling points are also shown to be spaced out at intervals of approximately 100 metres.

Suggestions to improve this fieldwork using sketch maps

- The student could increase the number of sampling points, and repeat the fieldwork at various times of the year, to enhance the validity of the fieldwork results.
- The student could have also ensured the sampling points more closely matched the path of the 20 metre contour line to control for the variable of slope gradient.

How can these sketch maps be produced?

Draw a simple sketch map referring to an Ordnance Survey map (you can view 1:25 000 scale maps at streetmap). Make sure to include a scale (which can be approximate) and a north arrow.

Sketch map applications

A-level Geography students can produce sketch maps as part of their NEA (non-exam assessment).

1.3 OS maps (at a variety of scales)

What is an OS map?

As outlined in Section 1.1, an OS map is one produced by the Ordnance Survey, which is the national mapping agency for Great Britain. The OS Explorer series is often used for hiking in Great Britain because it uses a 1:25 000 scale which shows footpaths, car parks, contour lines, campsites and other details. A 4 cm grid square represents 1 square kilometre.

Example

As part of Changing places on the AS Paper 2, 2022, a question used the OS maps from **Figure 6** and **Figure 7**.

Figure 6: An OS map of Great Chesterford, a village in north-west Essex in 1950.

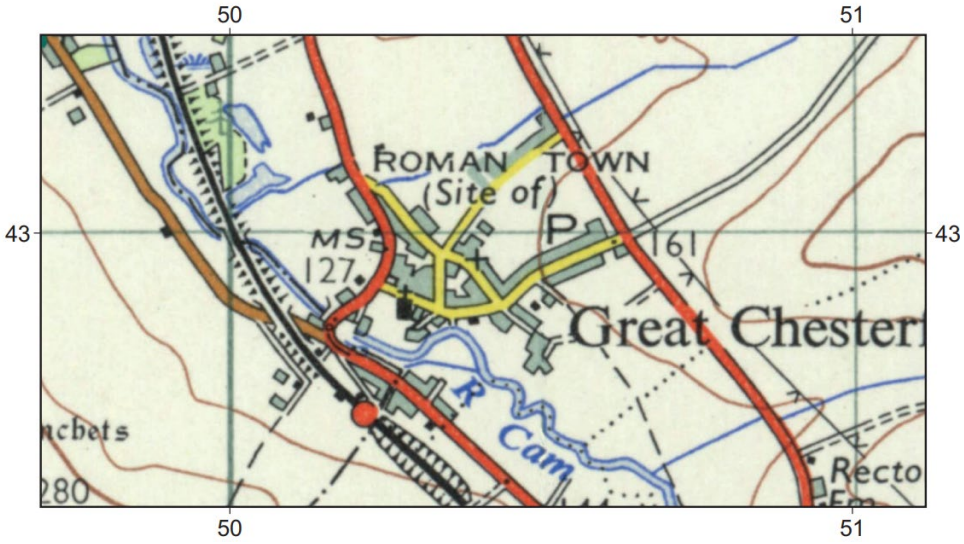
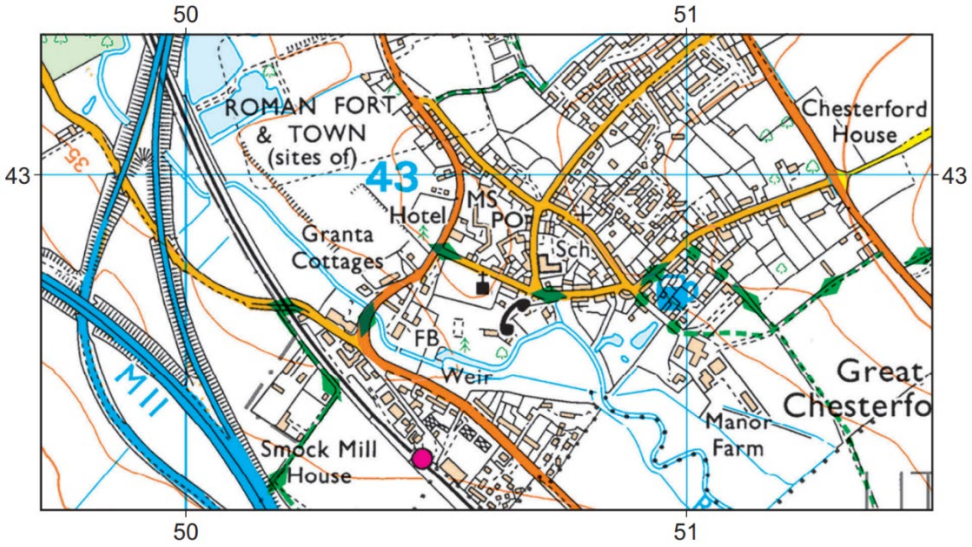


Figure 7: An OS map of Great Chesterford, a village in north-west Essex in 2021.



Example commentary

- The road layout broadly remains the same from 1950 (**Figure 6**) to 2021 (**Figure 7**) although in 2021 the M11 motorway can be seen about 1 km to the west of the village centre.
- The track to the east-north-east of the village has also become a recognised road.
- In 1950 the village has a nucleated (grouped together) pattern of housing, mainly between the two main roads and to the north of the river. There is some more linear (in a line) housing heading east from the village and close to the station.
- By 2021 the land area covered by buildings has more than doubled. A fairly large housing area has been built to the north-east of the village centre, and there is some infill of new housing to the north-east of the school.
- Areas to the south of the village, close to the river, have seen little development and there is also a lack of expansion to the west.
- From 1950 to 2021, there is also development around the train station, and some more linear development heading south-east from here.
- The railway line also indicates continuity running north-west to south-east. There is a train station in both maps in grid square 5042.
- The village shows more amenities in 2021, for example the school and the post office. However, with **Figure 7** being a more detailed map it's possible that these amenities were also present in 1950.
- The two churches/places of worship in **Figure 6** are also seen in **Figure 7**.
- Continuity is shown in the River Cam which flows from the north-west to the south-east of both maps.

What about other map scales?

The Ordnance Survey also produces a Landranger series with a 1:50 000 scale. In this case 2 cm on the map represents 1 km in the real world. OS Landranger maps cover a larger area than OS Explorer maps, but not in as much detail.

1.4 Diagrams

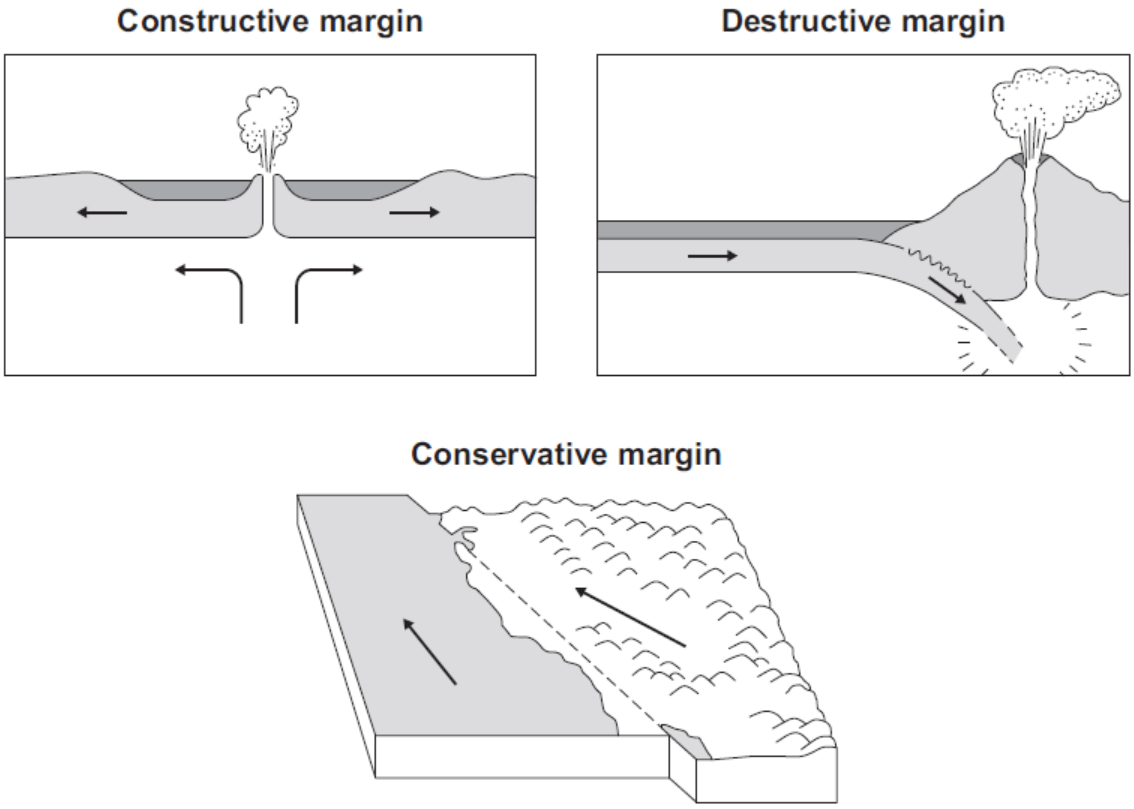
What is a geographical diagram?

A geographical diagram is a drawing which aids understanding of a geographical concept or process. They can be produced by hand or using a computer.

Example

Diagrams are simple yet effective. An example that featured in GCSE Paper 1, June 2023 is shown below.

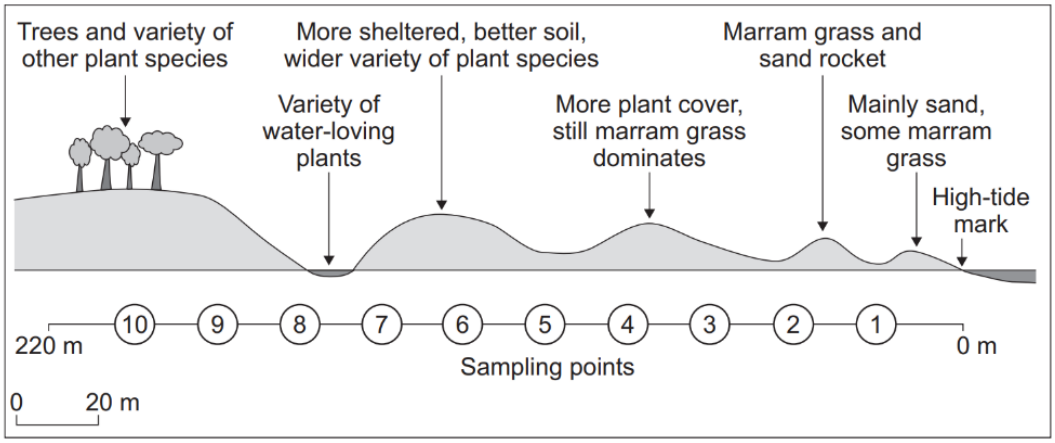
Figure 8: Diagrams of different plate margins.



These diagrams are effective because they simplify the complex concept of plate tectonics and the use of arrows to show direction of movement highlights the associated tectonic processes.

The following examples appeared in the AS Paper 2, 2023 and both detail how sampling strategies can be shown for fieldwork in differing locations. **Figure 9** on the next page, shows a sand dune transect produced during A-level fieldwork in a coastal location. The scale and sampling points show that the transect is over a distance of 220 metres. The student's aim was to investigate the changes in vegetation (plant succession) in a sand dune ecosystem in North Wales (psammosere). They wanted to see if there was a wider variety of plant species as you move inland and away from the sea.

Figure 9: Sand dune transect diagram.



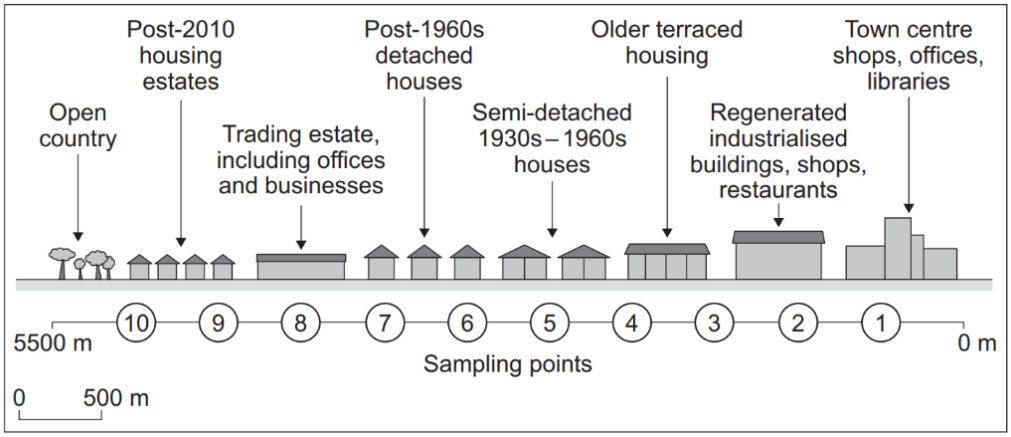
This diagram is effective because the annotations are fairly detailed and are more useful than single-word labels. The vegetation sampling points, taken every 20 metres, show a systematic sampling method which reduces bias because the points are pre-determined. The diagram annotations show that species such as marram grass are more common closer to the sea.

Suggested ways to improve the Figure 9 diagram

More sampling points, at shorter distances, would improve the accuracy and level of detail of the diagram. Additional transect diagrams from nearby could be produced for comparison.

The below diagram was produced using OS maps combined with local knowledge and fieldwork. The numbers represent sampling points (where data was collected). The student's aim was to investigate if there was a change in dominant land use with distance from the town centre.

Figure 10: Urban land use transect diagram.



The **Figure 10** diagram is useful because it shows the changing land use characteristics moving outwards from the town centre. The annotations are clear and the scale shows the distance over which the land uses change. The decision to look at the dominant land use at 500 metres intervals shows a systematic sampling method.

Suggested ways to improve the Figure 10 diagram

Here are some possible improvements to the **Figure 10** diagram:

- It looks as though the transect heads west from the town centre, but this should be made clear.
- Sampling point 1 should be 0 m on the transect.
- Using a 500 m sampling interval is quite a large distance between survey sites, so the student could reduce this to 250 m to produce a more detailed diagram.

1.5 Field sketches

What is a field sketch?

A field sketch is a basic drawing of a study area which shows only key details. In Geography, the 'field' refers to learning outside of the classroom. As with sketch maps (see Section 1.2), a field sketch can be produced by hand or with mobile phone apps such as Skitch.

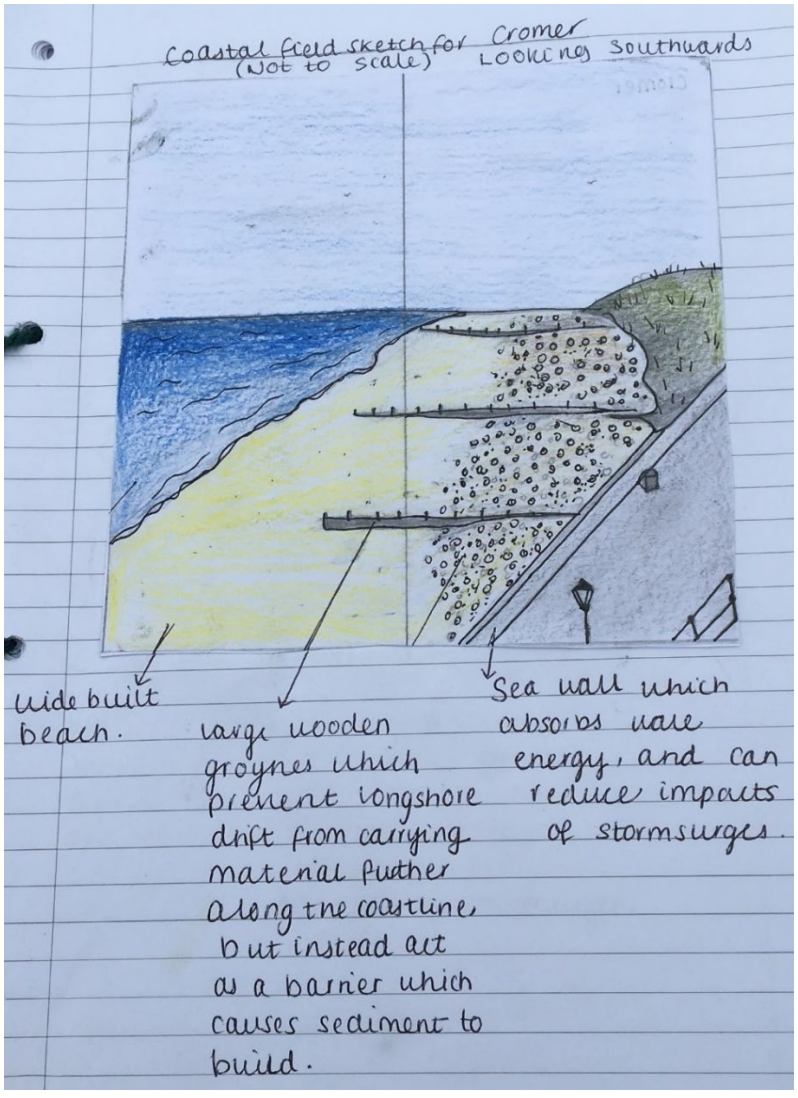
As seen in Section 1.2, it's usually important to add the following:

- Scale: Roughly how big is the area shown?
- Notes: Adding annotations (more than single words).
- Orientation: Add a north arrow.
- Time: Add time (and date).

Example

In the following examples, an A-level student was collecting data on the different approaches to coastal management along the Norfolk coastline.

Figure 11: Field sketch of coastal management in Cromer on the Norfolk coast.



- Scale - in this case the field sketch is marked 'not to scale', however you can measure a feature in the scene, such as the length of a groyne, then add this as an annotation to help add a sense of scale. The measuring tool in Google Maps can also be used to give the approximate distance covered in the scene.
- Notes - several appropriate notes are added as annotations, such as the fact that the groynes act as a sediment trap.
- Orientation - the field sketch looks south as noted at the top of the sketch.
- Time - this information is missing, which the student should add along with the date.

Figure 12: Field sketch of coastal management in Winterton-on-Sea on the Norfolk coast.

- Scale - this field sketch is marked 'not to scale'.
- Notes - several appropriate notes are added as annotations, such as the fact that the sand dunes are part of a Site of Special Scientific Interest.
- Orientation - the field sketch looks north, noted at the top of the sketch.
- Time - this information is missing, which the student should add along with the date.

1.6 Photographs

Why is photographic analysis important in geography?

Photographs are an excellent qualitative data source because they can indicate a powerful sense of place (qualitative data means information without numbers, such as text, audio and images). Photographs can also help analyse change over time.

Example

In A-level Paper 2, Changing places, 2023, a question included two photographs of the Albert Docks in Liverpool; one showing the working port in 1885 and the other below.

Figure 13: The Albert Docks, Liverpool, a shopping and entertainment area in 2021.

Example commentary

The two photographs show Liverpool's Alberts Docks photographed 136 years apart. The image from 1885 shows a busy working dock with several ships which will be unloading and loading goods from across the world at this time as well as warehouses for the storage of goods.

Figure 13 shows that place meaning has changed over time, with a focus in the modern day on entertainment, leisure and shopping. The site no longer appears to be a working dock. The historic geography of industrialisation and the importance of the shipping trade is shown in the older photograph. Even though the site function has changed, continuity with the past is shown in **Figure 13** with the area still being referred to as a dock, the waterfront views maintained, and the warehouses converted into service industries.

Note: Some questions invite you to use your own knowledge, beyond the figures. In some cases there is credit available for showing knowledge of how cities such as Liverpool have changed, with the introduction of large container ship ports such as Seaforth Dock and Liverpool.

How can photographs be used in fieldwork?

Photographs can be a useful form of data presentation in the NEA. The below example was featured in an investigation about coastal tourism, and in particular why beach huts at Mudeford Spit in Dorset can sell for more than £400,000. Read the BBC News article *Mudeford beach hut goes in market for £440,000.*

Figure 14: Annotated fieldwork photo – Beach hut survey at Mudeford Spit.

1.7 Geospatial, geo-located and digital imagery (GIS)

What is geospatial imagery?

Geospatial imagery means place-based geographical information linked to a map or other form of display such as a satellite photo. Geospatial imagery allows the viewer to analyse geographical patterns. 'Spatial' means relating to space and where things are located.

What is geo-located imagery?

Linked to geospatial imagery, geo-located imagery means place-based geographical information where the reader can see the specific location of the data being presented. This is often done using latitude and longitude co-ordinates.

What is digital imagery?

This means electronic data recreated by a computer into an image. Digital photography is a common example.

The three areas above all link into **Geographical Information Systems** (GIS). The creation and analysis of GIS maps and other images is an important area of study in modern Geography.

What is GIS?

Geographical Information Systems display data on a digital map or other base image such as a satellite photo. Different data can be added in layers onto the same base. GIS displays can be produced using websites or dedicated software packages.

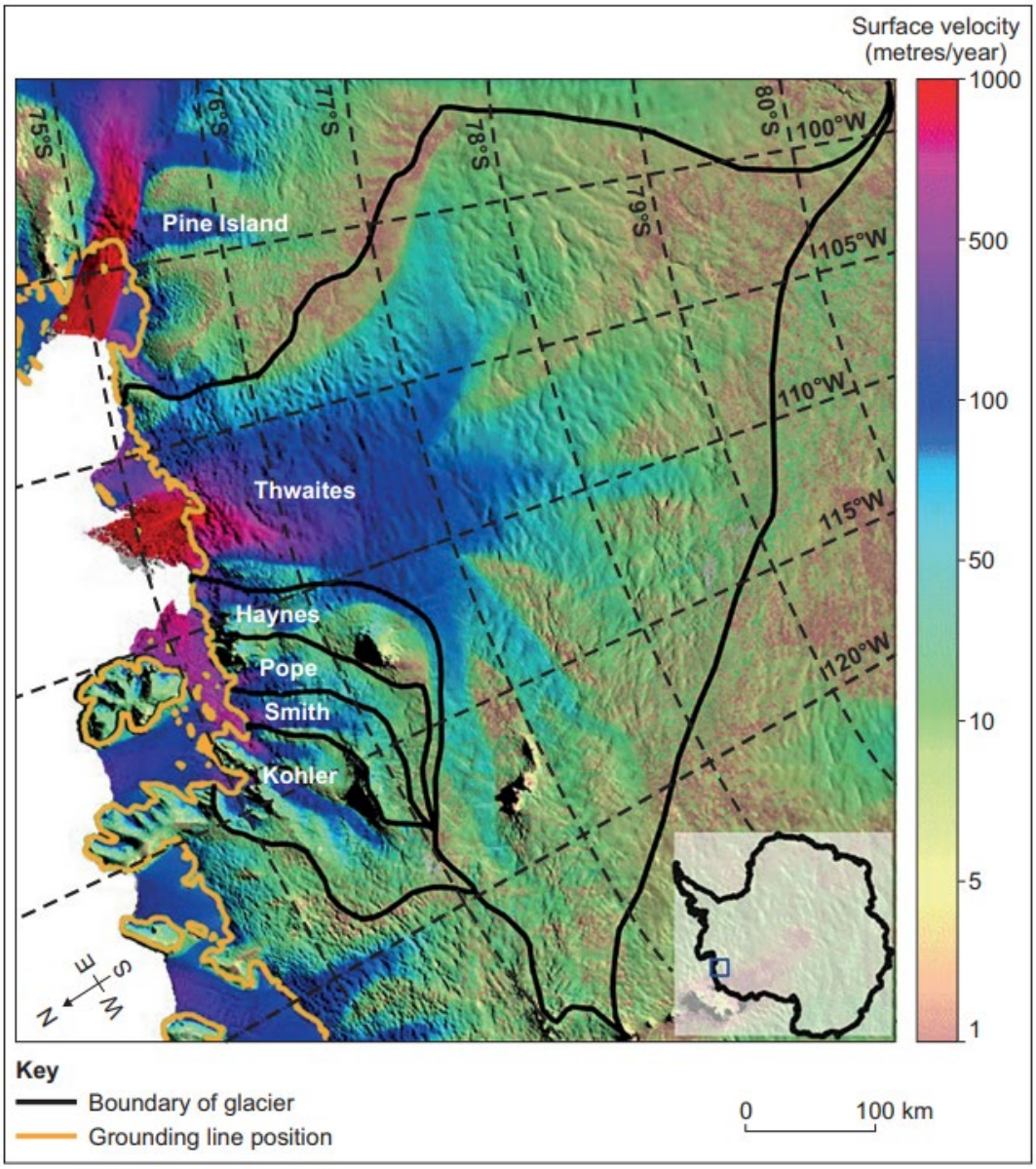
In GIS, each piece of data must appear at the correct place on the map (or other base layer). This is done using latitude and longitude. For example, most phones have built in GPS (Global Positioning System) which can help provide latitude and longitude co-ordinates for data. GIS packages can also use postcodes.

With GIS, you can add geospatial data layers together to look for geographical patterns. Many people work in GIS. They analyse the geospatial data and digital imagery to help make decisions which inform a variety of work sectors, for example flood management and monitoring air pollution.

Example

The below figure is an example of geospatial, geo-located and digital imagery, from A-level Paper 1, 2021.

Figure 15: The surface velocity of various glaciers, including Twaites Glacier, Antarctica.



Note: At the grounding line, glacier ice comes into contact with the sea and starts to float.

An example of a GIS computer software maker is Esri. Environmental Systems Research Institute is an American multinational Geographic Information System (GIS) software company with headquarters in California. Esri is best known for its ArcGIS products.

Example: Earthquake investigation

Step 1
Visit the ArcGIS website. You do not need a log in or to sign in.
Step 2
Click 'Map'.
Step 3
Click down arrow next to 'Add' then select 'Browse layers'.
Step 4
Choose 'Living Atlas'.
Step 5
In the Search box, type 'Recent Earthquakes' then add this 'Feature Layer' made by Esri. Click '+ Add'.
Step 6
Write down at least one location where there has been a recent earthquake of magnitude 7.5 or > (black dots).
Step 7
Now click the cursor on the black dot to access 'embedded information', for example the earthquake depth in km. Add this to your notes. ('Embedded information' means data within a GIS map, accessed by clicking on specific locations).
Step 8
When you have finished your investigation, click 'Remove' to take away this data layer.

Additional example: 'what3words' as an example of geo-located and digital imagery

"what3words" is a Smartphone app which has divided the world into 3 metre squares and given each one a unique identifier made from three words. It is an interesting and useful example of geo-located data. The website says, "Street addresses aren't accurate enough to specify precise locations, such as building entrances, and don't exist for parks and many rural areas. This makes it hard to find places and prevents people from describing exactly where help is needed in an emergency. That's why we created what3words."

Useful weblinks

- BBC Bitesize Geographic Information Systems and choropleth maps
- Esri UK Education YouTube Careers with GIS
- What is GIS? GIS Day | November 20

Section 2: Cartographic skills

2.1 Atlas maps

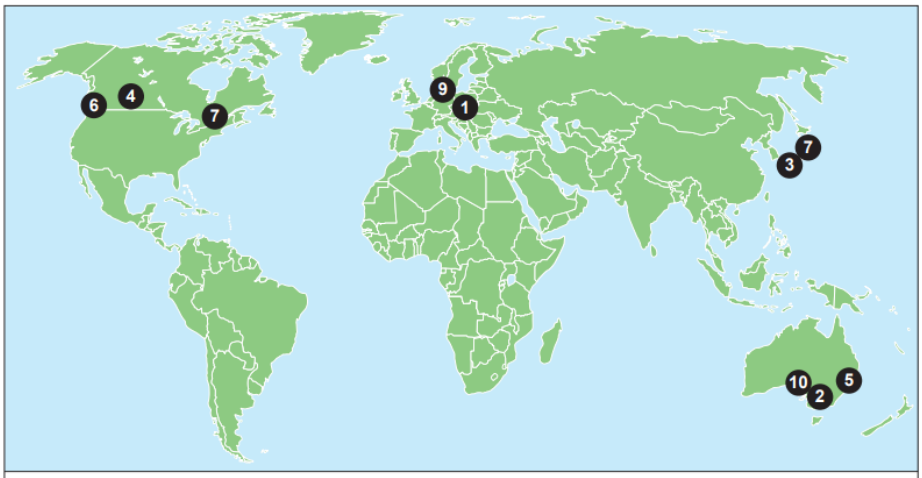
What is an atlas map?

An atlas map refers to the variety of maps which are used in printed atlas books. These can include world maps as well as maps showing continents and countries. Further maps may be included, such as those showing relief features or precipitation data.

Example

In A-level Paper 2, Contemporary Urban Environments, 2021, the below figure of an atlas map of the world was used.

Figure 16: The world's most liveable cities, 2018.



Key

Cities ranked by liveability in 2018 (100 = ideal)

1	Vienna (Austria)	99.1	6	Vancouver (Canada)	97.3
2	Melboune (Australia)	98.4	7	Toronto (Canada)	97.2
3	Osaka (Japan)	97.7	7	Tokyo (Japan)	97.2
4	Calgary (Canada)	97.5	9	Copenhagen (Denmark)	96.8
5	Sydney (Australia)	97.4	10	Adelaide (Australia)	96.4

Example commentary

Two of the Top 10 cities are in Europe - Vienna and Copenhagen. These are in the mid-latitude zone where climate will be relatively mild and avoid unpleasant extremes, which enhances liveability. Japan also has two cities in the Top 10, a country known for its education standards, clean streets and reliable public transport, all of which increase liveability scores. Three of the Top 10 cities are in Canada, this suggests that Canadian cities have several positive endogenous factors which boost liveability, such as an attractive built environment, open spaces and a strong sense of place which encourages topophilia (or love of place). Australia also has three cities in the Top 10, all in the south-east region of the country. These

cities all benefit from coastal locations which are likely to be scenically attractive which boosts liveability.

In A-level Paper 2, Resource Security, 2019, the below figures, two maps commonly found in atlas, were used alongside a graph of energy supply for selected European countries for the question 'assess the relationship between energy supply and physical geography'.

Figure 17: Average annual precipitation.

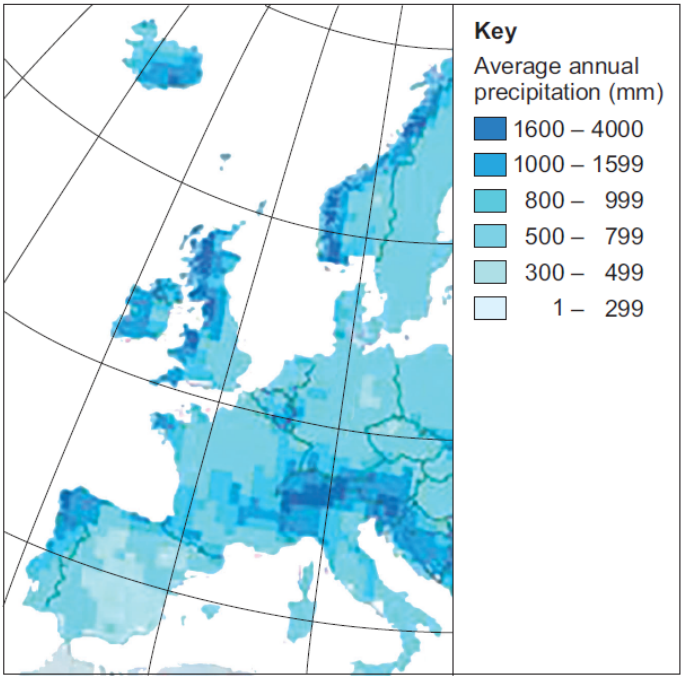
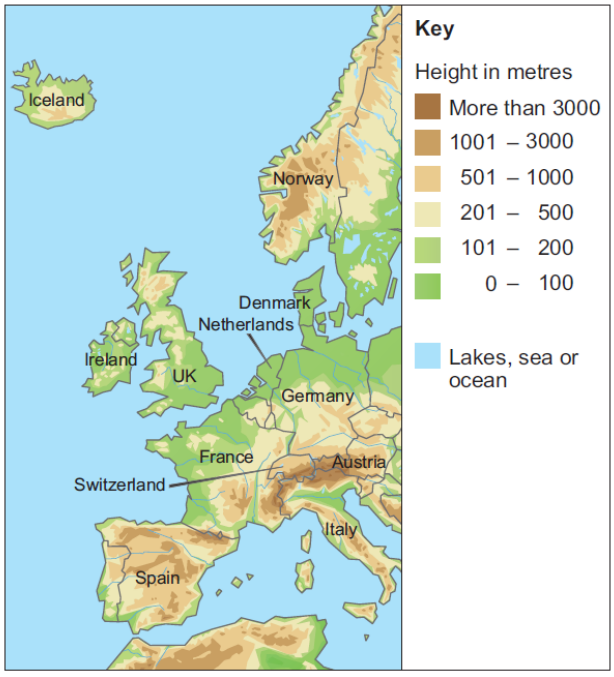


Figure 18: Relief map of Europe.



Example commentary

Norway was shown to generate about 97% its electricity from Hydro-Electric Power. This links very strongly to physical geography, as **Figure 18** shows steep relief and land over 1001 metres above sea level. In addition, **Figure 17** shows very high precipitation with areas of over 1600mm annually. Norway therefore exploits its steep land and rainy climate effectively to make electricity via HEP. The development of HEP requires dams to be built, often in steep river or glacial valleys. Water is sent downhill to drive turbines to generate the renewable electricity.

The same can be said of Austria with about 62% if its electricity from HEP. Austria also shows steep relief in **Figure 18**, and high precipitation in **Figure 17**, which again are the ideal requirements for HEP.

2.2 Weather maps – including synoptic charts

What is a weather map?

A weather map shows the expected atmospheric conditions in particular locations over a short-term period, for example one day or the next few days. Weather forecasts can include temperature, cloud cover, precipitation, wind speed and direction and atmospheric pressure. In contrast, climate refers to the average weather conditions in a location recorded over several decades. The Meteorological Office, abbreviated as the Met Office, is the UK's national weather and climate service. Its headquarters are in Exeter in south-west England.

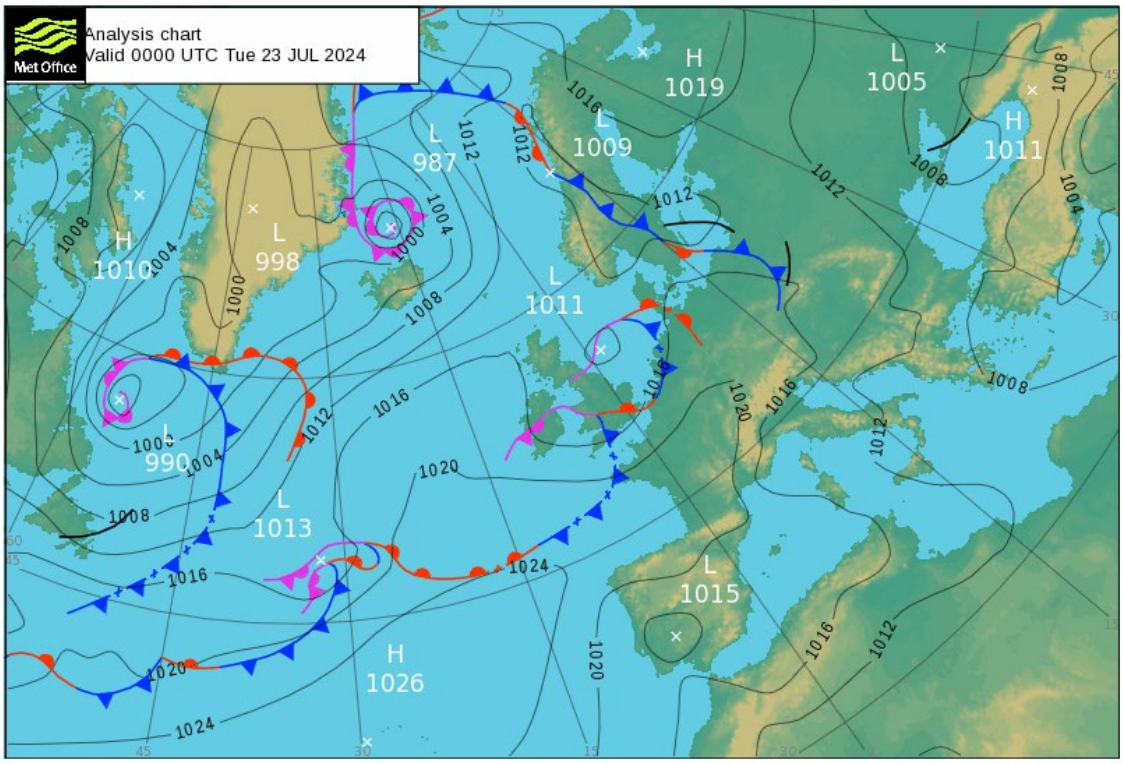
What is a synotopic chart?

A synoptic chart means a weather map which shows weather systems and how they are forecasted to change over time. The main feature shown on a synoptic chart is air pressure. On a synoptic chart, lines joining areas of equal air pressure are called isobars. Weather fronts mark the boundary between two different air masses which often have contrasting properties. Air masses are large bodies of air with fairly uniform temperature and humidity. The arrival of an air mass via a front will bring a change in the weather.

Example

The below synoptic chart is an example taken from the Met Office.

Figure 19: Surface pressure chart for the North Atlantic and Europe.



Useful weblink

Met Office *How to read synoptic weather charts.*

2.3 Maps with located proportional symbols

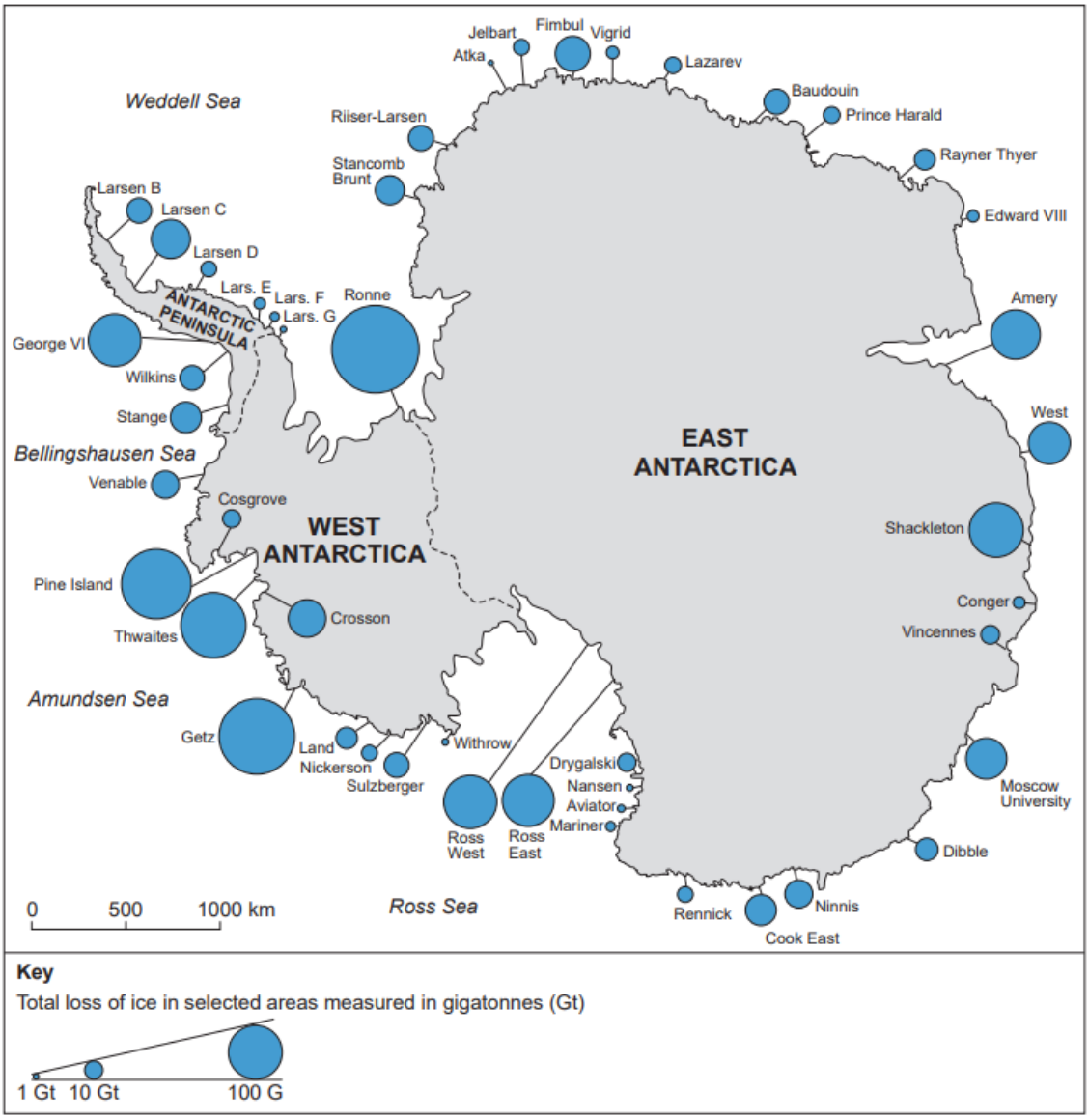
What are maps with located proportional symbols?

A proportional symbol means data presentation where the symbol size is relative to the value in question. Proportional symbols allow you to compare relative differences across a data set. Placing the data on a map adds an interesting spatial component for further analysis.

Example

In A-level Paper 2, Global Systems and Global Governance, 2022, the below figure was used alongside a graph of ice from 1992-2017 with the 6-mark question asking both figures to be analysed.

Figure 20: The distribution of the changing ice extent across Antarctica in 2013.



Example analysis

The overall picture shows a significant reduction in ice mass. The largest proportional circles are West Antarctica. The largest area is the Ronne zone, with the proportional symbol indicating 170 Gt ice loss. This is 1.7 times the ice loss recorded at the most significant site in East Antarctica, the Shackleton site, which recorded 100 Gt of ice loss. There are also significant losses of ice on the Antarctic Peninsula with the largest; George VI site which recorded a loss of 100 Gt. East Antarctica is vast at about 3000 km across, so it represents the largest ice store, but has several symbols with less than 10 Gt of ice loss, such as Vigrid. However, the data only shows loss in a single year, 2013, so these patterns may change annually.

2.4 Maps showing movement: Flow line, desire line and trip line maps

What is a flow line?

A flow line map represents the volume of movement between locations along the route or general direction of travel taken. These maps usually have arrows and have a scale whereby the thickness of the line represents the value in question. For example, traffic flows in a town or pedestrian flows in a town centre could be shown on a flow line map of an area under investigation.

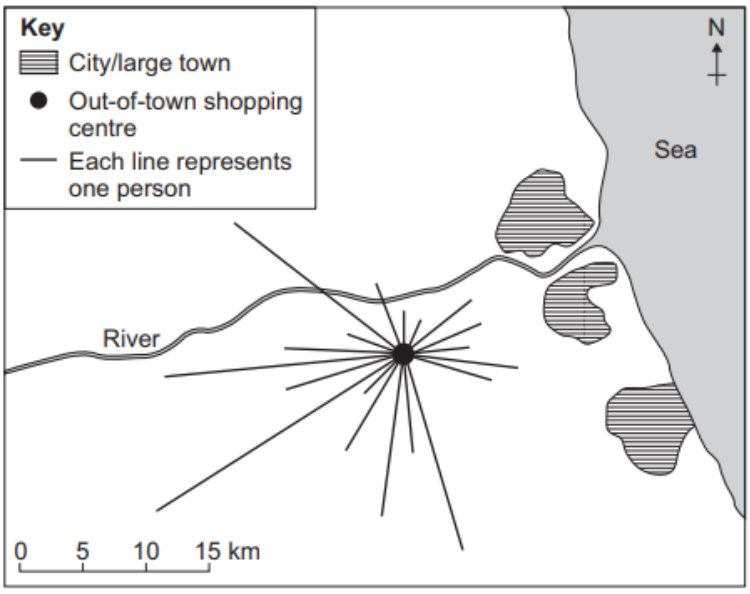
What is a desire line map?

A desire line map represents movement from various origins to a single destination. The exact route is not taken into account and the movement is shown "as the crow flies". Again these maps usually have a line drawn proportionate to the volume of flow and have a scale to help interpret the flow.

Example

An example featured in GCSE Paper 3, 2021, from a student enquiry showing the origins of those visiting an out-of-town shopping centre shows a simplified desire line map.

Figure 21: Desire line to show where people came from when visiting an out-of-town shopping centre.



What is a trip line map?

A trip line map represents movement from an origin to a destination for a single trip. These maps are useful when investigating sphere of influence, for example, of a railway station or a supermarket. There is no key or scale as the maps only display single journeys from each origin to the particular destination.

2.5 Choropleth maps (maps showing spatial patterns)

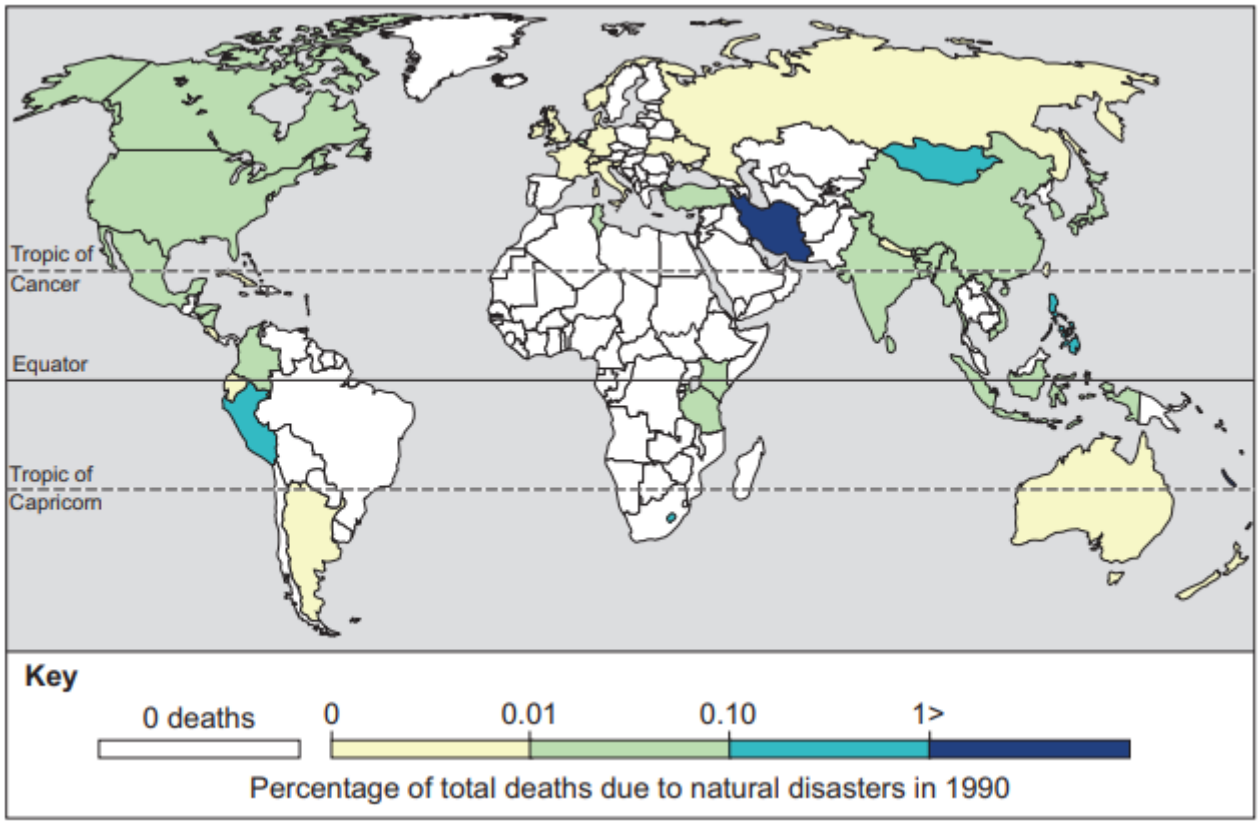
What is an choropleth map?

A choropleth map is a type of statistical thematic map that uses colour to represent data spatially. Generally, the darker the colour/shade, the more of the value is represented in the area.

Example

In AS Paper 1, Hazards, 2023, the below figure was used alongside another choropleth map detailing 2017 data with the 6-mark question asking both figures to be analysed.

Figure 22: The deaths from natural disasters as a share of total deaths in each country in 1990.



Example commentary

Natural disasters account for a very small proportion of deaths globally. In both 1990 only one country has more than 1% of deaths attributed to natural hazards, Iran. The majority of countries in both Africa and South America have no deaths due to natural hazards, with only seven countries having any deaths from natural hazards in both continents in 1990.

2.6 Isoline maps (maps showing spatial patterns)

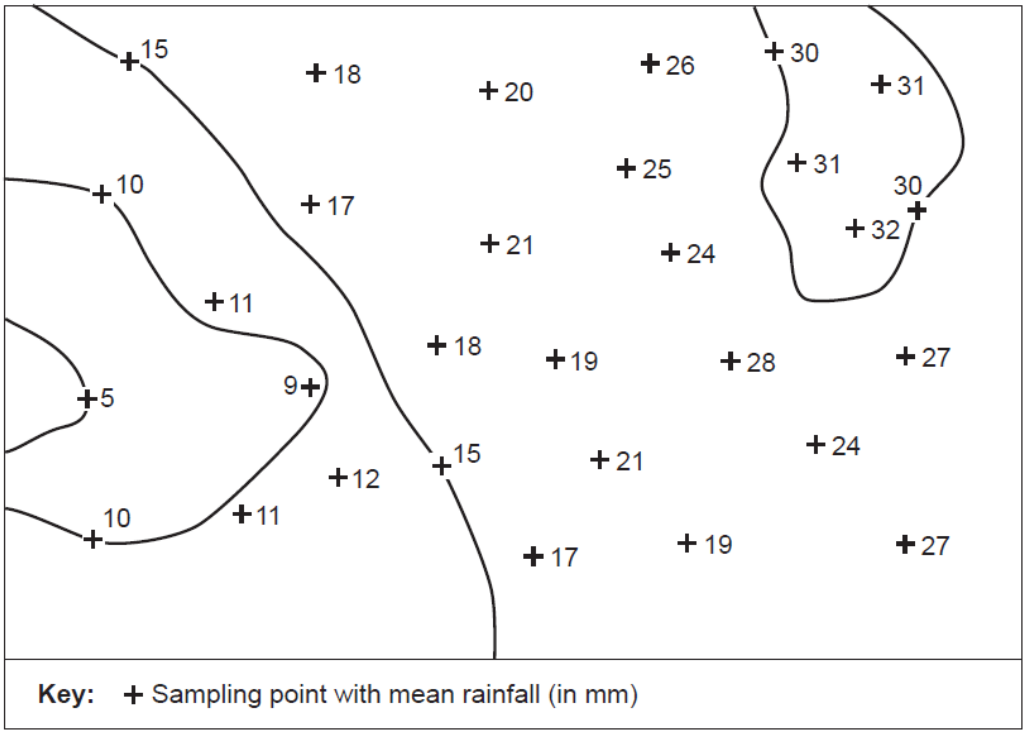
What is an isoline map?

Isolines are lines which join data points of the same value. A common example is the contour lines seen on OS maps, which connect points on the map which have the same height above sea level.

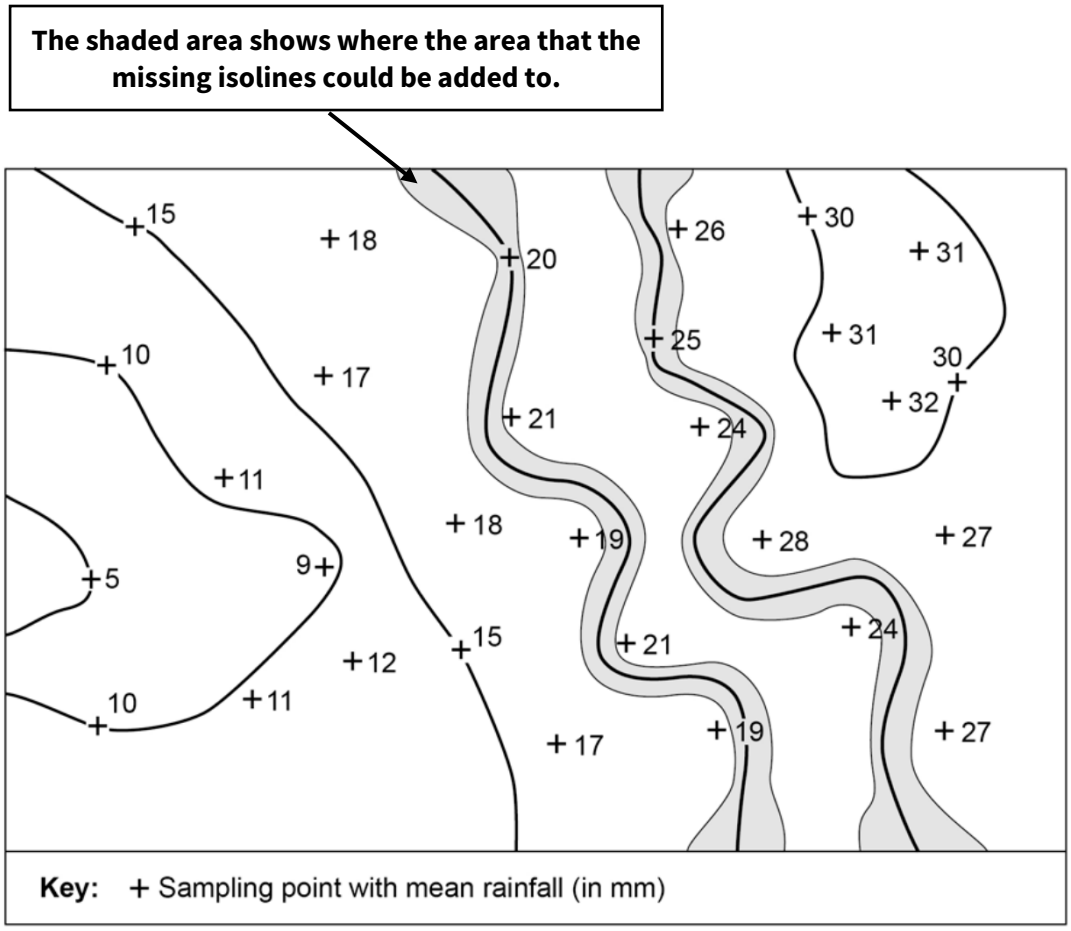
Example

As part of the Geography fieldwork investigation and geographical skills questions in AS Paper 2, 2019, the following unfinished isoline maps appeared. This was part of a student's enquiry into factors affecting surface run-off and flood risk in a local area. In this investigation, one aspect of data collection was to measure the amount of rain in several rain gauges placed in the ground. The student measured the amount of rain in each gauge each day for three consecutive days. The mean rainfall was then calculated. The questions asked the isoline to be completed and then to asses the usefulness of this data presentation method.

Figure 23: Rainfall isoline map to be completed by adding the 20 and 25 millimetre isolines.



Completed isoline map



Example commentary

An isoline map is a quantitative and objective way to present the data making analysis of patterns easier. However, on this isoline map there may be too few plot locations to identify clear spatial patterns and this may make analysis difficult. An isoline map is more suited to data that has gradual changes over space rather than large changes between areas. Overall, an isoline map gives a visual and geographical representation of the data to see areas of equal value, but this example could have been enhanced by colour shading.

2.7 Dot maps (maps showing spatial patterns)

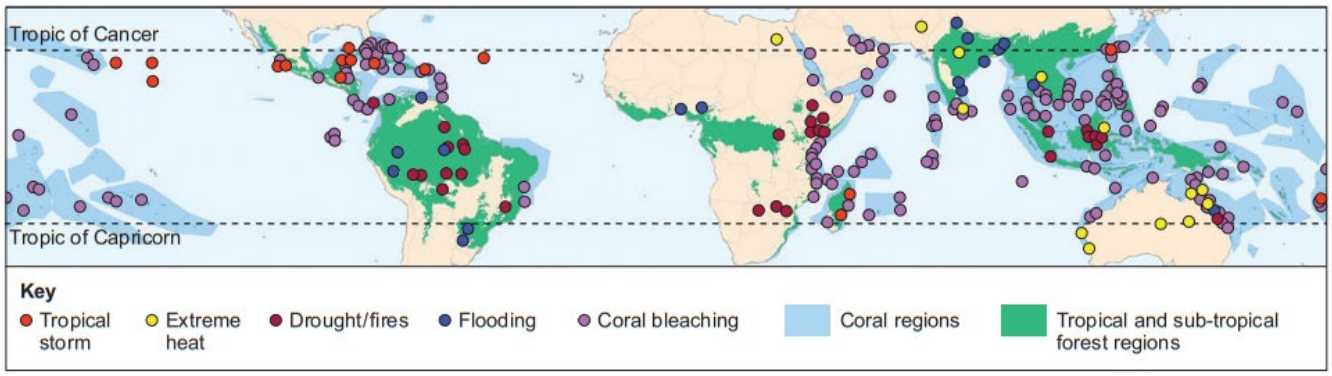
What is a dot map?

A dot map shows information as individual spots on a base map. They help show spatial distribution with each dot represents a piece of geographical information.

Example

As part of Ecosystems under stress in A-level Paper 1, 2021, the below map was given to analyse as part of a 6-mark question.

Figure 24: Selected climate extremes and impacts affecting coral and forests in tropical and sub-tropical regions.



Example commentary

Studying the distribution of climate extreme dots, it can be seen that both coral and forest regions are under threat from a range of climate extremes. Many of the dots appear in clusters/groups, for example drought/fires in the Amazon region of South America and in east Africa.

Nearly all of the climate extreme dots are in the tropical zone, meaning the area between the Tropic of Cancer and the Tropic of Capricorn. However, extreme heat and flooding appear outside of these zones. The dots for extreme heat are mainly near the Tropic of Cancer and Tropic of Capricorn latitude lines. However, some of these yellow dots are anomalies to this trend, for example there is a yellow dot near the south of India.

There are a few cases where extreme heat dots are in the same location as drought/fire dots, but this is rarely the case. However, this can be seen on the island of Borneo in south-east Asia, and in north-east Australia. Overall coral bleaching dots appear to be the biggest and most wide-ranging threat to the regions. Almost every coral region is affected by bleaching.

Section 3: Graphical skills

3.1 Line graphs (simple, comparative, compound and divergent)

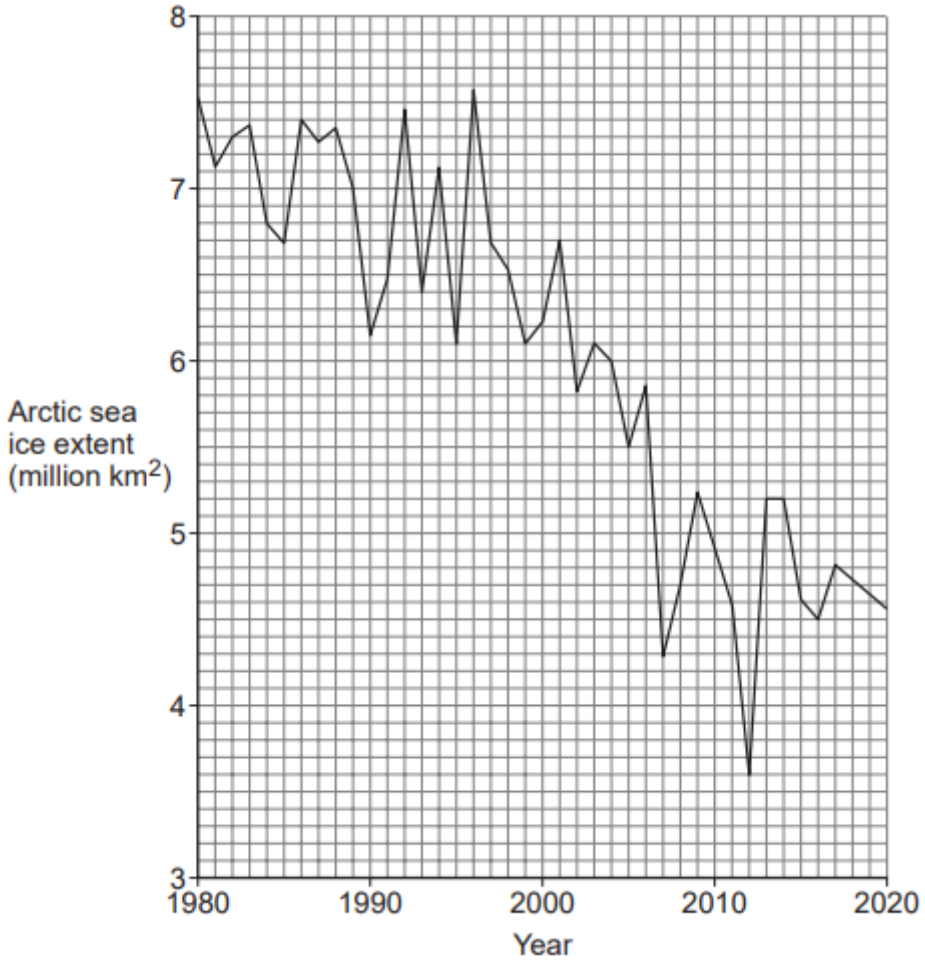
What is a simple line graph?

A simple line graph shows how data values change over time, tracking one variable so there is only a single line. Points are connected to graphically display the changes, with time shown on the x-axis.

Example

In the challenge of natural hazards in GCSE Paper 1, 2023, the below simple line graph was given.

Figure 25: Average monthly Arctic sea ice extent in September between 1980 and 2020.



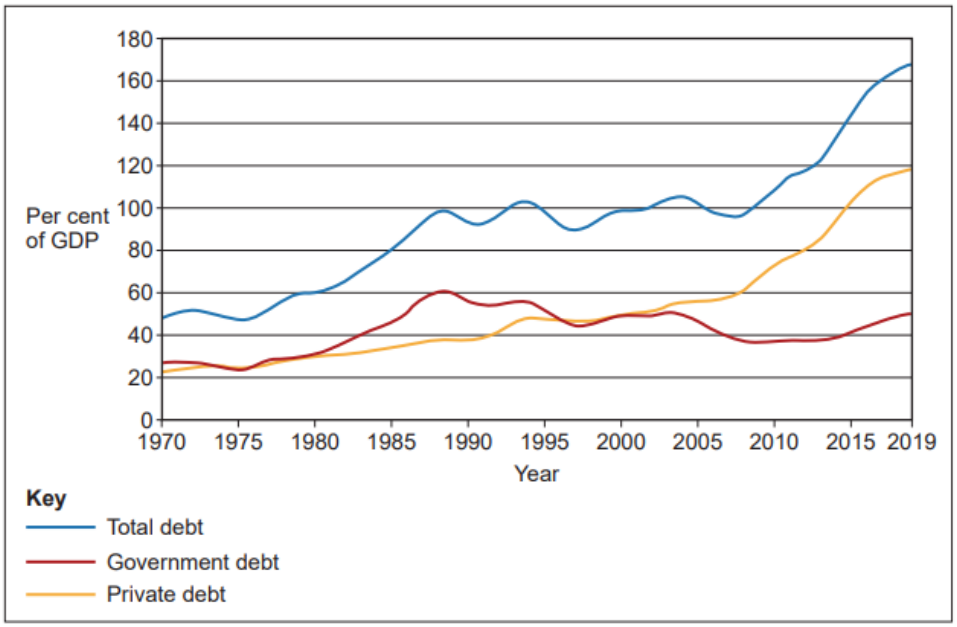
What is a comparative line graph?

A comparative line graph means a line graph used to compare two or more data sets on the same graph. Time will be marked on the x-axis.

Example

In Global systems and global governance, A-level Paper 2, 2023, the below comparative line graph detailed the total debt population change was given to analyse as part of a 6-mark question.

Figure 26: The total debt in NEEs (Newly Emerging Economies) and LICs (Low Income Countries) between 1970 and 2019.



Example commentary

In **Figure 26** all three debt lines end in 2019 higher than the 1970 starting points, and all three show fluctuations.

Total debt (blue line) increases from about 48% of GDP to about 168% of GDP (more than treble). Private debt (yellow line) increases to about 118% of GDP (more than five times its 22% starting point in 1970).

Government debt (red line) increases much less than private debt. It ends up in 2019 at 50% of GDP, and is the only line to end in 2019 lower than a previous peak (which was 60% of GDP in 1988).

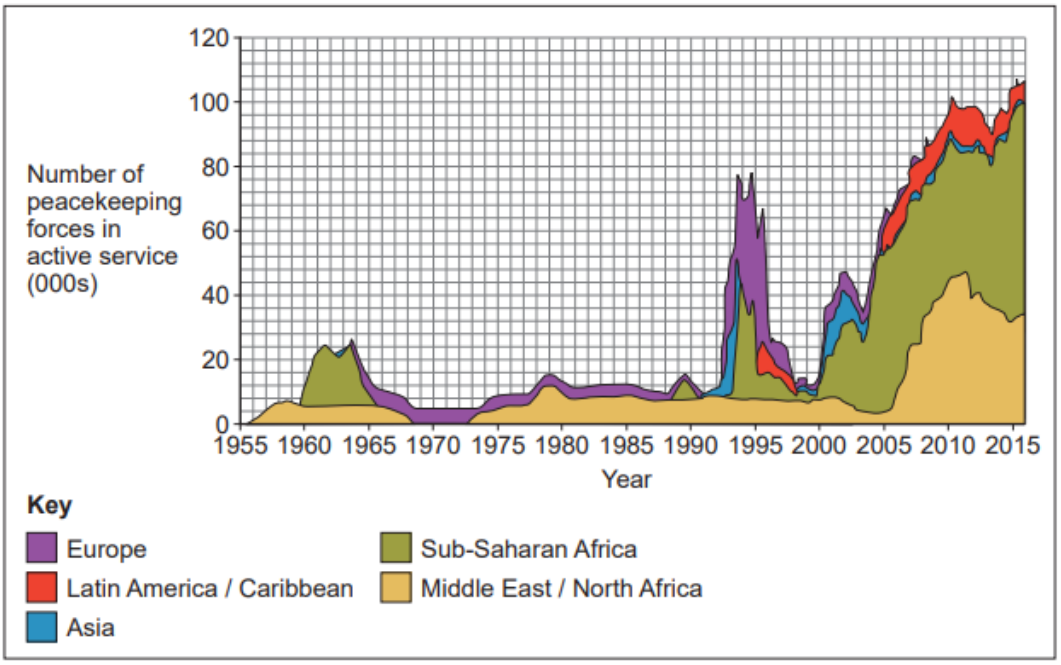
What is a compound line graph?

A compound line graph uses several variables stacked on top of each other to show the total quantity across all variables. It can be useful to use a ruler to measure the coloured/shaded sections, then compare your measurement to the y-axis key from the bottom to get the values shown.

Example

In Global systems and global governance, A-level Paper 2, 2021, the below compound line graph detailed the number of peacekeeping forces in active service was given to analyse as part of a 6-mark question.

Figure 27: UN peacekeeping forces involved in active service in different regions between 1955 and 2016.



Example commentary

Figure 27 shows an increasing trend in the number of peacekeeping forces in active service. There have also been fluctuations between 1955 and 2016. The number of forces has increased rapidly since 2003. In 2016 there were a total of about 106,000 forces in active service. There was also a peak in 1995 with just over 76,000 forces.

Most of the recent increases have been in Sub-Saharan Africa and Middle East/North Africa. The Sub-Saharan Africa region had most forces in service in 2015 with a total of 68,000 (green area). The Middle East/North Africa regions had 32,000 forces in service.

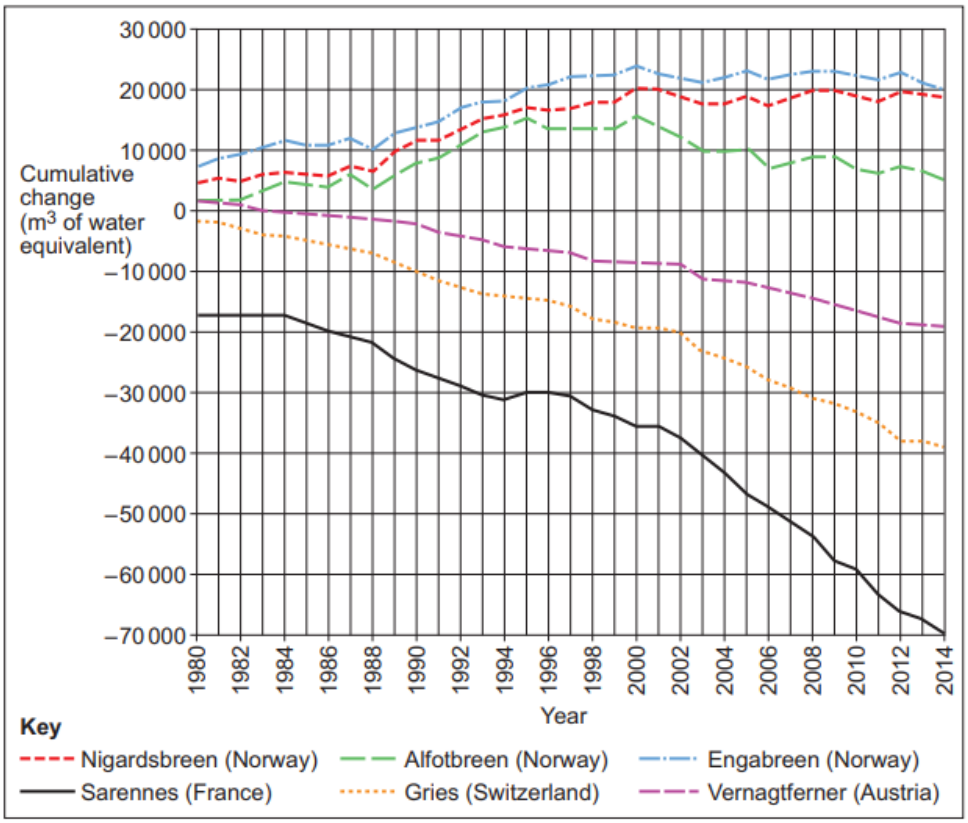
What is a divergent line graph?

A divergent line graph is a line graph which shows how data values deviate from a mean (or average) value. The mean is represented by a zero axis shown horizontal across the graph.

Example

In Glacial systems and landscape, AS Paper 1, 2023, the below simple line graph detailed population change was given to analyse as part of a 6-mark question.

Figure 28: Cumulative change in glacial mass of six European glaciers compared to 1945 levels.



Example commentary

There are useful mnemonics which can help analyse all line graphs, such as TEA (Trend, Evidence, Anomaly):

Trend: In **Figure 28** between 1980 and 2014 the three glaciers located in Norway all have positive cumulative change, whereas the other three glaciers located elsewhere in Europe all have negative cumulative change.

Evidence: Nigardsbreen and Enabreen have an approximate cumulative change of 20,000 m^3 of water by 2014, whilst Alfotbreen has approximate cumulative change of 5,000 m^3. Vernagrferner located in Austria had a negative cumulative change of -19,000 m^3 by 2014 and Gries located in Switzerland also had a negative cumulative change of -39,000 m^3 by 2014.

Anomaly: Sarennes in France has a much larger negative cumulative change, equalling more than Vernagrferner and Gries combined with a negative cumulative change of -70,000 m^3 by 2014.

3.2 Bar graphs (simple, comparative, compound and divergent)

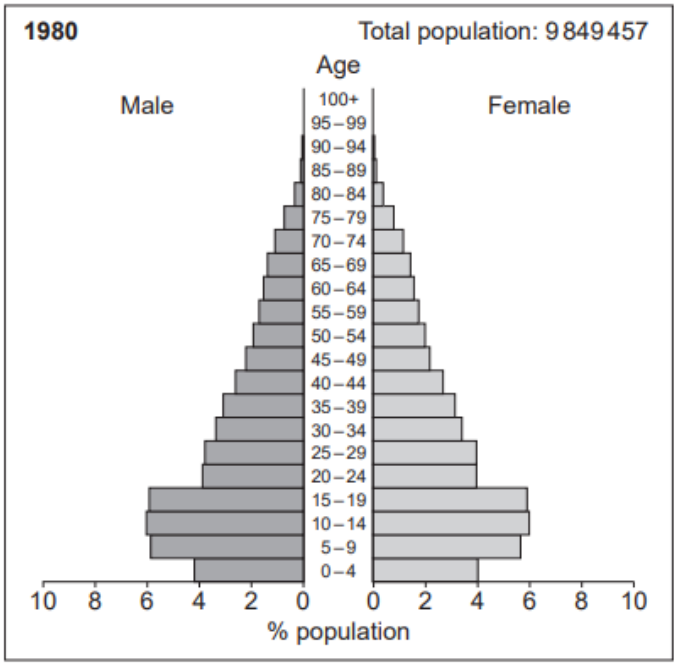
What is a simple bar graph?

A simple bar graph displays data in the form of bars in proportion to the value they represent. They allow quick comparison of quantitative data.

Example

One form of simple bar graph is a population pyramid as shown in Population and environment, A-level Paper 2, 2021 where two population pyramids were given to analyse population change.

Figure 29: Population Pyramid for Cuba, 1980.



Example commentary

Remember the useful mnemonic HALT (Highest, Anomaly, Lowest, Trend):
Highest value: The largest age range is 10-14 year olds for both male and female with just over 6% of the population each.
Anomaly: 0-4 for both male and female sticks out as there is a dramatic reduction from previous age groups.
Lowest value: the higher age ranges, over 80+ are the smallest values.
Trends: For both male and female, there is a bulge of young dependents aged 5-19 all above 5.5%, whilst age 20-24 are both at approximately 4% with each age group above this decreasing slightly, causing the pyramid to taper.

What is a comparative bar graph?

A comparative bar graph shows a comparison between two or more sets of data.

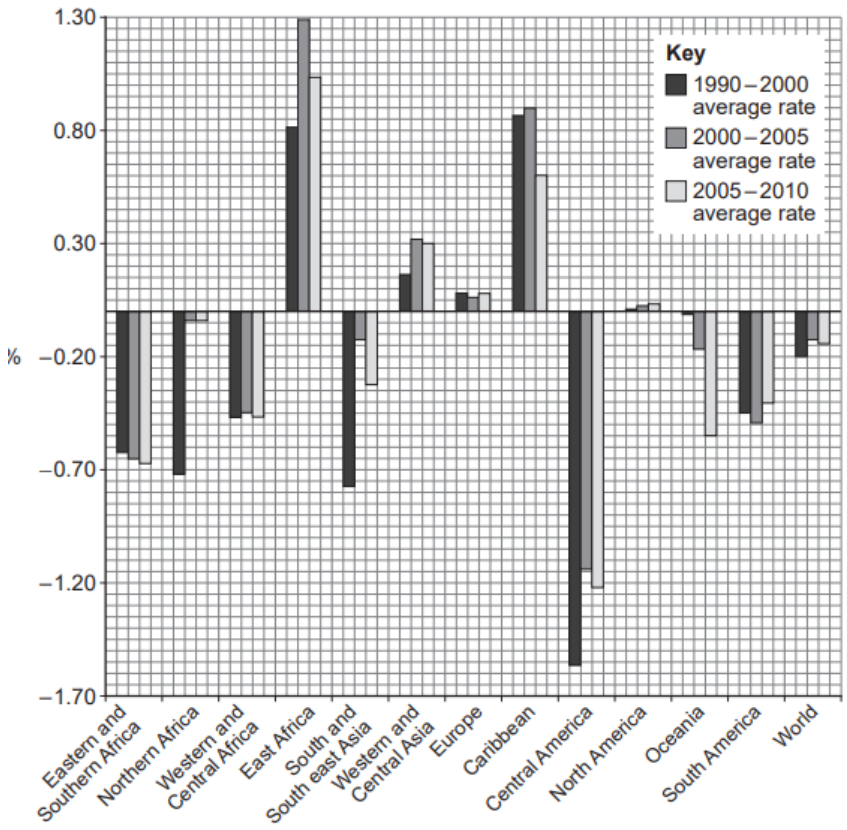
What is a divergent bar graph?

A divergent bar graph shows data values in opposite directions.

Example

In Water and carbon cycles, A-level Paper 1, 2022, the below bar graph was used and is an example of comparative and divergent bar chart.

Figure 30: Regional changes in forest cover between 1990 and 2010.



Example commentary

13 regions are shown in **Figure 30**. Eight out of the 13 regions show a decrease in forest cover, and this applies to all three time periods. The other five regions show forest increase with significantly different percentages.

The highest amount of forest loss was in the region of Central America, with two out of the three comparative bars showing more than 1.2% decrease. The most significant period for forest loss was 1900-2000, with just over 1.55% loss.

Eastern and Southern Africa shows the second highest combined loss over the three time periods, with the worst time period being 2005–2010 at nearly 0.7% decline.

North Africa is somewhat of an anomaly. After seeing more than 0.7% loss from 1990 to 2000, the next two time periods both saw much less at just under 0.05% loss.

Regarding afforestation, East Africa and the Caribbean region stand out. The most significant forest gain period was in East Africa from 2000 to 2005, with nearly 1.3% increase.

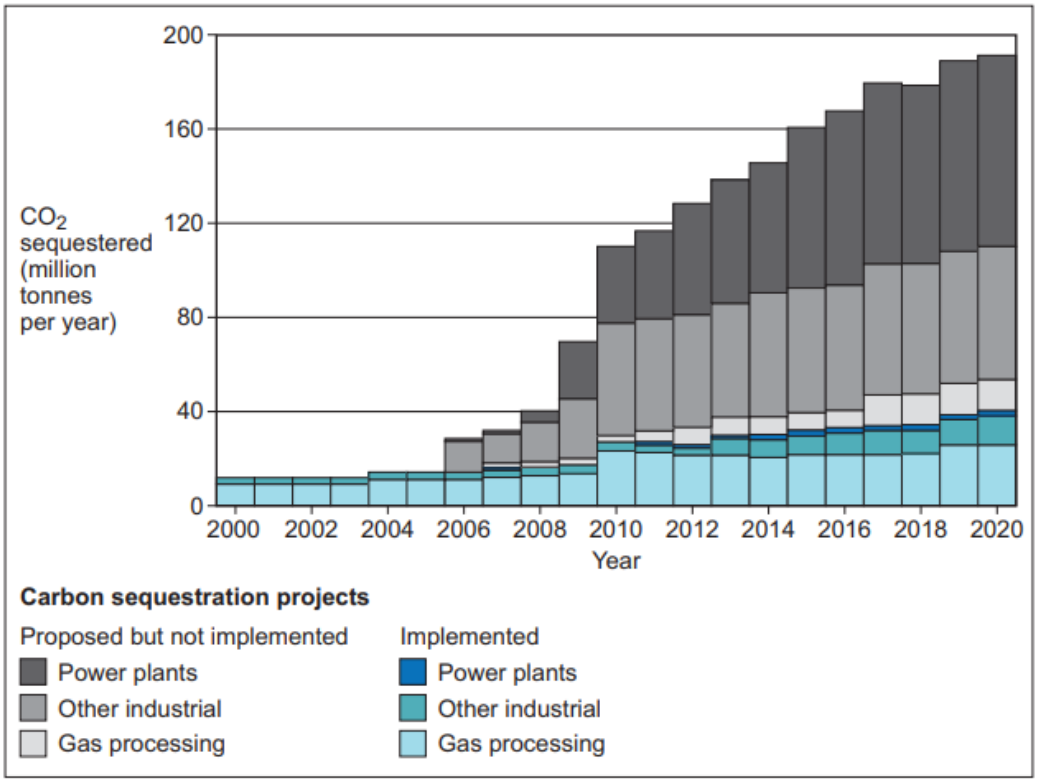
What is a compound bar graph?

A compound bar graph uses several variables stacked on top of each other to show the total quantity across all variables. As shown with compound line graphs, it can be useful to use a ruler to measure the coloured/shaded sections, then compare your measurement to the y-axis key from the bottom to get the values shown.

Example

In Water and carbon, A-level Paper 1, 2023, the below compound bar chart was given to assess the challenges associated with carbon sequestration.

Figure 31: Global proposed carbon sequestration rates compared to implemented carbon sequestration rates between 2000 and 2020.



Example commentary

From 2000–2003, there were approximately 10 implemented carbon sequestered projects; the majority were gas processing with only one of other industrial.

From 2004 onwards the amount of implemented carbon sequestration projects remained small reaching a peak of 40 by 2020. However, from 2006 onwards there was the emergence of proposed by not implemented carbon sequestration projects. In 2006 these were slightly more than the implemented projects at approximately 11, but from 2009 onwards these were much greater in number. From 2010, the prosed projects were in excess of 80; split roughly half power plants and the other half other industrial, by 2020 these had nearly doubled to 155, 80 of which were power plants, 60 other industrial and 10 gas processing. Far outnumbering the 40 implemented projects.

3.3 Scatter graphs (and the use of best fit line)

What is a scatter graph?

A scatter graph uses points to represent values for two different numerical variables.

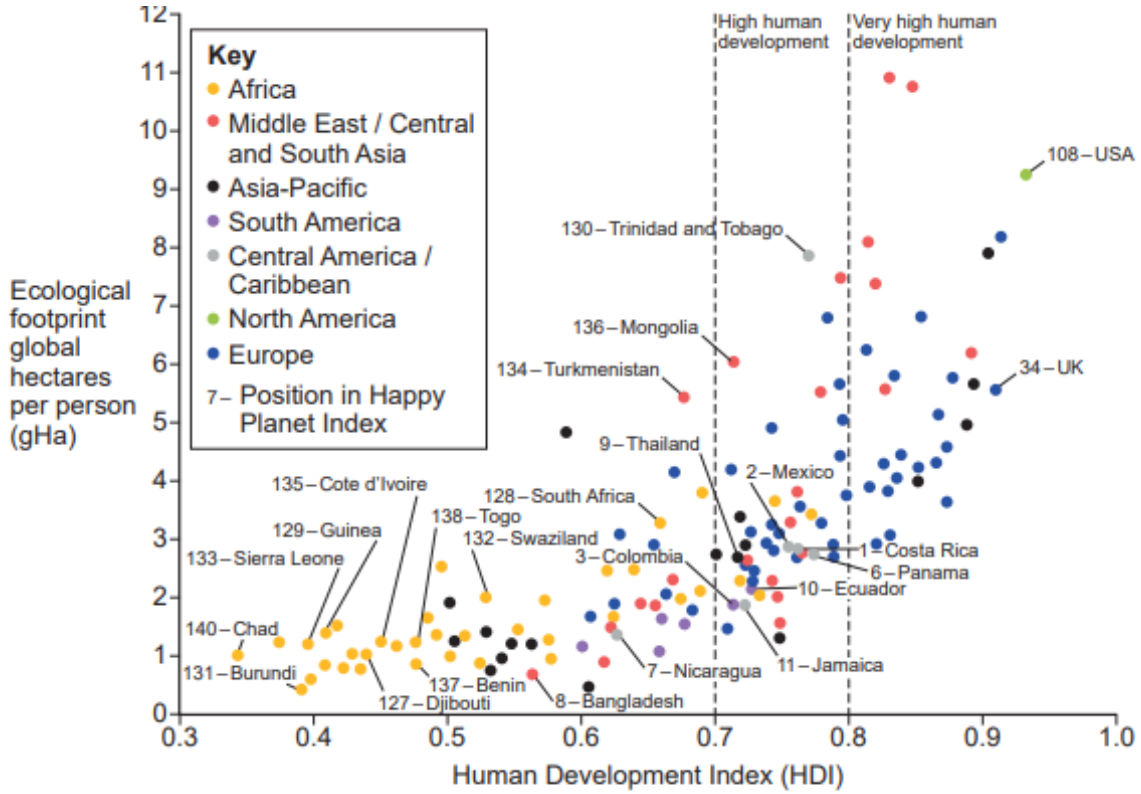
What is a best fit line graph?

A best fit line goes through the middle of a collection of points on a scatter graph, ideally with a similar number of points on either side of the line. A stronger correlation is shown when the points are close to the best fit line. Not all scatter graphs feature a best fit line.

Example

In Population and the environment, A-level Paper 2, 2022, the below scatter graph was given to analyse as part of a 6-mark question.

Figure 32: The ecological footprint, Human Development Index (HDI) and Happy Planet Index in selected countries for 2016.



Note: The Happy Planet Index is based on a ratio of a country's well-being measurements (such as life expectancy, equality and satisfaction) divided by its ecological footprint. The numbers reflect the position in the index. The higher the number, the happier the nation.

Example commentary

There is a clear correlation between HDI and the ecological footprint; the higher the HDI the higher the ecological footprint. For example, the USA has the third highest ecological footprint and the highest HDI, whereas Burundi has the lowest ecological footprint and an HDI around 0.4, less than half that of the USA. African countries tend to have low HDIs and low ecological footprints. Whereas European countries mainly have an HDI above 0.7 and an ecological footprint above 2.

The relationship between the Happy Planet Index and the ecological footprint is less clear. For example, Costa Rica is number one but has a similar ecological footprint to South Africa at 128. Trinidad and Tobago is at rank 130 but has an ecological footprint more than four times higher than Guinea at 129. On the whole countries with low Happy Planet ranks have a low ecological footprint. Although there are some anomalies, such as Bangladesh at 8 with an ecological footprint of less than 0.5.

3.4 Pie charts and proportional divided circles

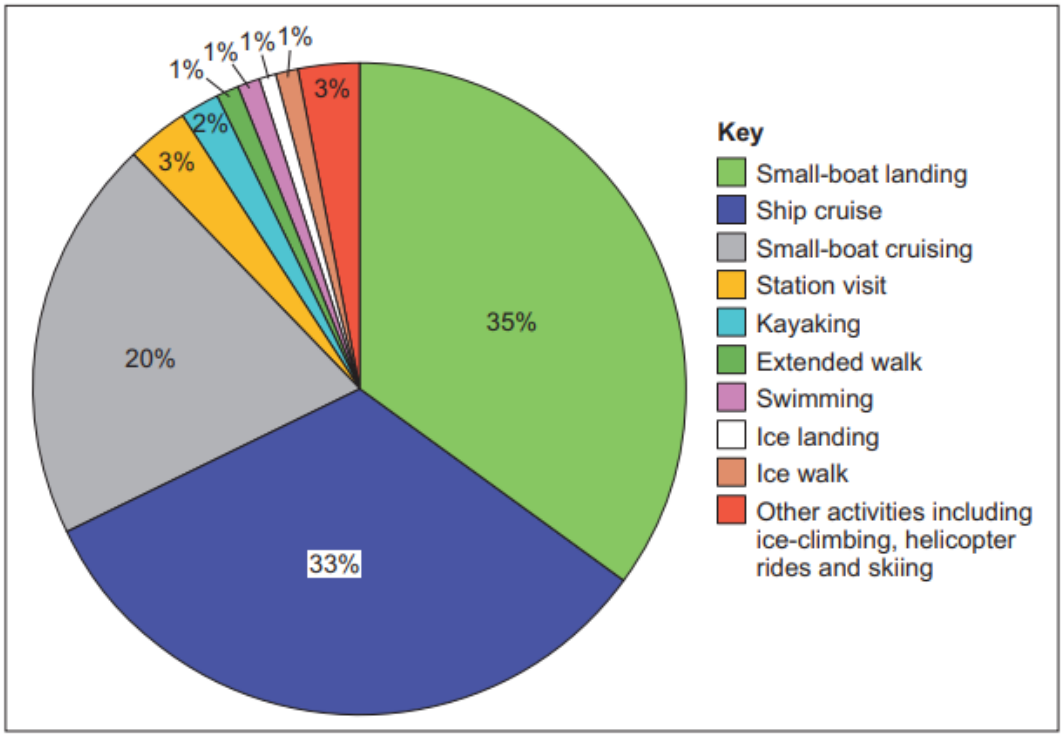
What is a pie chart?

A pie chart shows percentages in a circle divided into segments. Each data value is shown as a proportion of 360, because there are 360 degrees in a circle.

Example

In Global systems and global governance, A-level Paper 2, 2020, the below pie chart was given as part of a 6-mark question assessing the threat tourism poses to Antarctica.

Figure 33: Percentage breakdown of main tourist activities for visitors to Antarctica in 2016–17. In the 2016–17 season there were 44,202 visitors to Antarctica.



Example commentary

Up to 53% of people may not actually be landing on Antarctica so threats may be less direct. However, a third are large cruise ships which run the risk of ice-collision and subsequent oil spills. 4% of visitors do more extreme activities such as ice-walking, swimming and kayaking. These activities will require more infrastructure and so pose a larger threat to the natural landscape and the local wildlife. A well as this 1% do extended walks which will take people further away from the landing sites. Although a small percentage it still amounts to approximately 4,400 people.

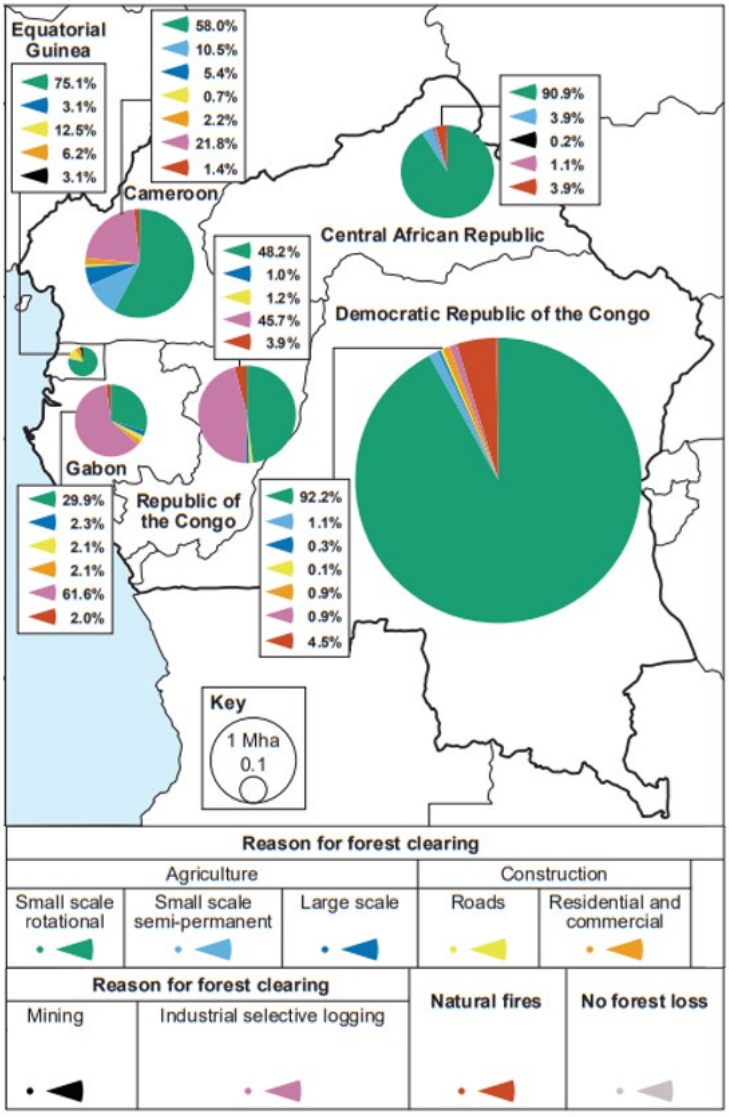
What is a proportional divided circle?

A proportional divided circle is similar to a pie chart, often comparing variables across a number of circles.

Example

In Ecosystems under stress, A-level Paper 1, 2022, the below pie chart was given as part of a 6-mark analyse question.

Figure 34: National estimates of forest loss by area and cause in equatorial West Africa, 2000–2014.



Example commentary

The largest amount of forest loss is found within the Democratic Republic of the Congo, with most of the forest clearing, 92.2% for the purpose of small-scale rotation. Industrial logging accounts for nearly half of the deforestation in the Republic of the Congo and almost 16% more in Gabon at 61.7%. Most of the other causes of deforestation are negligible, though an anomaly is the high proportion of clearance attributed to road building, 12.5% in Equatorial Guinea.

3.5 Triangular graphs

What is a triangular graph?

A triangular graph is a graph with three axes. Each axis is divided into 100, representing percentages. Triangular graphs are used when there are three variables which add up to 100. Triangular graphs help us to see data patterns and clusters.

Example

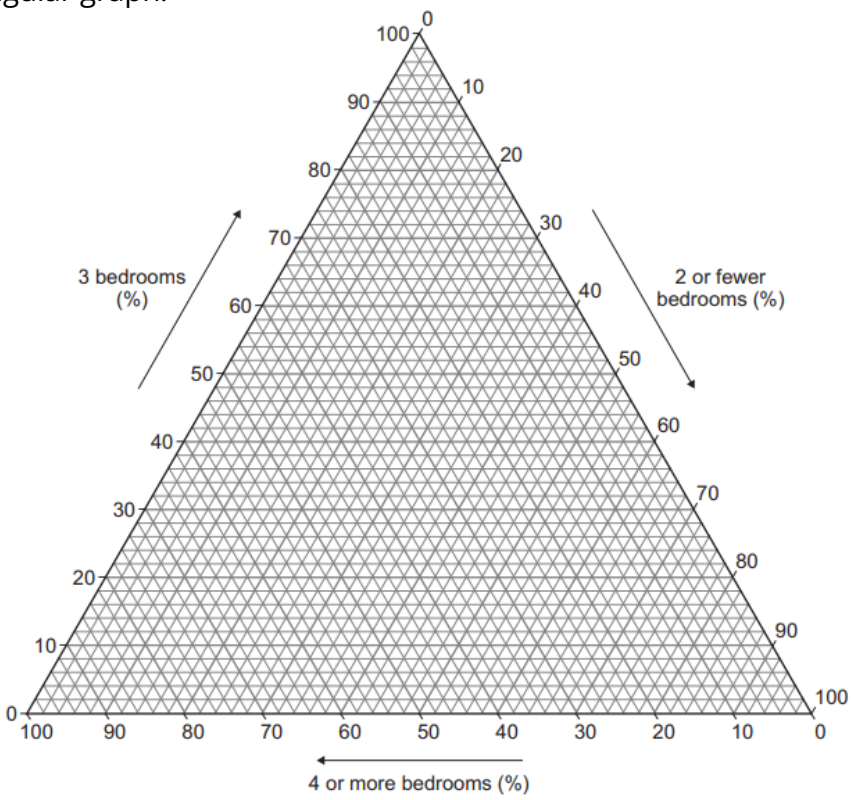
As part of the Geography fieldwork investigation and geographical skills questions in AS Paper 2, 2020, the following data was given.

Figure 35: Secondary data set.

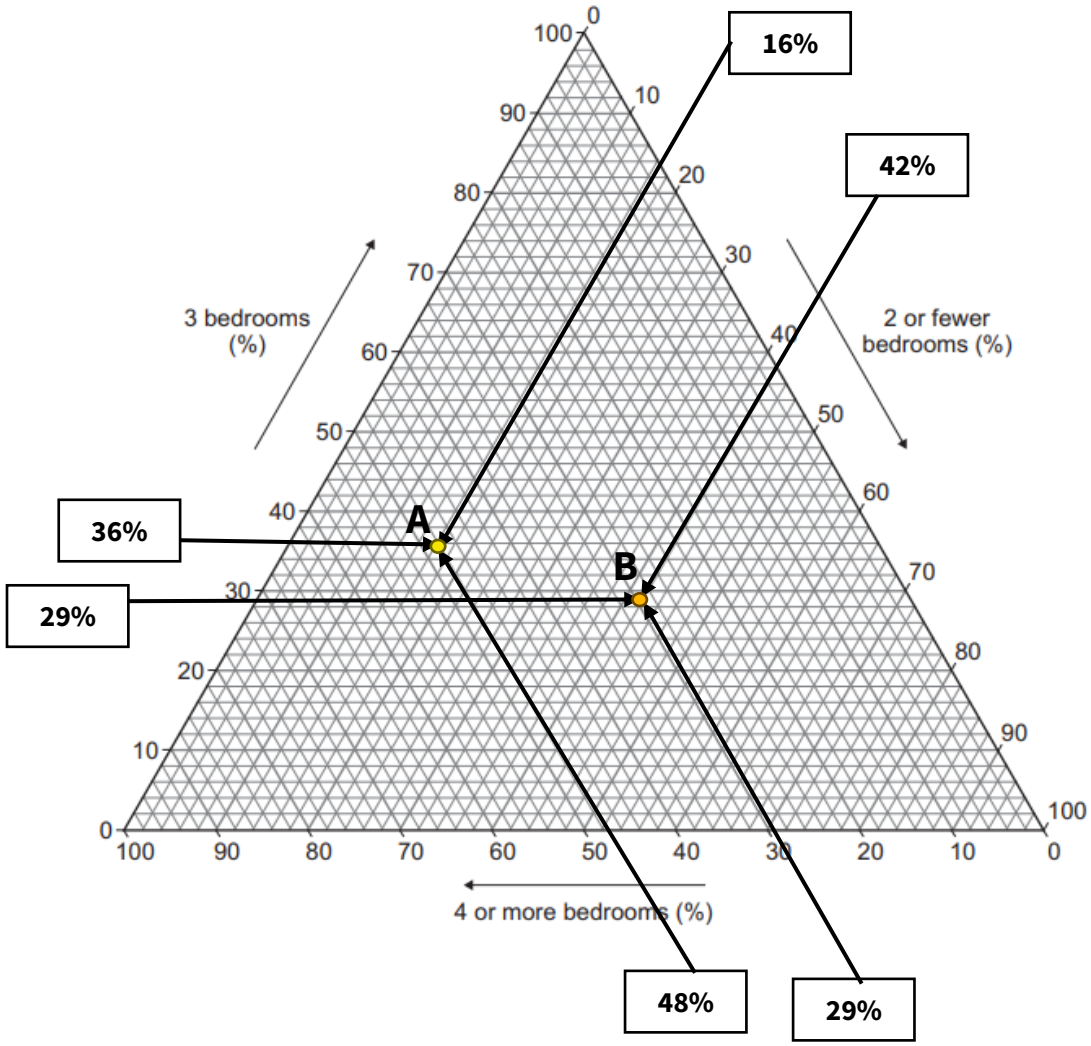
Number of bedrooms	Site A (%)	Site B (%)
4 or more	48	29
3	36	29
2 or fewer	16	42

This data is from a student comparing house size in two housing estates which were both five years old. **Site A** is a housing estate built on a greenfield site, **Site B** is a housing estate built on a brownfield site. The question was to plot the data from **Figure 35** onto **Figure 36.**

Figure 36: Triangular graph.



Completed triangular graph

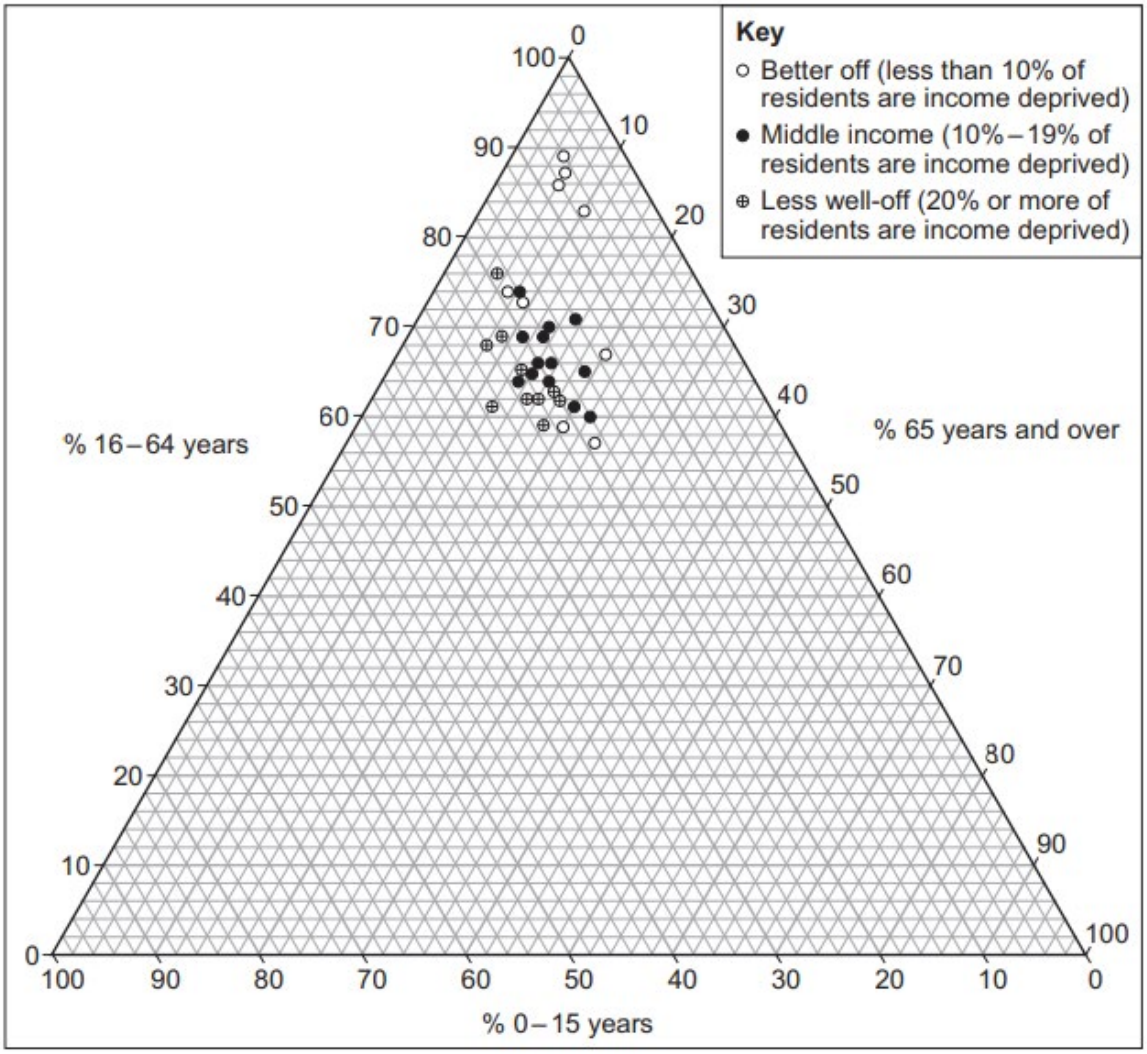


As part of Changing Places A-level Paper 2, 2023, the data in **Figure 37** was given and a question asked to plot this data onto **Figure 38** and then analyse the completed data shown.

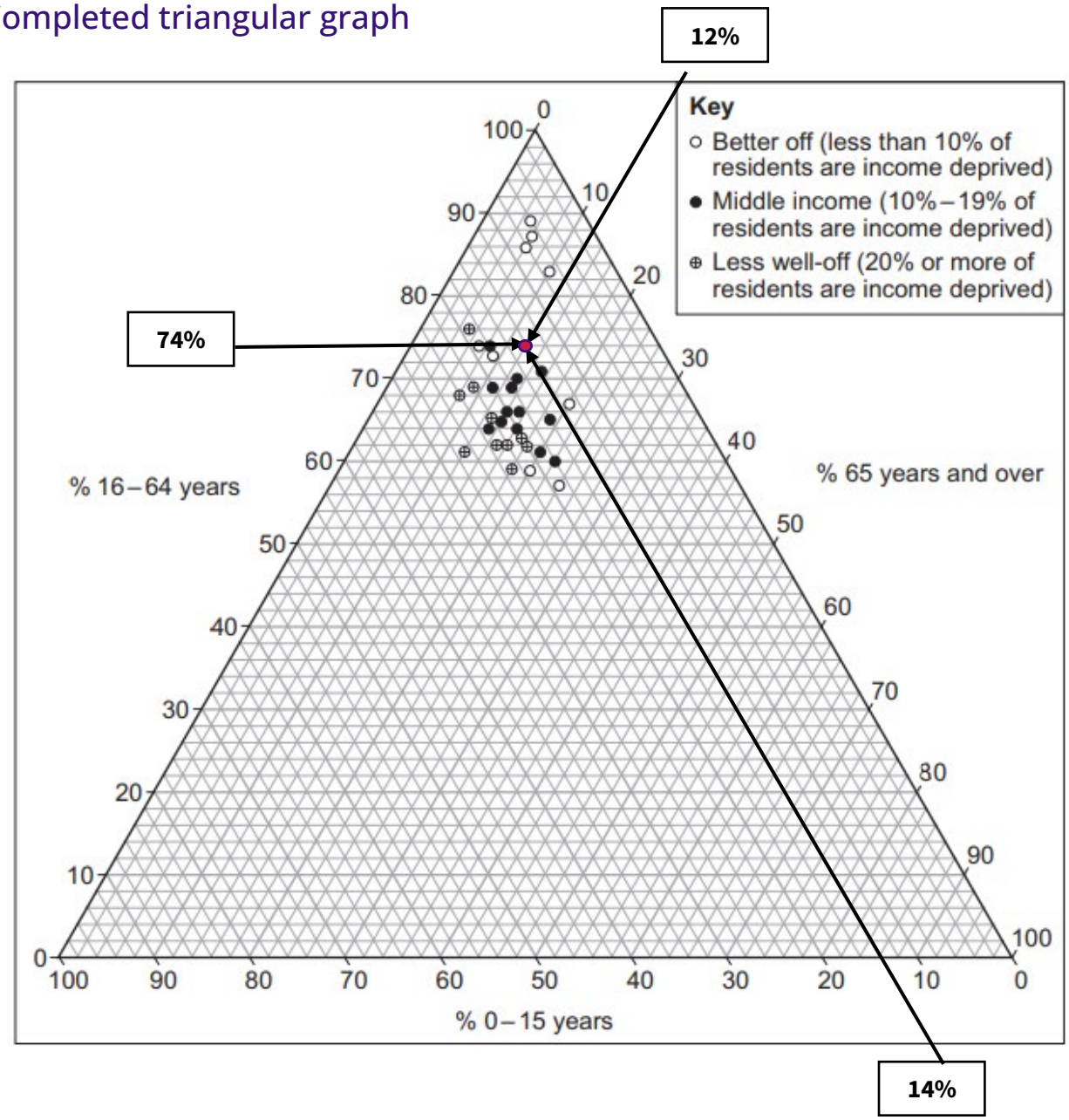
Figure 37: Data for Southville ward, which has not been completed on **Figure 38**.

Ward	% 0–15 years	% 16–64 years	% 65 years and over
Southville (Middle income)	14	74	12

Figure 38: shows the age breakdown of the population of council wards in Bristol in 2011. The wards have been categorised by level of income deprivation.



Completed triangular graph



Example commentary

There is a clear relationship between socio-economic status and age breakdown in Bristol. The wealthier the ward the less children there are. The four wards with lowest amounts of 0-15 year olds are all better-off wards, all less than 10%. Whereas only one of the less well-off wards have less than 20% of 0-15 year olds. Most of the middle-income wards are found in a narrow band of age breakdown having between 10-20% over 65-year olds and 60-70% 16-64-year olds.

3.6 Graphs with logarithmic scales

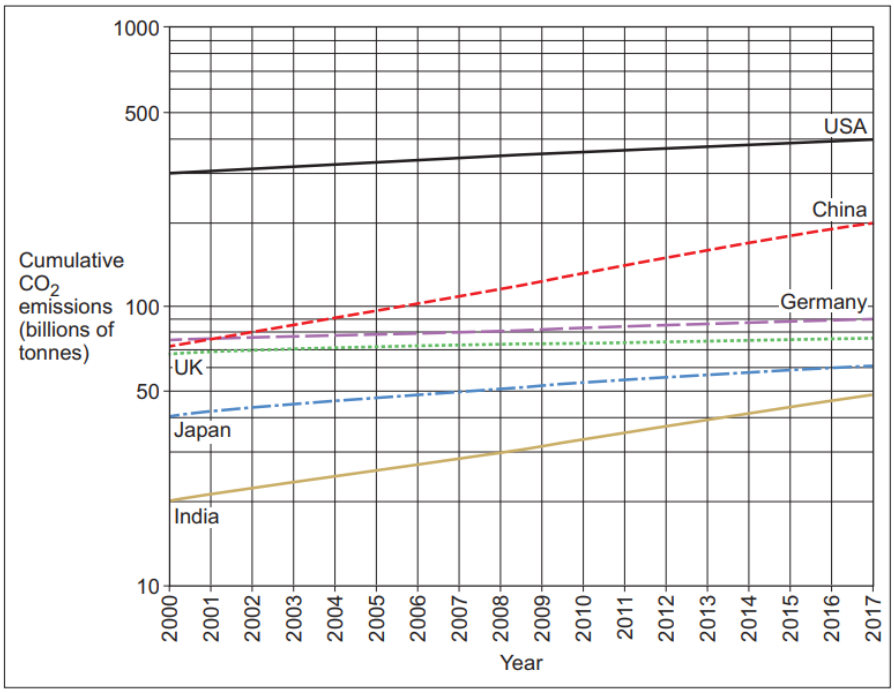
What is a logarithmic scale?

A logarithmic scale is a non-linear scale often used when analysing a large range of data values. Unlike common graph scales which have equal increments, logarithmic scales are exponential, meaning they increase more quickly into larger increments.

Example

In Water and carbon cycles, AS level Paper 1, 2023, the below graph with a logarithmic scale was used.

Figure 39: Information about the cumulative emissions of carbon dioxide (CO_2) produced from burning fossil fuels and the manufacture of cement between 2000 and 2017 for selected countries.



Example commentary

All countries have increased the total amount of CO_2 they have emitted. China and India have seen the most rapid increase in total emissions. The total amount of CO_2 emitted by India has more than doubled over the time period, adding almost 30 billion tonnes to its total, going from 20 billion tonnes to almost 50 billion tones. Although visually China's line has a similar steepness to India's line, the logarithmic scale shows that the magnitude of increase in China's emissions is significantly larger. China almost triples the amount of CO_2 it has emitted, adding almost 130 billion tonnes to its total, from just over 70 billion tonnes to 200 billion tonnes. Between 2000-2017, China was responsible for more CO_2 emitted into the atmosphere than India, Japan and the UK added together. The USA increased its CO_2 emissions from 300 to 400 billion tonnes, with the total amount of CO_2 emitted by the USA significantly larger than all other countries.

3.7 Dispersion diagrams

What is a dispersion diagram?

A dispersion diagram is a graph showing the range of values for a single set of data.

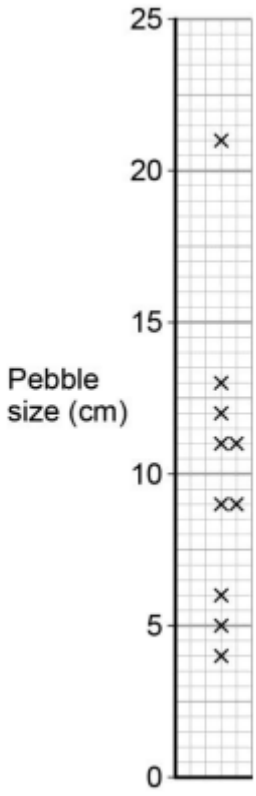
Example

An example featured in GCSE Paper 3, SAMs1, from a student enquiry collecting primary data, measuring pebble sizes at one location on a beach.

Figure 40: Fieldwork data set.

Pebble size is measured along the long axis.

Sample	Pebble size in centimetres
1	12
2	5
3	7
4	9
5	4
6	11
7	9
8	11
9	6
10	13
11	21



Section 4: Statistical skills

4.1 Measures of central tendency – mean, mode and median

What is central tendency?

Measures of central tendency identify basic features of a data set and allow you to compare differences between data sets. Mean, median and mode are calculations that give you a single value which helps provide a useful summary of a data set.

Measure of central tendency		
Mean	Sometimes referred to as the 'average', this is calculated by adding up all the individuals values in a data set, then dividing by the total number of values.	The mean makes use of all the data values and gives you a simple overview of the whole data set. It works best when the data values span a fairly narrow range. However, it's heavily influenced by extreme values ('anomalies' or 'outliers'). In this case the mean will not be very representative of the data set.
Median	This is the middle value of the data set. Arrange all the values in order ('ranking') then identify the middle value in the sequence. If you have an even number of values, the median is half way between the two middle values (add them together then divide by 2).	The median is straightforward to calculate. It's not affected by extreme values in the data set. However, it's not as arithmetically sound (accurate) as the mean.
Mode	This is the most frequently occurring value in a data set.	The mode is the easiest measure of central tendency to obtain. It is not affected by extreme values in the data set. However, it's not useful with data that has no repeated values (if each value only occurs once). It's also not very useful with data which has more than one modal value because this could cause confusion.

- The mean is influenced by extreme values.
- The median is not affected by extreme values.
- The mean is more arithmetically sound than the median.
- The mode is not useful with data that has no repeated figures.

Example

A student counted the number of pedestrians entering a park during a specific time period for 11 days.

Day	1	2	3	4	5	6	7	8	9	10	11
Number of pedestrians	7	12	5	32	17	19	14	22	8	29	22

Mean = 17	**Median = 17**	**Mode = 22**
7+12+5+32+17+19+14 +22+8+29+22 = 184 184 divided by 11.	32 29 22 22 19 **17** 14 12 8 7 5	This value occurs twice, all other values occur only once.

A student counted the number of pedestrians entering a park during a specific time period for 12 days.

Day	1	2	3	4	5	6	7	8	9	10	11	12
Number of pedestrians	9	19	8	16	8	5	24	16	23	13	7	18

Mean = 13.8 (to 1 decimal place)	**Median = 14.5**	**Mode = 16 and 8**
9+19+8+16+8+5+24 +16+23+13+7+18 = 184 166 divided by 12. This value is a recurring number, so it is given to 1 decimal place.	24 23 19 18 16 **16** **13** 9 8 8 7 5 As there is not a single value In this case, the 2 middle values are added up and divided by 2. 16 + 13 = 29. 29/2 = 14.5	This data set has two modes, occurring in different parts of the data set. The term for this is bi-modal.

4.2 Measures of central tendency – range and inter-quartile range

What is range and interquartile range?

Range means the difference between the highest and lowest values in a data set. Inter-quartile range (IQR) means the range of the middle 50% of the data set. The IQR tells you the spread or concentration of data around the median. The IQR has the advantage of removing the influence of extreme values.

Interquartile range formula

Upper quartile (UQ) = $\frac{(n+1)}{4}$

Lower quartile (UQ) = $\frac{(n+1)}{4} \times 3$

Interquartile range (IQR) = UQ – LQ

(n = number of items in the data set)

Example 1

19 food and drink outlets in a coastal town were rated for their Index of Visual Quality score (IVQ), with 10 being high and 1 being low (calculating the inter-quartile range is more straightforward when there is an odd number of data points).

This example calculates the IVQ median, mode, range and interquartile range for the sample of 19.

Food/drink outlet	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
IVQ score	8	8	7	5	6	8	8	9	10	6	7	8	10	9	4	5	10	8	7

Step 1

Add the frequency of IVQ scores in a table such as the one below.

Score	1	2	3	4	5	6	7	8	9	10
Frequency	0	0	0	1	2	2	3	6	2	3

Step 2
Rank all the IVQ scores vertically, highest to lowest as shown in the column below.

10	
10	
10	
9	
9	Upper quartile
8	
8	
8	
8	
8	Median
8	
7	
7	
7	
6	Lower quartile
6	
5	
5	
4	

Step 3 Work out the median = 8

Step 4 Work out the upper quartile
Upper quartile (UQ) = $\frac{(19+1)}{4} = \frac{(20)}{4} = 5^{th}$ value

Step 5 Work out the lower quartile
Lower quartile (UQ) = $\frac{(n+1)}{4} \times 3 = \frac{20}{4} \times 3 = 5 \times 3 = 15^{th}$ value

Step 6 Work out the inter quartile range
Interquartile range (IQR) = UQ - LQ = 9 – 6 = 3

Example 2
In AS Paper 2, 2020, the data was given to calculate the mean and interquartile range and then interpret the data. The context of the question was a student planning a fieldwork investigation into place satisfaction in her local town.

Site A refers to a housing estate built on a greenfield site.
Site B refers to a housing estate built on a brownfield site.

As part of the investigation, the student collected data from 11 residents on each housing estate by knocking on doors and asking people if they would take part in the survey.
The 11 residents were asked to give a score for the following categories:
- local surroundings
- community
- noise
- air quality.

The residents were asked to give a score out of 10 on a sliding scale, with 0 being very low satisfaction and 10 being very high satisfaction.

The student then calculated an overall place satisfaction score by adding together the individual values.

The question asked for completion of **Figure 41** by calculating the mean and the inter-quartile range (IQR) for **Site A**.

Figure 41: Fieldwork data set.

Site A

Resident	Score
1	38
2	25
3	33
4	28
5	34
6	27
7	26
8	32
9	24
10	29
11	23

Site A mean score = _____

Site B

Resident	Score
1	33
2	39
3	33
4	36
5	16
6	17
7	8
8	34
9	14
10	35
11	32

Site B mean score = **27**

Site A with satisfaction scores ranked

Rank	Score
1	38
2	34
3	33
4	32
5	29
6	28
7	27
8	26
9	25
10	24
11	23

Site A

Inter-quartile range:

Upper-quartile (UQ) = $\frac{n+1}{4}$ th position = _____ score

Lower-quartile (LQ) = $\frac{3(n+1)}{4}$ th position = _____ score

Inter-quartile range (IQR) = _____

IQR is the difference between UQ and LQ

Site B IQR is 19

Completed interquartile range

Site A

Resident	Score
1	38
2	25
3	33
4	28
5	34
6	27
7	26
8	32
9	24
10	29
11	23

Site B

Resident	Score
1	33
2	39
3	33
4	36
5	16
6	17
7	8
8	34
9	14
10	35
11	32

Site A mean score = **29**

Site B mean score = **27**

Site A with satisfaction scores ranked

Rank	Score
1	38
2	34
3	33
4	32
5	29
6	28
7	27
8	26
9	25
10	24
11	23

Site A

Inter-quartile range:

Upper-quartile (UQ) = $\frac{n+1}{4}$ th position = **33** score

Lower-quartile (LQ) = $\frac{3(n+1)}{4}$ th position = **25** score

Inter-quartile range (IQR) = **8**

IQR is the difference between UQ and LQ

Site B IQR is 19

Example commentary

Site A (the greenfield site) has a mean place satisfaction score slightly higher than the **Site B** score (brownfield site). This shows that place satisfaction is similar, and fairly high, in both locations. The slightly higher mean for **Site A** suggests residents had higher place satisfaction overall.

However, there is significant difference in the IQR for each site. **Site A's** IQR is 8, which is 11 lower than **Site B's** IQR of 19. This means that the place satisfaction scores of **Site A** are more clustered around the median. Conversely, **Site B's** place satisfaction scores are more spread out from the median so there was more variation in responses. In **Site B** some people were very satisfied with the area but others very much the opposite. The spread of data around the median in **Site B** was probably due to some very low or high scores for the survey criteria.

4.3 Measures of central tendency – standard deviation

What is standard deviation?

Standard deviation (SD) allows you to measure the spread (or distribution) of values around the mean. An advantage of calculating standard deviation is that it uses all the values in a data set (unlike the range and inter-quartile range).

Example

In A-level Paper 1, 2023, the data in **Figure 42** was given to complete and then interpret the data.

Figure 42: Data showing the minimum extent of Arctic ice between 2002 and 2015. A standard deviation calculation has been started.

Year	Minimum extent (millions of km^2) x	$x - \bar{x}$	$(x - \bar{x})^2$
2002	5.95	0.779	0.607
2003	6.13	0.959	0.920
2004	6.04	0.869	0.755
2005	5.56	0.389	0.151
2006	5.91	0.739	0.546
2007	4.29		
2008	4.72	–0.451	0.203
2009	5.38	0.209	0.044
2010	4.92	–0.251	0.063
2011	4.61	–0.561	0.315
2012	3.62	–1.551	2.406
2013	5.35	0.179	0.032
2014	5.28	0.109	0.012
2015	4.63	–0.541	0.293
	$\sum x$ = 72.39		$\sum(x - \bar{x})^2$ = 7.123
	$\bar{x}$ = 5.171		

Key

x = minimum extent
$\bar{x}$ = mean
$\sum$ = sum of
σ = standard deviation
n = number in sample

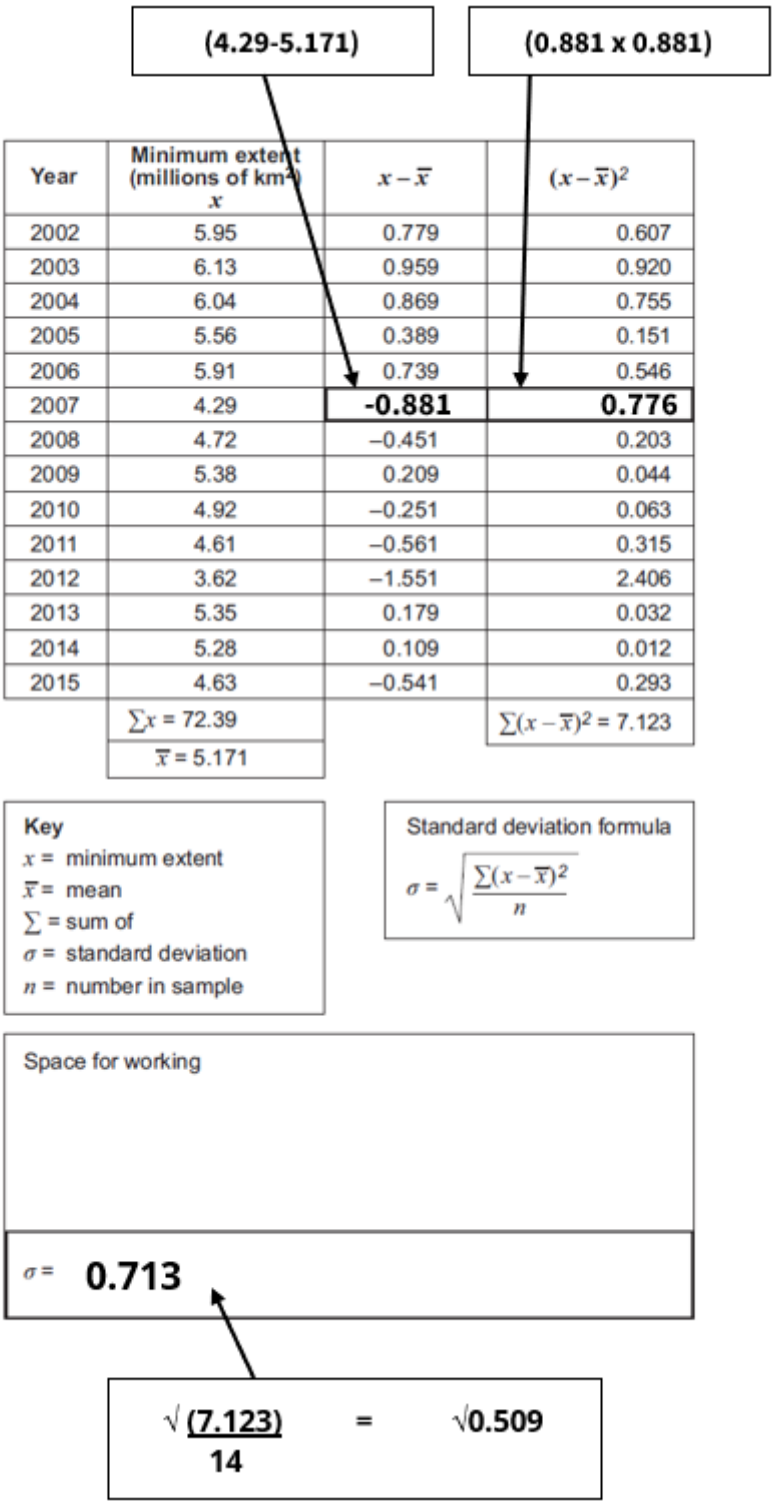
Standard deviation formula

$$\sigma = \sqrt{\frac{\sum(x - \bar{x})^2}{n}}$$

Space for working

σ =

Completed standard deviation



Example commentary

The relatively small size of the SD would suggest that there is a strong degree of clustering around the mean and further that there is a lack of extreme values within the data set.

In a normal distribution 68.2% of the data lies within 1 SD of the mean. In this case 71% of the data lies within 1 SD suggesting the data is normally distributed.

4.4 Spearman's rank correlation (inferential and relational statistics – to include application of significance tests)

What is Spearman's rank correlation?

The Spearman's rank correlation gives a numerical value which indicates the type and strength of a relationship.

For example:

- Positive relationship (the closer the result is to 1, the stronger the positive relationship is).
- Negative relationship (the closer the result is to -1, the stronger the negative relationship is).
- No relationship (the result is close to 0).

Why use a significance test?

A significance test tells you how reliable the result is, and whether the result is significantly difference from what could occur by chance.

There are some additional terms:

Significance test

This is a process to indicate whether a statistical test result is more likely to be statistically significant (or valid), or if it is more likely to have occurred by chance (be a fluke). 'Insignificant' results can be ignored.

0.05 significance level

5 divided by 100. This means the 95% significance level (i.e. you can be 95% confident the result is not a fluke, or you could say there is 5% chance of a fluke).

0.01 significance level

1 divided by 100. This means the 99% significance level (i.e. you can be 99% confident the result is not a fluke, or you could say there is 1% chance of a fluke).

Null hypothesis

This is a statement which says there is no relationship between the variables in question. 'Null' means 'nothing'.

You should reject the null hypothesis if your calculated value is greater than the critical value at the chosen significance limit.

Degrees of freedom

This means the number of independent pieces of information used to calculate a statistic.

Example

In AS Paper 2, 2023, the data in **Figure 43** was given to complete and then interpret the data. The data is the result of a fieldwork investigation into changes in urban land use in a medium-sized town in the south of England. The student collected data at 10 points along a transect on a main road from the town centre to the edge of the town. A systematic sample was used and at 500 metre intervals he recorded an estimate of the percentage of buildings that were used as shops. They estimated this by surveying the ground floor land use on both sides of the road, and in all directions, as far as they could see.

Figure 43: Data set and calculations.

Sampling point	Distance from town centre (m)	Rank of distance	Shops (%)	Rank of % shops	d	d^2
1	500	10	60	2	8	64
2	1000	9	45	3	6	36
3	1500	8	25	4	4	16
4	2000	7	10	7.5	–0.5	0.25
5	2500	6	5			
6	3000	5	20	5	0	0
7	3500	4	15	6	–2	4
8	4000	3	10	7.5	–4.5	20.25
9	4500	2	70	1	1	1
10	5000	1	0	10	–9	81

$\sum d^2 =$ _____

$6 \times \sum d^2 =$ _____

$$R_s = 1 - \frac{6\sum d^2}{n^3 - n}$$

$$= 1 - \frac{\text{_____}}{990}$$

$= 1 -$ _____

$R_s =$ _____

Key

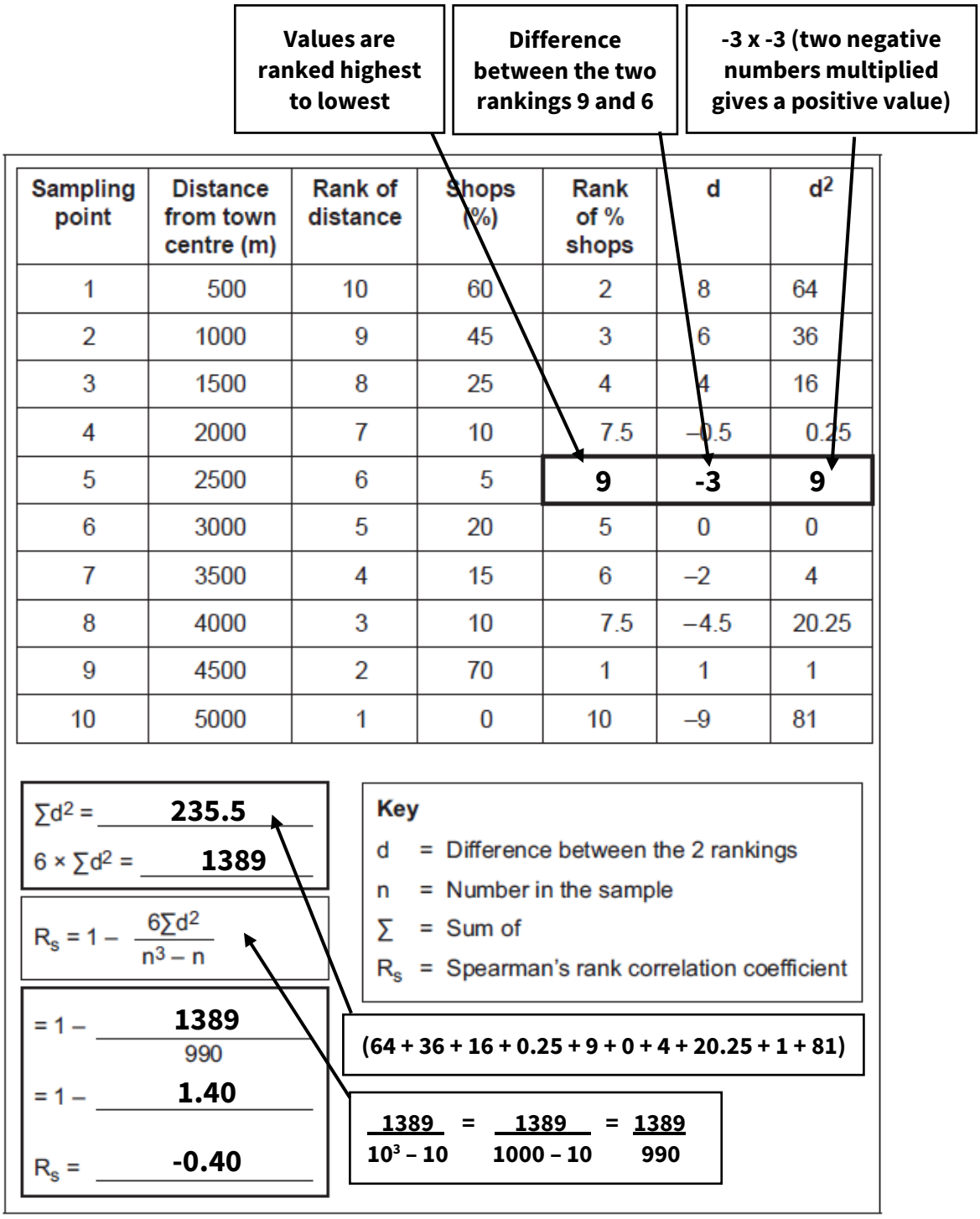
d = Difference between the 2 rankings

n = Number in the sample

$\sum$ = Sum of

R_s = Spearman's rank correlation coefficient

Completed Spearman's rank correlation



The following question asked to interpret the findings above with the use of **Figure 44**.

Figure 44: critical values of R_s for Spearman's rank correlation coefficient.

n	Level of significance	
	0.05	0.01
10	0.564	0.746

Example commentary

The result of -0.40 suggests a weak negative relationship (because it is closer to -1 than 1). This means, with limited confidence, that as distance from the town centre increases, the percentage of shops in the land use decreases.

However, the result does not exceed the 0.01 or 0.05 significance levels. This means that there is some chance the result occurred by chance. The hypothesis ('The percentage of buildings used as shops will decrease with distance from the town centre') can therefore be **rejected**. The data does not reliably support the hypothesis.

Note: If there was a null hypothesis, such as 'There is no correlation between distance from town centre and the percentage of shops', then this would **be accepted**.

4.5 Chi-square test (inferential and relational statistics – to include application of significance tests)

What is Chi-squared test?

This is a comparative test to compare the results you actually find in a study compared to what you expected to find.

- The data will be organised into categories.
- The data values must be the **frequencies** of the categories (not percentages).
- There will be a **null hypothesis** which may be disproved, e.g. 'There is no difference between the observed data and the expected data'.
- You should reject the null hypothesis if the calculated value is greater than the critical value at the chosen significance level.

Example

In A-level SAMS Paper 2, the incomplete data set in **Figure 45** was given to complete. The investigation is trying to determine whether any stretch of the coastline of Great Britain may be more or less susceptible to coastal flooding. The 96 most severe floods have been analysed.

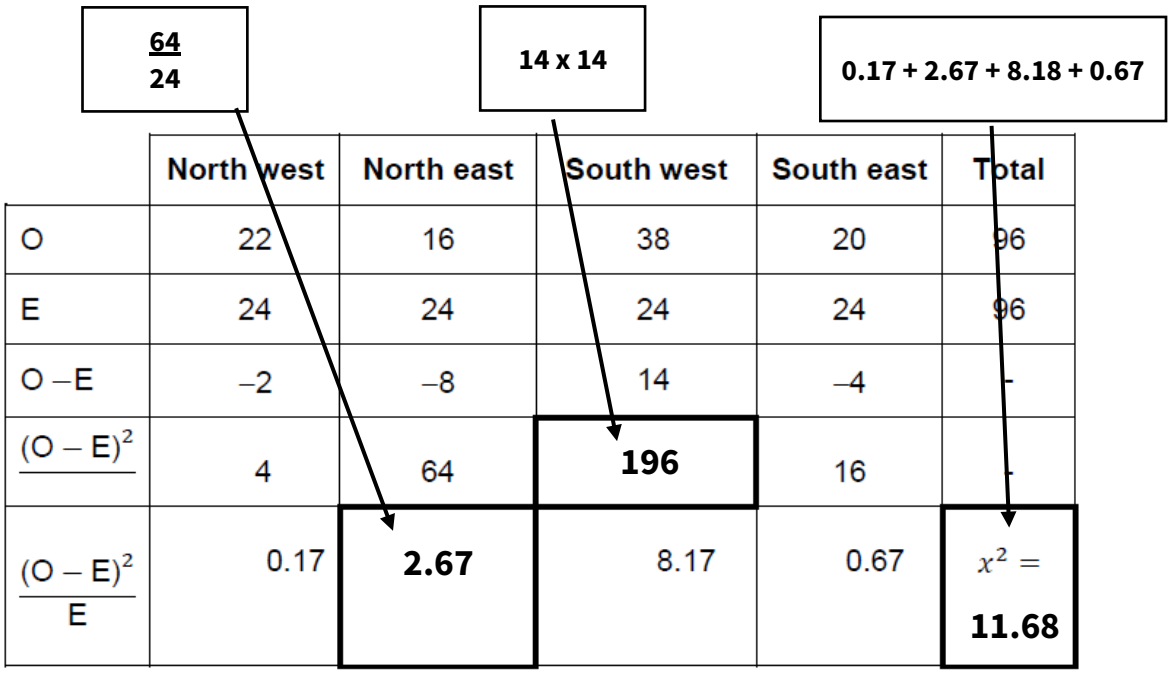
The coastlines have been split into four broad categories: north-west, north-east, south-west and south-east.

Figure 45: Data relating to coastal flooding in Great Britain.

	North west	North east	South west	South east	Total
O	22	16	38	20	96
E	24	24	24	24	96
O – E	–2	–8	14	–4	-
$\frac{(O-E)^2}{}$	4	64		16	-
$\frac{(O-E)^2}{E}$	0.17		8.17	0.67	$x^2 =$

O – Observed frequencies
E – Expected frequencies

Completed Chi-square test



	North west	North east	South west	South east	Total
O	22	16	38	20	96
E	24	24	24	24	96
O – E	–2	–8	14	–4	-
$\frac{(O-E)^2}{}$	4	64	**196**	16	-
$\frac{(O-E)^2}{E}$	0.17	**2.67**	8.17	0.67	$x^2 =$ **11.68**

O – Observed frequencies
E – Expected frequencies

The question also asked to interpret the findings above with the use of **Figure 46**.

Figure 46: critical values of Chi-squared with 3 degrees of freedom.

Degrees of freedom	Significance level	
	0.05	0.01
3	7.82	11.34

Example commentary

The 96 most severe coastal floods were analysed and the coastline was split into four sections. It was expected that each section would have 24 incidents of coastal flooding.

The Chi-square value of 11.68 is greater than the 95% and 99% significance levels. This means that the null hypothesis can be rejected.

There **is** a significant difference in the location of the worst coastal floods. There is less than 1% probability that these results could occur by chance. Looking at the data, flooding is much more likely (with statistical significance) to affect the south-west compared to the other areas, most notably the north-east.

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Retreat of Thwaites Glacier, West Antarctica, over the next 100 years using various ice flow models, ice shelf melt scenarios and basal friction laws. By Hongju Yu[1], Eric Rignot[1,2], Helene Seroussi[2], and Mathieu Morlighem[1]
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Joice Ferreira, Júlio Louzada and Jos Barlow Philosophical Transactions of the Royal Society B Royal Society (Great Britain) 2020. Rightslink.
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Figure 30: Source: FAO-Global Forest Resources Assessment 2010 at www.fao.org/docrep/013/i1757e/i1757e.pdf
Figure 31: Explaining successful and failed investments in U.S. carbon capture and storage using empirical and expert assessments Ahmed Abdulla[1,2], Ryan Hanna[2,3], Kristen R Schell[1], Oytun Babacan[4] and David G Victor[2,5,6] Published 29 December 2020 • © 2020 The Author(s). Published by IOP Publishing Ltd Environmental Research Letters, Volume 16, Number 1