Chapter 17 How are people and places increasingly at risk from and vulnerable to extreme weather?

Key terms

Flash floods
Global warming
Greenhouse gases
Hydrographs
Significance

Learning objectives

After studying this chapter, you will be able to discuss these ideas and concepts and provide located examples of them:

- The frequency of extreme weather events in the UK and elsewhere and whether this frequency is increasing.
- The increasing threat posed by those hazardous events because of human behaviour and natural changes.
- The increasing flood risk posed by increased storm activity.
- The changing nature of drainage basins also contributes towards higher flood risks.

The frequency of extreme weather events

▲ **Figure 1:** The impact of the flash flood in Big Thompson Canyon, Colorado in the summer of 1976.

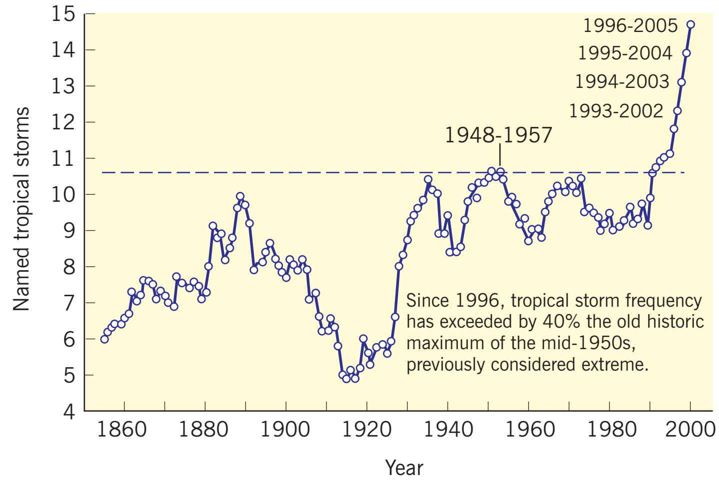
It is often suggested that extreme weather events are becoming more common and that the reason for this is global warming, caused by human activity. This chapter does not debate the causes of global warming but it is important to determine whether extreme weather events are actually becoming more frequent and if they are, whether the rise is significant, whether the change is long term (or just a 'blip'), and whether these events are related to global warming.

Key terms

Global warming is the trend of rising global temperatures since the 1960s.

Hurricanes

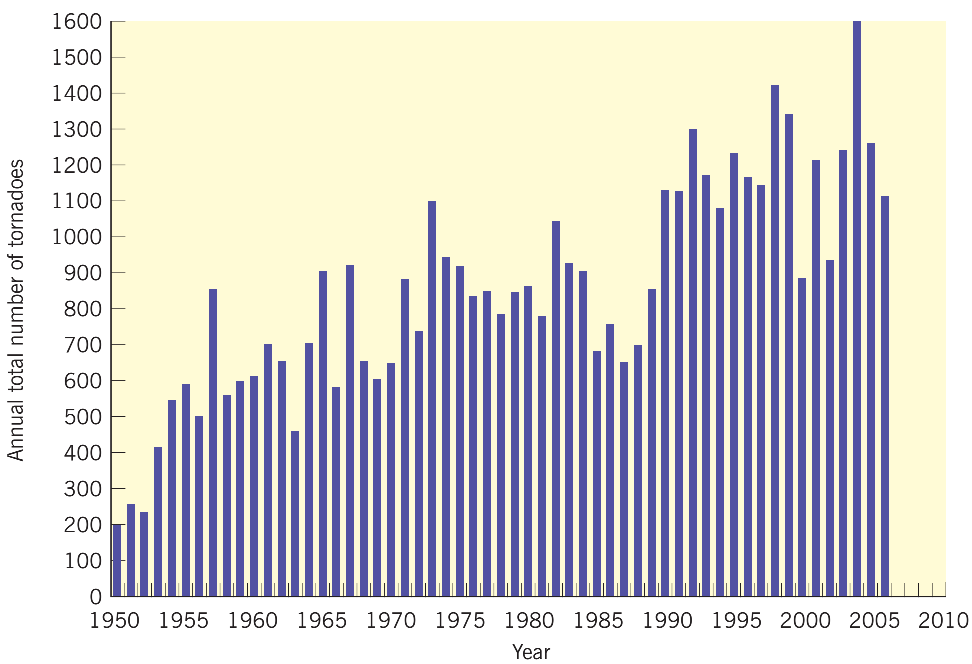
There is no consensus at all about the frequency of hurricanes. Some experts contend that the number of hurricanes has increased in recent years, whilst others reject that view. Another group suggests that although there may be little evidence for an increased number of hurricanes there is evidence that they are becoming stronger. Yet another group has found that there is evidence that stronger hurricanes are less likely to make landfall (in the USA) and thus they will do less damage. According to the 2007 Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC-AR4), it is ‘more likely than not’ that there is a human contribution to the observed trend of hurricane intensification since the 1970s. In the future, ‘it is likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation’ associated with ongoing increases of tropical sea surface temperatures. According to the IPCC-AR4, on a global scale, there is ‘no clear trend’ in the frequency of tropical cyclones. However, as shown on Figure 2, the frequency of tropical storms has increased dramatically in the North Atlantic. Reasons for this increase are currently subject to a fierce debate among climate scientists. At least two recent scientific studies suggest a significant statistical link between the increased frequency and global warming, but research to identify how this link works is still going on, and is highly controversial.



▲ **Figure 2:** The increasing frequency of North Atlantic tropical storms.

Tornadoes

One of the main difficulties with tornado records is that a tornado, or evidence of a tornado, must have been observed. Unlike rainfall or temperature, which may be measured by instruments, tornadoes are brief, highly localised and very unpredictable. If a tornado occurs in a place with few or no people, it is not likely to be documented at all. Unfortunately, this affects much of what we know today. ‘Tornado alley’ was very sparsely populated until the twentieth century, and so it is possible that many significant tornadoes may never have made it into the historical record.



▲ **Figure 3:** Tornado frequency in the USA since 1950.

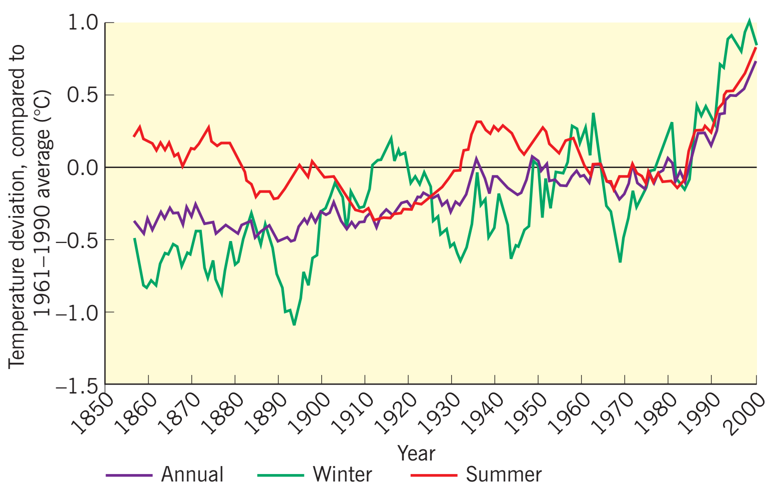
In the film, An Inconvenient Truth, Al Gore added the 2004 USA tornado season into his collection of weather phenomena apparently related to climate change: 'Also in 2004, the all-time record for tornadoes in the United States was broken'.

However, the evidence here is not much clearer than it is for hurricane frequency and intensity. Figure 3 shows an apparent upward trend since 1950 but improvements in recording techniques and the use of satellite imagery has added a new dimension to meteorology and added considerably to the chance of these very local and quite brief events being recorded. They remain unusual, for even in tornado alley the 'average' frequency of a tornado hitting any particular square kilometre would be about once every thousand years.

It is important to add that this problem with the records means nothing, one way of the other, about the global warming debate. It simply means that tornado frequency has probably not changed significantly.

Key terms

Greenhouse gases include water vapour, carbon dioxide and methane. The contribution of humans to the rising quantities of carbon dioxide and methane is, for many, a prime cause of global warming.



▲ **Figure 4:** Temperature deviations in Europe since 1850.

Drought, heatwaves and summer storms

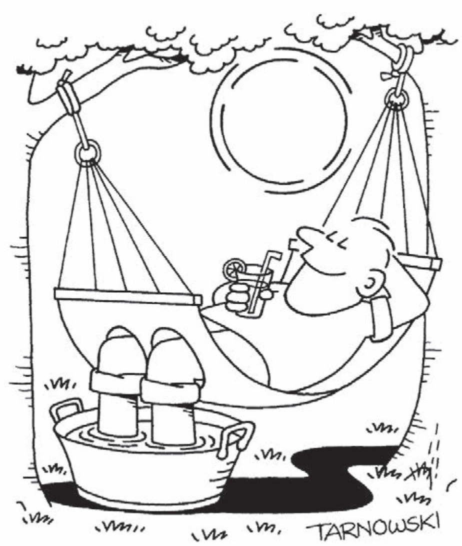
As Figure 4 shows, the temperature increase in Europe over the last 150 years is about 0.95 °C, which is higher than the global average. The warmest year in Europe was 2000; the next 7 warmest years occurred in the last 14 years. If you look carefully at Figure 4, it is also quite obvious that if the data stopped in 1980 the 'trend' would be so slight as to be undetectable. In other words, the interesting changes have happened in the last 30 years.

In the past 3 decades, hot summer days (those with temperatures above 25 °C) and heatwaves have become more frequent. The most severe changes have been observed in western and southern parts of Europe. At the same time, the number of frost days has decreased even more, due to a greater warming in winter than in summer.

Examiners' tip

Remember that global warming can be measured, and is accepted as a fact by most experts. The reasons for global warming are more controversial, and several theories exist. It may very well have several causes.

The rainfall pattern is more varied than that of temperature, showing marked increases in some regions but significant decreases elsewhere. Related to increasing temperatures, however, there is evidence of more violent thunderstorms and the resultant flash floods.



▶ **Figure 5:** A cartoon showing that some people might enjoy heatwaves.

The causes of rising frequency

Climate change does pose some threats for us in Europe, as it does for the rest of the world. To say that 'climate is changing' is not controversial. To say that 'the changes are significant and amount to a trend' is more debatable. Records are incomplete and quite recent in origin, so spotting trends in them is not easy. This weakness allows those people who dispute the human causes of global warming to dispute the evidence of climate change itself.

Any shift in average climate will almost inevitably result in a change in the frequency of extreme events. For less adaptable societies in the developing world, a shorter return period of extreme weather events may not allow them to fully recover from the effects of one event before the next one strikes.

Every region of the world experiences record-breaking climate extremes from time to time. In 1989, for example, the 'Big Wet' in eastern Australia brought torrential downpours and the worst flooding in two centuries. Many people in England will remember the storm of October 1987. Early this century, a trend towards increased drought in the North American Midwest culminated in the 'Dust Bowl' decade of the 1930s, after which conditions eased. During the 1970s and 1980s annual rainfall over the Sahel zone of northern Africa dropped 25% below the average, leading to severe desiccation and famine.

Key terms

Significance can be measured and assessed statistically to show the chances of a trend or relationship occurring by chance.

Taking it further

A useful link is the BBC website: www.bbc.co.uk/weather/features/understanding/extreme_climate.shtml.

The rising impact of extreme climatic events

Year	Number of events	Victims	Total losses Original values (US$ m)	Insured losses	Major events
1994	680	13,000	89,000	21,000	Earthquake Northridge
1995	615	20,800	172,000	16,000	Earthquake Kobe, floods North Korea
...					
2000	890	10,300	38,000	9,600	Floods UK, Typhoon Saomai
2001	720	25,000	40,000	12,000	Tropical Storm Allison, hailstorm USA
2002	700	11,000	60,000	14,000	Floods Europe
2003	700	109,000	65,000	16,000	Heatwave Europe, earthquake Bam/Iran
2004	650	235,000	150,000	47,000	Hurricanes Atlantic, typhoons Japan, tsunami
2005	670	101,000	220,000	99,000	Hurricanes Atlantic, earthquake Pakistan
2006	850	20,000	50,000	15,000	Earthquake Yogyakarta/Indonesia
2007	950	15,000	75,000	30,000	Winter Storm Kyrill, floods UK

Figure 6: The losses from extreme events in recent years.
Source: www.munichre.com

The risk of a disaster increases according to changes in the vulnerability of a population and changes in its capacity to cope. These can be shown using the disaster 'risk equation'.

$$R = \frac{H \times V}{C}$$

R – Risk V – Vulnerability
H – Hazard C – Capacity to cope

There are a number of reasons why the vulnerability of populations has increased and their capacity to cope has decreased. The sections below consider these reasons in greater detail.

A rise in global population: There has been a rise in global population from 2.5 billion to 6.5 billion between 1950 and 2008. The existence of more people produces a greater impact of the personal tragedies and economic losses that extreme events provoke. The most significant aspect in terms of extreme weather events has been the growth of population in areas that were previously only lightly populated – some of them because of the potential hazard risk.

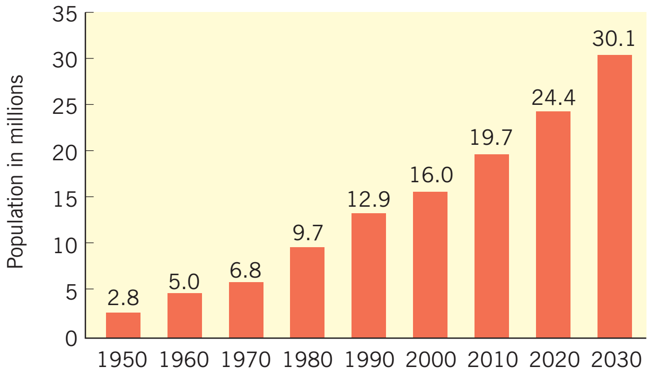


Figure 7: The past, present and predicted population of Florida.

Source: www.flsuspop.org

In Florida for example, the threat from hurricanes and tropical storms was recognised by the original Native Americans, who stayed well away from the coastline. The 1900 United States Census identified only four cities in Florida with more than 5,000 inhabitants. The total population of the state was recorded as 528,542. Rapid development for tourism and retirement changed that and will, by most forecasts, go on fuelling rapid growth.

A rise in urban population: There has also been a rise in the concentration of the population in urban areas, which makes that population more vulnerable. Over 50% of humanity now live in cities, and it is forecast that the proportion will rise to nearly 70% by 2050. These concentrations of people are inevitably more exposed to severe climatic events, especially since so many cities are situated on low-lying land, close to oceans and major rivers. In cities such as Manila, Jakarta, Mexico City and Lagos, the urban poor, living under terrible conditions of squalor, crime and insecurity, now make up 30 to 40% of the population – a figure that will increase in the next few decades.

With budgets cut by austerity programmes imposed by the IMF and World Bank, city governments cannot always provide the basic services needed by this swelling urban mass, such as water, electricity, and infrastructure. Nor are they in a very strong position to protect exposed environments from the risks associated with extreme weather events.

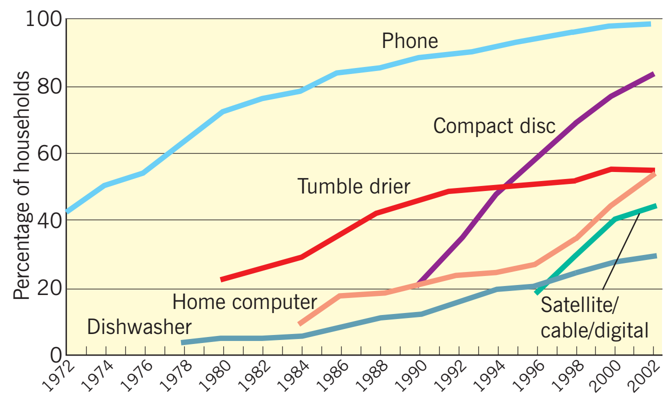
There is very powerful evidence from New Orleans – in a country that prides itself on being wealthy – that the disaster of Katrina was not an ‘equal opportunity event’.

- Low-income residents had fewer choices about how to prepare for the imminent arrival of Katrina.
- Since the storm was at the end of the month many low-income residents of New Orleans lacked the economic resources to pay for evacuation.
- Furthermore, low-income New Orleanians are those who are least likely to own vehicles, making voluntary evacuation more costly and logistically more difficult.
- These residents were also more reliant upon television and radio for news of the storm, and alarm from these channels only became heightened in the last 48 hours before the storm arrived.
- Although most of these residents joined the flow of traffic out of the city on Sunday, many remained in their homes, hoping for the best, and others headed to the Superdome rather than taking the few city buses available to out-of-town shelters. Those going to the Superdome believed that these shelters would provide sufficient protection until the storm had passed but they hadn’t considered the flooding that occurred when several levees were breeched.
- The people hit hardest by the flooding were those from the neighbourhoods of federally subsidised housing, where poverty was most concentrated.
- Not coincidently, they were least able to leave the city without assistance.

It is very likely that events of this magnitude will recur as the world becomes more urbanised.

Increasing cost of disasters: The rising value of property and growing numbers of expensive consumer goods has led to an increase in the cost of disasters. Historically, the cliché has been that such events 'cost lots of money but few lives' in the rich world but 'lots of lives and not so much money' in the poor world. This is partly explained by rising levels of material wealth in the rich countries.

Rising affluence in the new superpowers, such as China (see table) and India, will inevitably lead to an increase in the financial losses caused by extreme weather events.



▲ **Figure 8:** Rising household ownership of consumer durables in the UK between 1972 and 2002.

Source: www.statistics.gov.uk

	1990	1995	1999	2000	2001	2002
Motorbike	1.9	6.3	15.1	18.8	20.4	22.2
Washing machine	78.4	89.0	91.4	90.5	92.2	92.9
Fridge	42.3	66.2	77.7	80.1	81.9	87.4
Colour TV	59.0	89.8	111.6	116.6	120.5	126.4
Video		18.2	21.7	20.1	19.9	18.4
Hi-Fi		10.5	19.7	22.2	23.8	25.2
Camera	19.2	30.6	38.1	38.4	39.8	44.1
Air conditioner	0.3	8.1	24.5	30.8	35.8	51.1
Shower		30.1	45.4	49.1	52.0	62.4
VCD/DVD player			24.7	37.5	42.6	52.6
Computer			5.9	9.7	13.3	20.6
Mobile phone			7.1	19.5	34.0	62.9
Car			0.3	0.5	0.6	0.9

◀ **Figure 9:** Consumer durable ownership in China 1990–2002 (number owned per 100 urban households).

Source: www.chinability.com

Awareness of loss: There seems to be a greater awareness of the potential loss and thus rising insurance cover for those losses. It is also argued that disaster losses are greater in the rich countries because levels of insurance are higher. Even in rich countries the insurance position is not as simple as it might seem.

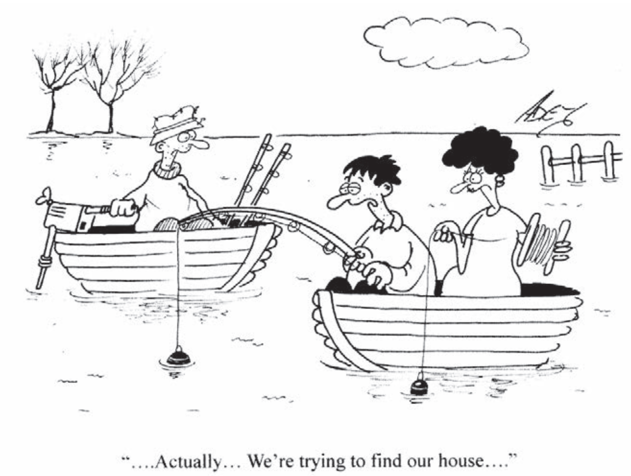
In general in the USA and much of Europe, homeowners' insurance policies cover damage caused by wind and wind-driven rain, but contain a provision that excludes coverage for flood damage. In America's Gulf region, some (about 15% in Mississippi and up to 40% in New Orleans) but not most homeowners carried separate flood insurance, which is underwritten by the federal government. Immediately following Katrina, the insurance industry was quick to deny responsibility for covering most of the damage its policy holders were suffering, wasting little time spreading the message that most damage was flood related. Unsurprisingly, those who did not have the 'extra' flood insurance policies were the poorest people in the city who lived in the most vulnerable area.

Key terms

Flash floods occur when there is a very sudden increase in the discharge of a river, usually as a result of a storm event.

Flash floods

Like tornadoes, flash floods are localised events that can cause very considerable damage – but usually within a fairly small area. They are usually the secondary impact of an extreme weather event, such as a convectional storm. If the amount of rainfall far exceeds the averages, the channels are unable to cope with the increased runoff, and flooding results. Flash floods can also result from a prolonged period of heavy rain, leading to saturation of the ground, which is then unable to absorb any more rainfall.



▲ **Figure 10:** Flash floods can lead to a very rapid rise in water levels.

▲ **Figure 11:** Flash flood warning in Death Valley, California.

Flash floods can occur in any environment, but they are especially dangerous in regions that are either arid or semi-arid. Every year people die and property is destroyed when stream beds that are only wet on a few occasions each year are suddenly – and often very unexpectedly – filled with water. Sometimes the heavy rainfall takes place so far away that no rainclouds are visible as a sudden flood sweeps down from the mountains.

Case study: Big Thompson Canyon flood

A devastating example of a flash flood was the Big Thompson Canyon flood in Colorado, in August 1976. Big Thompson Canyon is a narrow canyon, typical of the river basins in this region of the Rockies. Very steep rock forms the canyon walls, with little soil or vegetation to absorb runoff from storms. In some places, the canyon walls are almost vertical. The river drops more than 1,000 m and exits the canyon into the rolling plains. Highway 34 stretches the length of the canyon and is dotted with homes, restaurants and other businesses.

▲ **Figure 12:** The flood in Big Thompson Canyon on 1 August 1976.

Case study: Big Thompson Canyon flood *(continued)*

31 July: afternoon	About 3,000 tourists and locals start to gather in the canyon, preparing to take part in Colorado's 'centennial party' in this popular hiking and camping area.
31 July: afternoon	A weak but very wet air stream begins to cross the mountains from the east.
31 July: early evening	The rain begins. Usually, fast moving air from the west at 3,000 metres is enough to keep thunderstorms out of the area, but not on this occasion.
31 July: evening	As darkness falls, 360 mm of rain falls over a 3-hour period – a year's rainfall in an evening.
31 July: evening	The canyon fills with water, turning the river from a 50 cm trickle into a 6 metre wall of water, travelling at speeds of up to 8 metres per second. Boulders weighing up to 275 tonnes are moved by the sheer force of the water, which sweeps everything before it.
31 July: evening	Peak discharge is reached very quickly, after about one hour, reaching 900 m^3/sec at the end of the canyon – a 'one in three hundred years' event. (The peak discharge would fill an Olympic swimming pool every 2.8 seconds.)
1 August: morning	After a night of appalling tragedies, the clean-up begins in the early hours. 144 people have died, some of whose bodies will never be recovered.

Figure 13: A timeline of the Big Thompson disaster of 1976.

'I will always remember that day . . .'

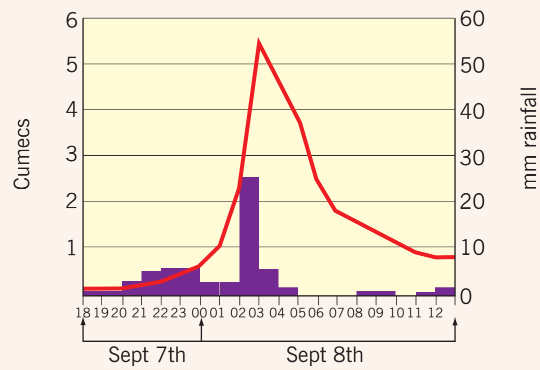
I was a junior in college. Three buddies and I worked at a popular restaurant that rested nearly on the edge of the dammed up lake. That summer we had decided to live in Estes Park rather than in the canyon, as we had the previous summer. I had that Saturday afternoon off, and had driven east along Highway 34 to Fort Collins. Driving back west to Estes, I had noticed how crowded the canyon was – I knew it was a huge weekend in Estes Park because of the centennial and bicentennial celebrations. After working at 'The Yum Yum Hut' for about an hour, my boss, Mr Pabst, looked out and said that 'one heck of a storm' was coming. It rained so hard that we could not even see the motel some 60 feet away. Then there was a deadly pause for about half an hour and we stepped outside, as no one was at the restaurant. My boss commented that it was strange that the clouds were quickly reversing tracks and moving to the west. Once again – tremendous rain. At about 8:30 p.m. we closed, but we listened to a short-wave radio broadcast in the canyon in which people were screaming for ropes. We really had no idea what was going on. At about 9:30 I was driving home up on Olympia Lane, just on the east edge of Estes Park, and I came to a sudden stop. There was a 20-foot-deep, 30-foot-wide hole in the middle of the road. I knew then that this was a strange incident. The next morning, Sunday, I got called into work in the morning shift – many of the morning workers were unable to get to work. I distinctly remember an Estes Park policeman coming in and I asked what kind of damage there was in the canyon. He sort of rolled his eyes and said, 'Bad!'. I asked him what he meant, and he said 'Lots of death'. He went on to say a temporary morgue was set up in Loveland. We all felt shock at that point. As the morning rolled on, more reports came in. This was huge – national news! I suddenly came to the shocking realisation that I had to get a hold of my parents. Many tourists had said that the national news reported that all this tragedy had occurred in Estes Park. They would be worried sick. I drove 25 miles to find a phone line. I was able to get through and discovered they had just (30 seconds earlier) turned on the television and heard the news. They suffered only 30 seconds of fear. I will always remember that day.

(Anonymous)

Case study: Flash floods in Inverness

The flash floods in Inverness in 2002 provide an example of an intense local event that can have a severe impact.

Inverness is situated on a narrow coastal plain, with steep hills to the south. Running off these hills are seven streams in small drainage basins that are short but have high gradients. This makes them very 'flashy', because any excess rainwater that cannot be absorbed by the ground has little distance to travel before it reaches the stream (see Figure 12). There is a very short time lapse between the rainfall 'event' and the peak discharge of the stream, as measured in cubic metres per second (m^3/sec).



▲ **Figure 14:** The hydrograph for one of the streams flowing through Inverness.

In the past, this flooding would have been unremarkable but, as with very many British towns and cities, development has recently taken place on or very close to the floodplains, so that land previously used for farming is now taken up by buildings, roads and other urban development.

Key terms

Hydrographs show how rainfall events and stream discharge change over time.

The 'event'

During Saturday 7 September 2002, Inverness experienced an exceptional amount of rainfall. In the 12-hour period prior to the start of the storm there was 7.4 mm of rain, saturating the ground. In the 12 hours covering the storm there was ten times that amount, a total of 74.2 mm. Between 2.00 a.m. and 3.00 a.m. no less than 31.2 mm of rainfall was recorded. Ironically, average rainfall for September 2002 in the Highland region was only 48 mm, about a quarter of the 30-year average. This emphasises just how local these intense events can be.

Fieldwork

Local research

A very good starting point for research into the flood risk of particular areas is to use the Environment Agency website at http://www.environment-agency.gov.uk/.

Type in your local postcode to bring up a map of your local area and show areas that are at risk from flooding. These risks are then classified as follows:

Significant: the chance of flooding in any year is greater than 1.3% (1 in 75).

Moderate: the chance of flooding in any year is 1.3% (1 in 75) or less, but greater than 0.5% (1 in 200).

Low: the chance of flooding in any year is 0.5% (1 in 200) or less.

A research plan can be drawn up to assess the potential risks in your local area and the awareness of those risks.

Task	Methodology
Identify an appropriate local river basin.	Use maps and digital photography to describe the basin and its characteristics.
Assess the risk of flooding.	Use the Environment Agency website for information about flood risk. www.environment-agency.gov.uk
Assess the conditions that are needed to bring about flooding in terms of rainfall intensity.	Use local and national meteorology records.
Assess the history of flooding and the conditions that brought about these floods.	Use newspaper files, the internet and local knowledge to establish a past record of flood events.
Examine any land-use changes that have taken place in the basin.	Use old maps and photographs to establish changes in farming and % urban area.
Examine any changes in the river management practices.	Interview local residents, local authority officials and appropriate river management personnel.
Explore local knowledge and attitudes towards flood risk.	Questionnaires in flood risk area to assess levels of knowledge about that risk.
Examine any flood prevention measures in place.	Interviews with the appropriate local authority and the agencies responsible for local river management.

Fieldwork *(continued)*

Aim:

To investigate if there is an increased risk of flooding in a local catchment area and if so, what the causes might be.

1. Use www.environment-agency.gov.uk to establish the areas at risk from flooding.
2. Visit those areas at risk and record the evidence of recent development, by taking photographs and video evidence.
3. Identify changes in land use by using old maps, photographs and guides.
4. Establish a history of flooding in the local area and the meteorological events that have triggered those floods.

Risk assessment

This is a low-risk activity, but always take care when taking photographs that you are not intruding on the privacy of others. Respect private property and always seek any necessary permission before you enter areas or take photographs.

Health and safety

Never take risks near water, and always operate in pairs when gathering data.

Data presentation

Copy the environment agency maps and identify on an overlay any land use changes that you have discovered.

Present the changes in a table or as a divided bar chart to show how they may have contributed to flooding.

Conclusion

Make a judgement about the frequency of flooding and offer a number of reasons as to the possible causes of any increased risk.

Evaluation

It would be useful to compare one basin with other similar-sized basins to judge whether or not they share the same characteristics and if not, why not.

Summary

Having studied this chapter and the case studies, as well as conducting your own fieldwork and research, you have a better understanding of changes in the impact of extreme weather events and the relative contribution to disasters of various factors. You will now be able to discuss these ideas and concepts and provide located examples of them:

- The frequency of extreme weather events in the UK and elsewhere and whether this frequency is increasing.
- The increasing threat posed by those hazardous events because of human behaviour and natural changes.
- The increasing flood risk posed by increased storm activity.
- The changing nature of drainage basins also contributes towards higher flood risks.

MCQ

To try an exam question using what you have learned in this chapter, turn to page 201.