Chapter 6

Responding to climate change

6.1 Demonstrators protest against climate change in San Francisco, California, USA.

Climate change risk and vulnerability

The **impact of climate change** can be devastating for some communities. Climate change can lead to economic disruptions as farming systems begin to collapse, and in cases where this leads to mass migration, the effects are felt on an even more widespread scale. As an issue of global magnitude, climate change thus affects every person on the planet. Having said that, there are some people who face greater risks than others, and some communities are more **vulnerable** to the impact of climate change than others.

Identifying and measuring risk

Risk is any factor that exposes people to danger or impedes (or threatens to impede) people achieving their goals. Risk can also be viewed as a motivation to make changes that find new solutions. If risk and vulnerability are to be addressed, they must first be identified, assessed and quantified.

One way of measuring the risk of climate change is the **Climate Change Vulnerability Index** (CCVI) that was developed by Maplecroft, a consultancy firm that specialises in identifying global risks. The CCVI is a composite indicator that combines three simpler composite indices:

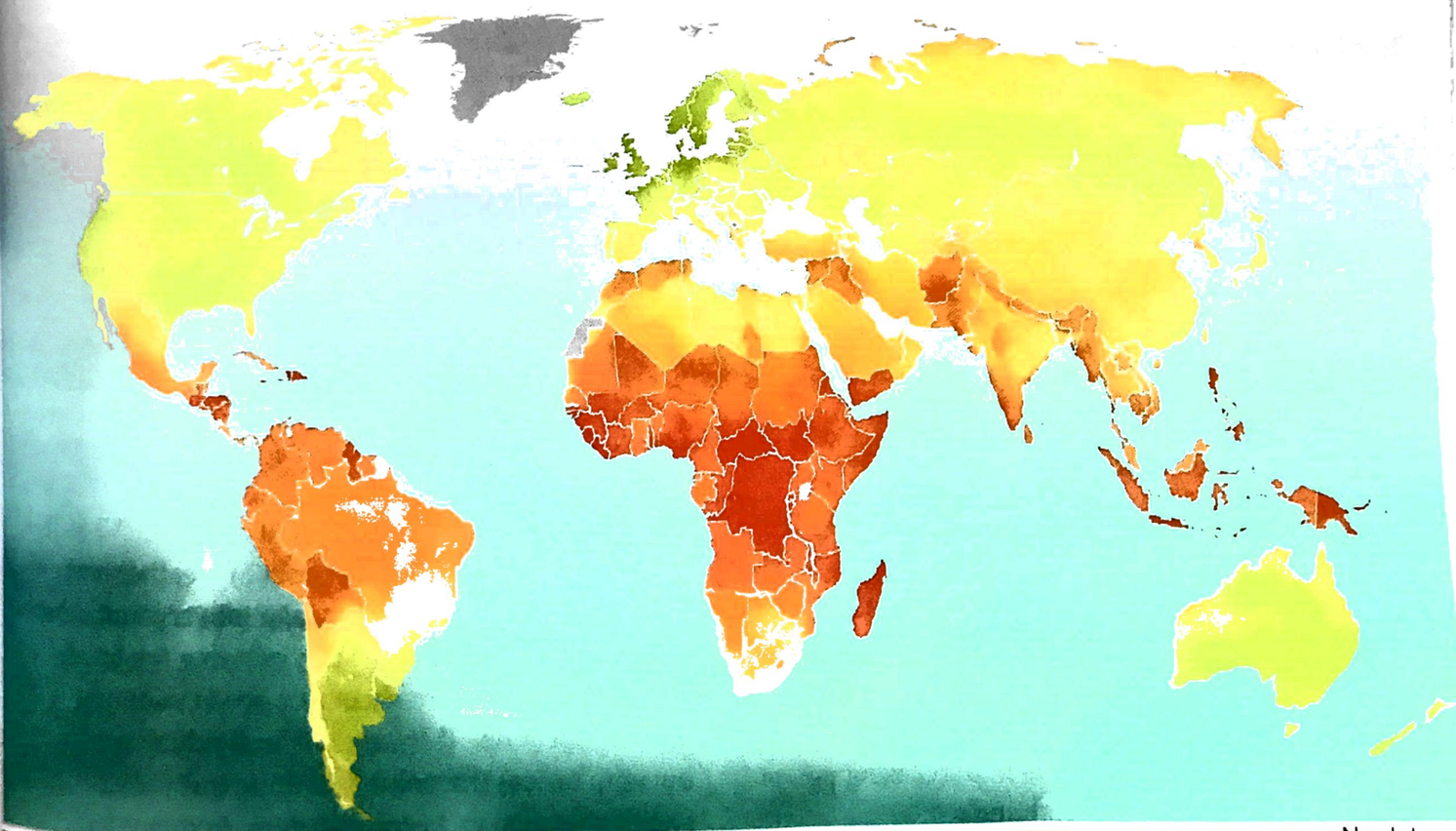
- **The Climate Change Exposure Index** analyses exposure to climate-related natural disasters by examining future seasonal climatic variability, climate extremes, long-term trends of climate change and sea level rise;
- **The Climate Change Sensitivity Index** analyses population patterns, economic development, natural resources, agricultural dependency, conflicts and individuals' financial situations to ascertain the susceptibility of communities to both short-term and long-term impacts of climate change; and
- **The Climate Change Adaptive Capacity Index** looks at future vulnerability by examining a government's capacity to adapt the country's policies, structures and infrastructure to combat climate change and manage disasters.

The CCVI examines most areas of the world in 25 square kilometre segments, and then calculates a risk score using a scale of 0 to 10. A score of 10 means the country is **highly resilient** to the impact of climate change, whereas a score of 0 means the country has minimal resilience to the impact of climate change, and is thus **highly vulnerable**. The scale of 0 to 10 is then divided into four segments to categorise each country according to a **four point classification**:

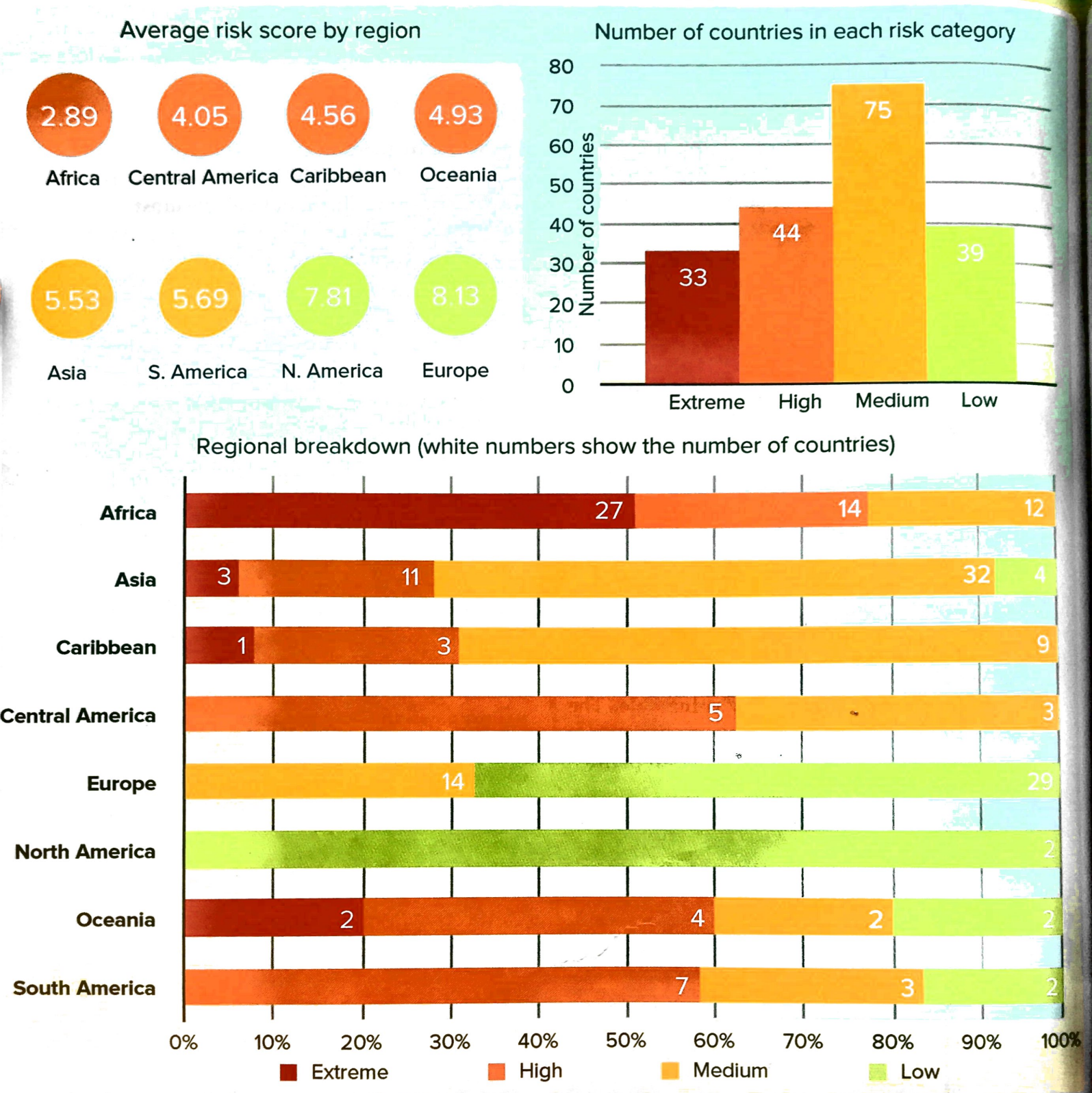
- **extreme risk** (a CCVI of 0.00 to 2.50)
- **high risk** (a CCVI of 2.50 to 5.00)
- **medium risk** (a CCVI of 5.00 to 7.50)
- **low risk** (a CCVI of 7.50 to 10.00).

The **world distribution** of the latest available data, which measures the CCVI of 191 countries, is shown in figure 6.2. Four of the five **most vulnerable countries** to climate change were in Africa – the Central African Republic (with a CCVI of 0.01), the Democratic Republic of Congo (0.20), Liberia (0.25) and South Sudan (0.41) – while the other extremely vulnerable country was Haiti (in the Caribbean, with a CCVI of 0.24). At the other end of the scale, four of the **most resilient countries** to the impact of climate change were in Europe – Denmark (with a CCVI of 10.00), the United Kingdom (9.96), Iceland (9.85) and Ireland (9.83) – the other country being Uruguay (in South America with a CCVI of 9.95). Figure 6.3 shows the **regional distribution** of countries measured by their CCVIs.

Another measure of vulnerability to climate change is the **Global Climate Change Risk Index** (CRI), developed by Germanwatch, an NGO based in Bonn, Germany that seeks to influence public policy in matters of trade, the environment, and relations between developed and developing countries. The CRI examines data that describes



6.2 Climate Change Vulnerability Index (CCVI), 2017. Source: © Verisk Maplecroft 2016.

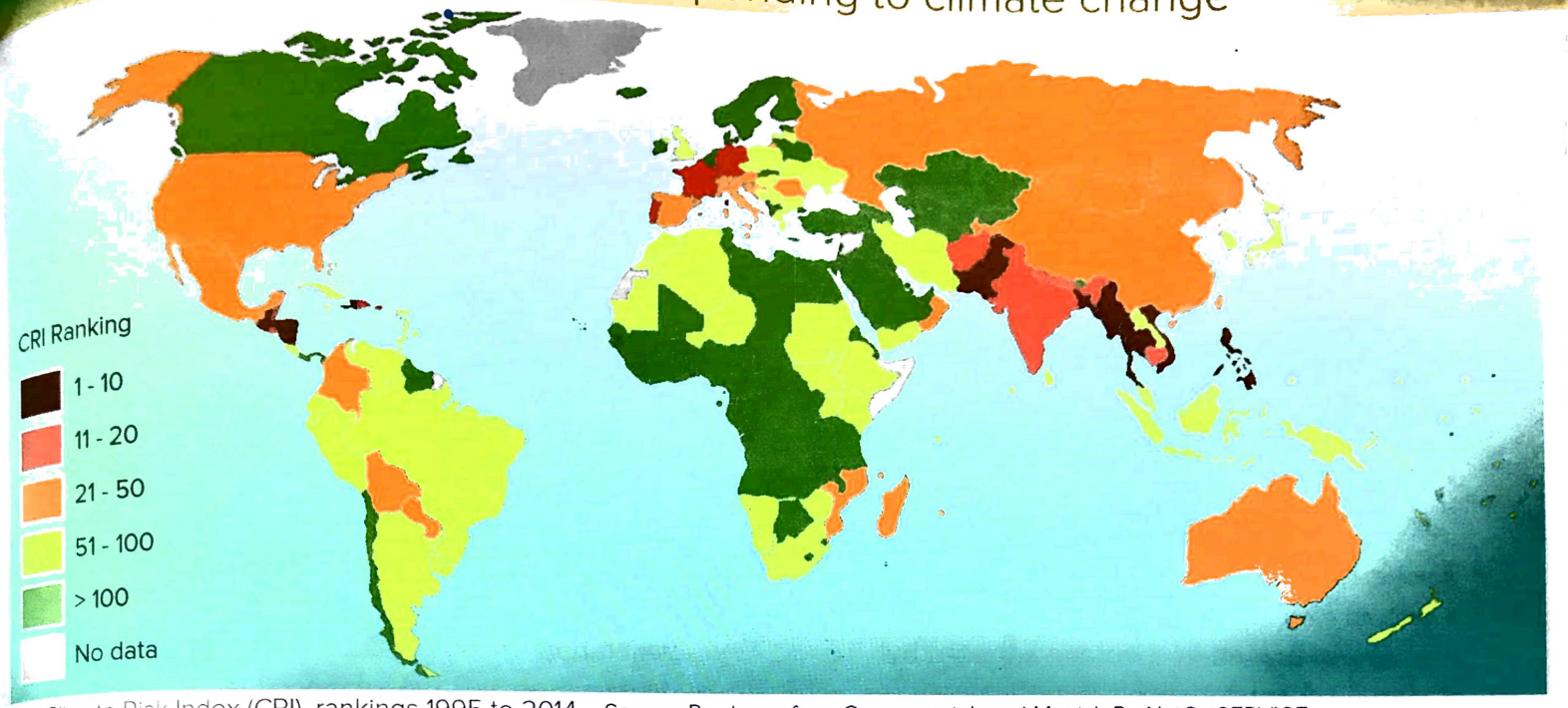


6.3 Distribution of risk arising from climate change, measured by the Climate Change Vulnerability Index (CCVI) for 191 countries, 2017. Source: Re-drawn from data © Verisk Maplecroft 2016.

extreme weather events and the **socio-economic situations** of the countries where they occur. **Four key factors** are examined with different weightings:

- **number of deaths** (16.67% weighting)
- **number of deaths per 100,000 inhabitants** (33.33% weighting)
- **sum of losses** in US dollars in purchasing power parity (PPP) (16.67% weighting)
- **losses per unit of Gross Domestic Product** (GDP) (33.33% weighting).

The CRI is **less comprehensive** than the CCVI as it focuses only on the direct impact of weather and climate events, and does not take into account other aspects of climate change such as rising sea levels, melting glaciers or ice sheets, or ocean warming and acidification. It focuses on individual events, but emphasises the point that these individual weather events are becoming more frequent and intense due to climate change.



6.4 Climate Risk Index (CRI), rankings 1995 to 2014. Source: Re-drawn from Germanwatch and Munich Re NatCatSERVICE.

The CRI is measured as a **ranking**, so the most affected country receives a score 1, the second most affected country receives a score of 2, and so on. Analysis of the CRI has shown that during the period 1995 to 2014, more than 525,000 people died as a result of weather events, and financial losses over the same period totaled US$2.97 trillion.

The major causes of death and damage were precipitation, floods and landslides, all of which are becoming more frequent due to climate change as the operation of the water cycle accelerates. During the 20 year period of 1995 to 2014, the countries that were **most affected** by weather events were Honduras, Myanmar and Haiti, followed by the Philippines, Nicaragua and Bangladesh. Details of the losses are shown in figure 6.4 and table 6.1.

A third measure of vulnerability to climate change is the **Climate Vulnerability Index** (CVI), which was developed by two university geographers, Caroline Sullivan and Jeremy Meigh. The CVI, which is used by UNESCO to measure the impact of climate change, is a single number that sums up

Table 6.1

The long-term Climate Risk Index (CRI) for the 10 most affected countries, 1995 to 2014 (annual averages)

CRI Rank 1995 to 2014	Country	The four key factors				Total number of events 1995 to 2014
		Death Toll	Deaths per 100,000 inhabitants	Total losses in US$ million (PPP)	Losses per unit of GDP (%)	
1	Honduras	302.75	4.41	570.35	2.23	73
2	Myanmar	7,137.20	14.75	1,140.29	0.74	41
3	Haiti	252.65	2.76	223.29	1.55	63
4	Philippines	927.00	1.10	2,757.30	0.68	337
5	Nicaragua	162.30	2.97	227.18	1.23	51
6	Bangladesh	725.75	0.52	2,438.33	0.86	222
7	Vietnam	361.30	0.44	2,205.98	0.70	225
8	Pakistan	487.40	0.32	3,931.40	0.70	143
9	Thailand	164.20	0.25	7,490.76	1.05	217
10	Guatemala	83.35	0.66	407.76	0.50	88

Source: Sönke Kreft, David Eckstein, Lukas Dorsch & Livia Fischer (2016) *Global Climate Risk Index 2016*, Bonn: Germanwatch e.V. p.6.

human vulnerability to climate change at any location. It differs from the CCVI and CRI by focusing mainly on **water-related issues** that arise from climate change. The CVI is calculated by examining six key variables:

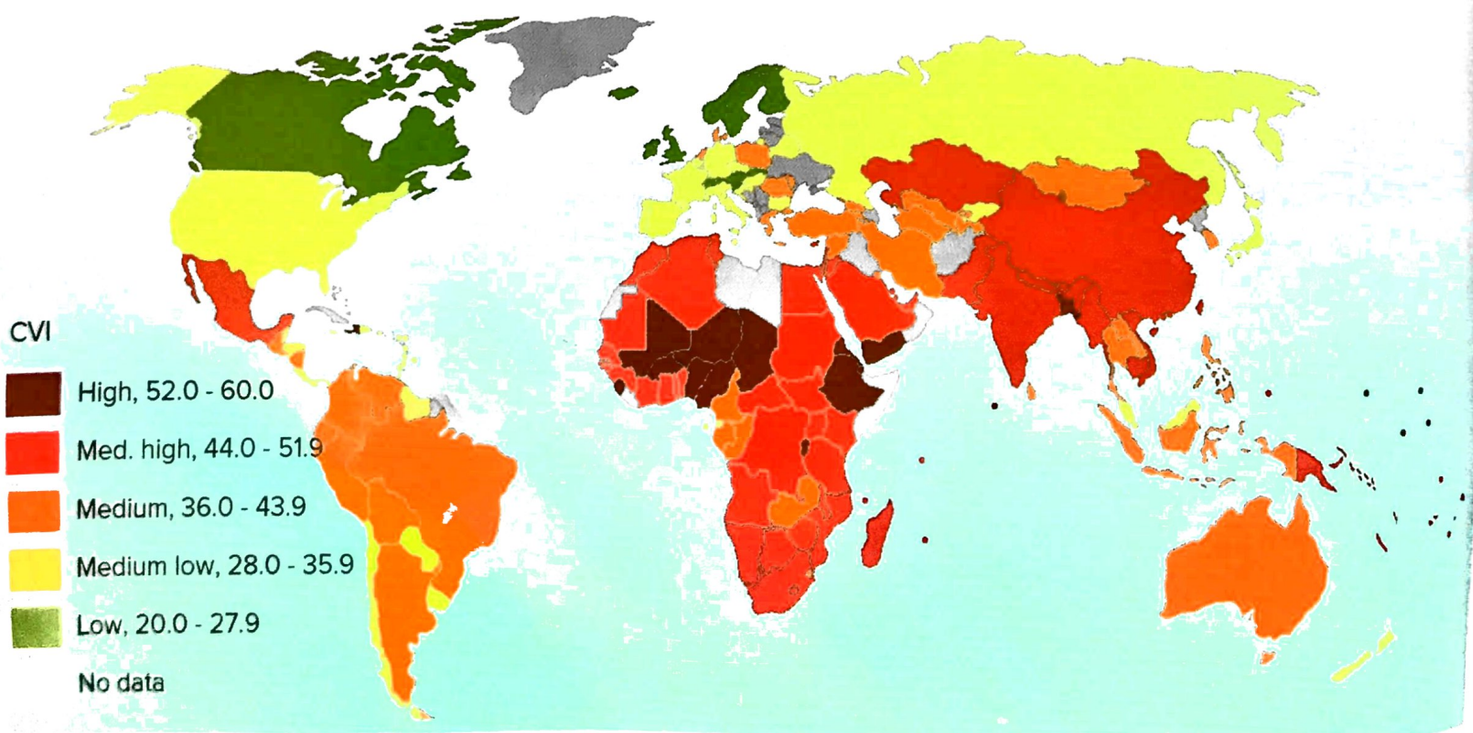
- **Resources** (R), which includes:
  - assessment of surface water and groundwater availability
  - evaluation of water storage capacity, and reliability of resources
  - assessment of water quality, and dependence on imported/desalinated water
- **Access** (A), which includes:
  - access to clean water and sanitation
  - access to irrigation coverage adjusted by climate characteristics
- **Capacity** (C), which includes:
  - expenditure on consumer durables, or income
  - GDP as a proportion of GNP, and water investment as a % of total fixed capital investment
  - educational level of the population, and the under-five mortality rate
  - existence of disaster warning systems, and strength of municipal institutions
  - percentage of people living in informal housing
  - access to a place of safety in the event of flooding or other disasters
- **Use** (U), which includes:
  - domestic water consumption rate related to national or other standards
  - agricultural and industrial water use related to their respective contributions to GDP
- **Environment** (E), which includes:
  - livestock and human population density
  - loss of habitats
  - flood frequency
- **Geospatial factors**, which include:
  - extent of land at risk from sea level rise, tidal waves, or land slips
  - degree of isolation from other water resources and/or food sources
  - deforestation, desertification and/or soil erosion rates
  - degree of land conversion from natural vegetation
  - deglaciation and risk of glacial lake outbursts

The CVI is calculated by weighting these variables according to their relative importance using the formula

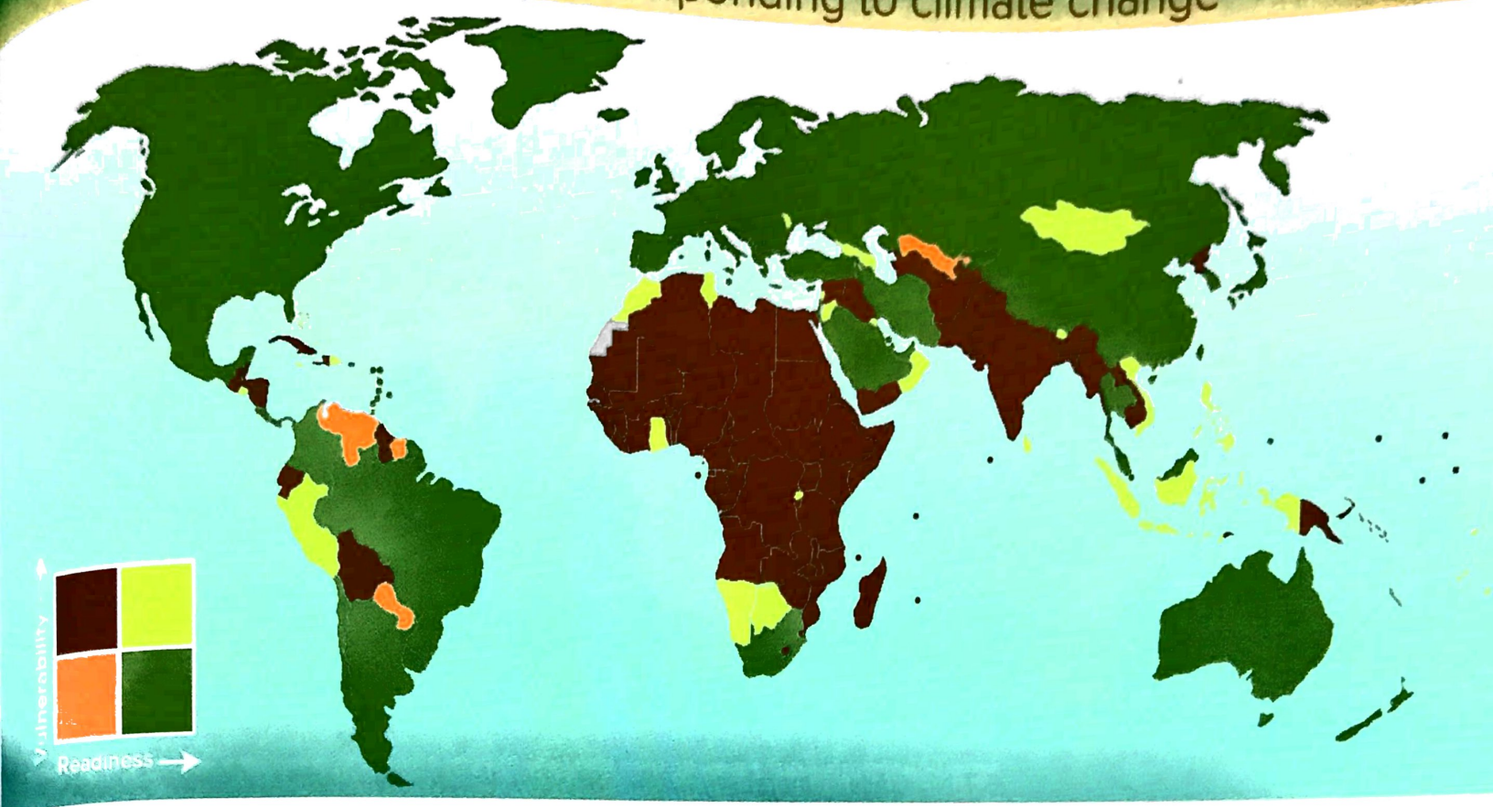
$$CVI = \frac{r_rR + r_aA + r_cC + r_uU + r_eE + r_gG}{r_r + r_a + r_c + r_u + r_e + r_g}$$

where R, A, C, U, E and G are the Resource, Access, Capacity, Use, Environment and Geospatial components, and the weight given to each factor is the factor r. The index values range from 0 to 100, with higher values representing higher vulnerability.

The **world distribution of vulnerability** due to climate change as measured by the CVI is shown in figure 6.5.



6.5 [illegible] Source: Redrawn from UNESCO



6.6 ND-GAIN vulnerability and readiness matrix. Source: Re-drawn from University of Notre Dame ND-GAIN data.

A fourth measure of climate change risk is the **ND-GAIN Index**, also known as the Notre Dame Global Adaptation Index. Developed by the University of Notre Dame's Environmental Change Initiative in Indiana, USA, ND-GAIN attempts to show which countries are best prepared to deal with global changes brought about by overcrowding, resource-constraints and climate disruption. The index is based on combining **two key dimensions**:

- **Vulnerability**: this measures a country's exposure, sensitivity and capacity to adapt to the negative effects of climate change. The vulnerability dimension considers six life-supporting sectors – food, water, health, ecosystem service, human habitat, and infrastructure.
- **Readiness**: this measures a country's ability to activate investment funds and convert them to adaptation actions. The readiness dimension measure considers three components – economic readiness, governance readiness and social readiness.

The ND-GAIN is calculated using the formula

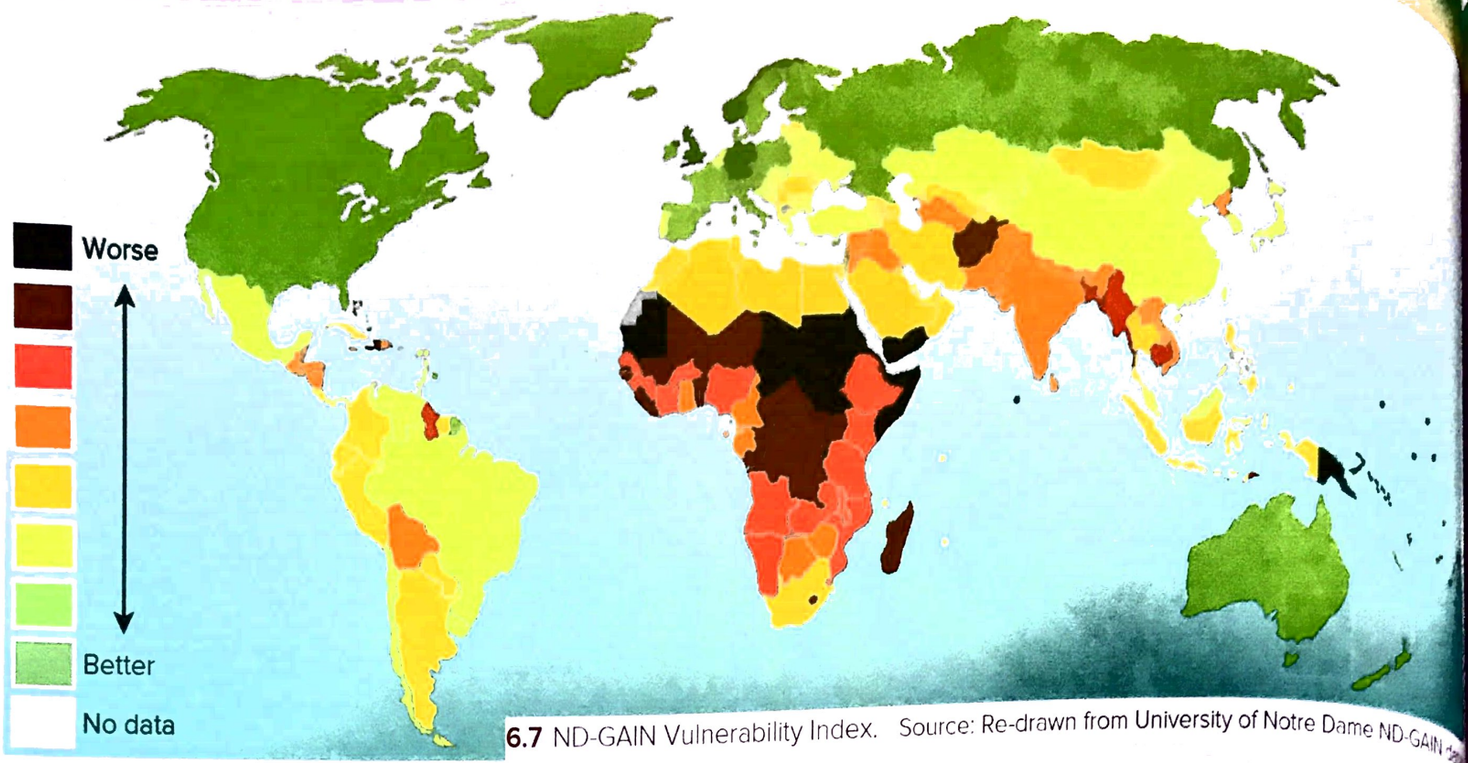
$$\text{ND-GAIN} = (\text{RI} - \text{VI} + 1) \times 50$$

where RI is the Readiness Index and VI is the Vulnerability Index. The Readiness Index is expressed on a scale of 0 to 1, where higher figures are better. The Vulnerability Index is expressed on a scale of 0 to 1, where lower figures are better.

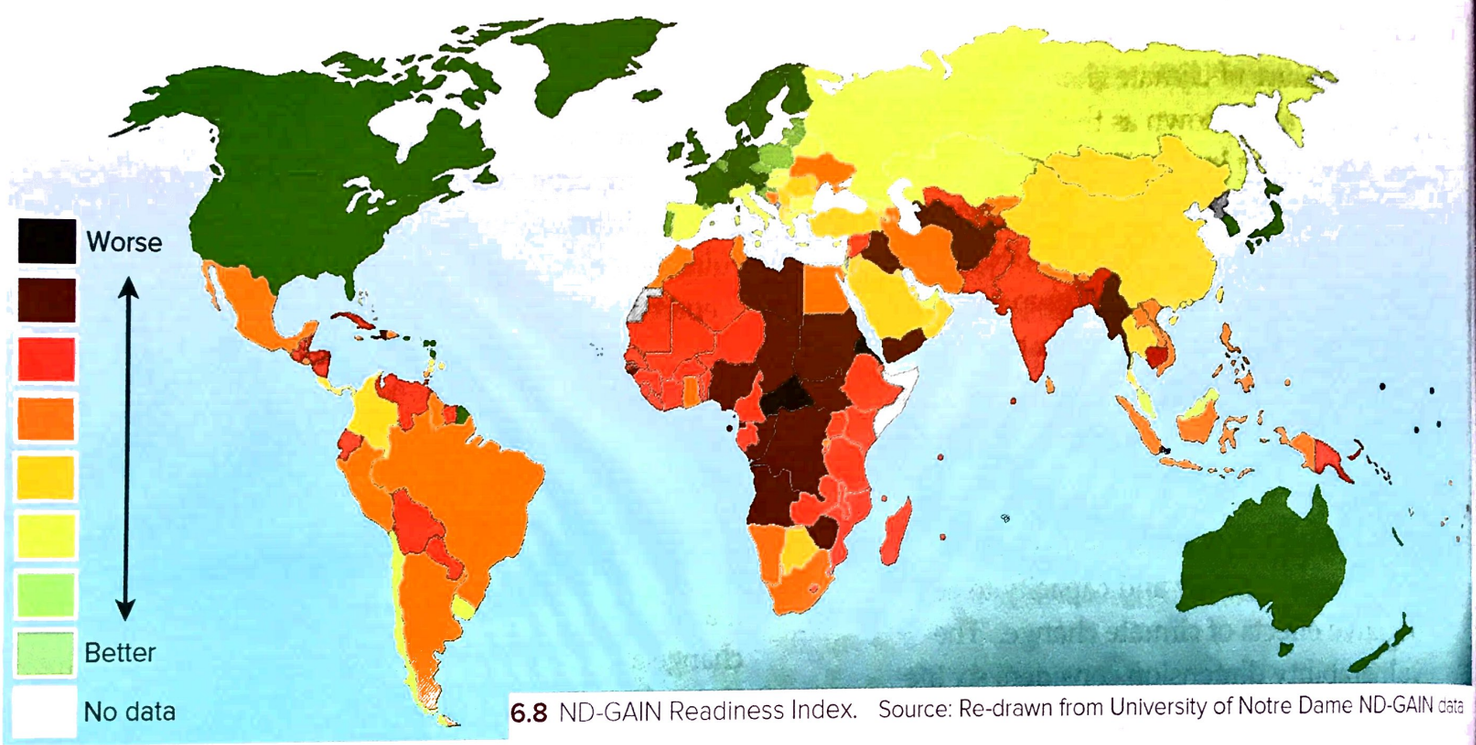
Figure 6.6 shows the **world distribution of risk arising from climate change** determined by the relative importance of each country's vulnerability and readiness. Countries in dark green have low vulnerability to climate change and are well prepared to respond to climate change pressures. Countries in light green are highly vulnerable but also well prepared to handle climate change challenges. Countries in orange are not very vulnerable to climate change impacts, but they are also poorly prepared if something should happen. The most exposed countries are shown in brownish maroon, as they are highly vulnerable to climate change and also poorly prepared to handle problem if, or when, they arise.

Figures 6.7 and 6.8 show the world distribution of each of the two dimensions of the ND-GAIN (**vulnerability** and **readiness**). Figure 6.9 combines these two factors to show the world distribution of the **overall risk** of climate change impacts.

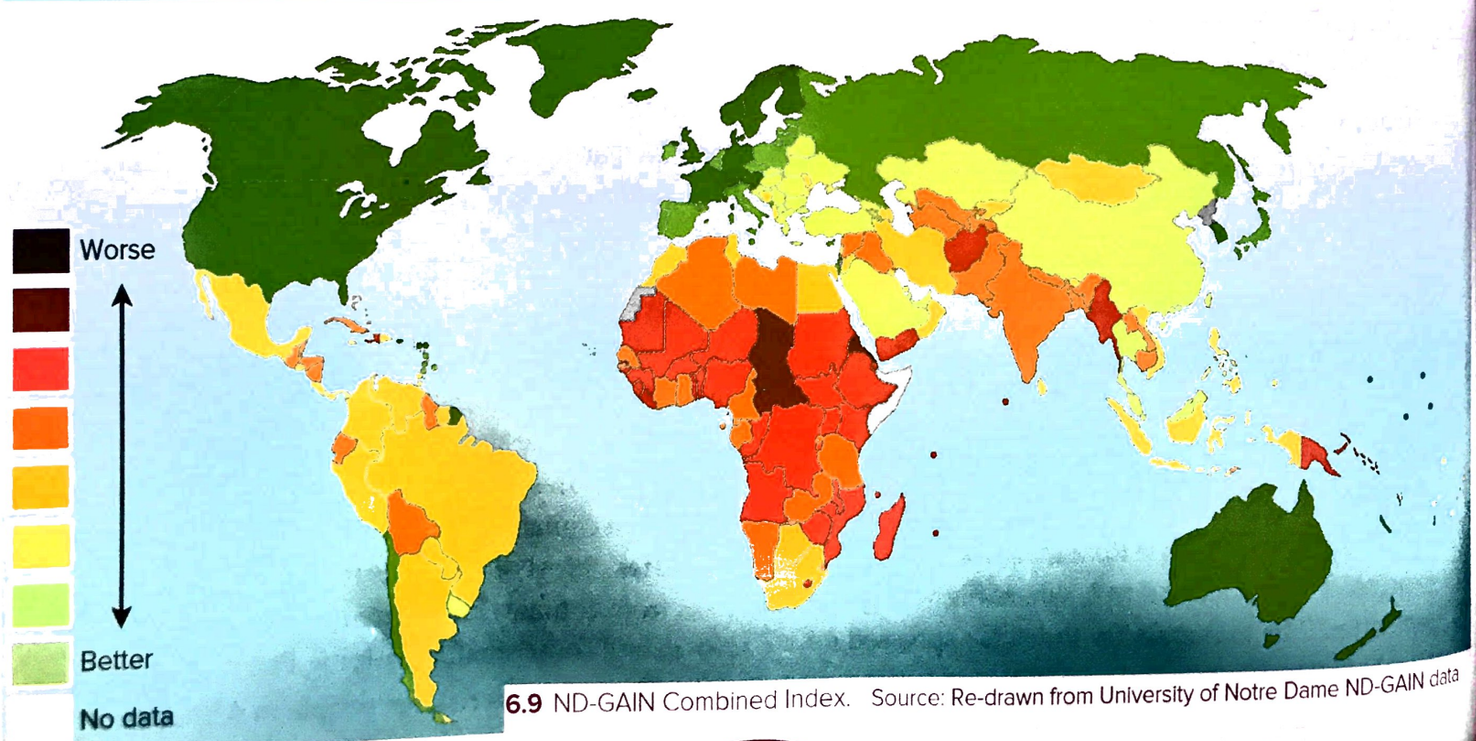
The **four measures** of climate change risk that we have examined emphasise **different factors**, so it is not surprising that the distributions of **climate change risk** they display differ from each other. Nonetheless, one strong common characteristic of all the measures is that the people most exposed to risks from climate change live in **low-income countries**. Most of the measures show the greatest risks from climate change are for people living in Africa and some small, low-lying Pacific nations. The CRI shows less risk for people in Africa, and



6.7 ND-GAIN Vulnerability Index. Source: Re-drawn from University of Notre Dame ND-GAIN



6.8 ND-GAIN Readiness Index. Source: Re-drawn from University of Notre Dame ND-GAIN data



6.9 ND-GAIN Combined Index. Source: Re-drawn from University of Notre Dame ND-GAIN data

places the greatest risk in some poorer countries in Central America, South and South-east Asia. The UNDP supports this finding, stating that 99% of the casualties of climate change will be in developing countries.

Within the countries at risk from climate change, certain demographic groups are **disproportionately affected:**

- **Poorer people** are more affected by climate change because they are less able to afford the rising food prices that result from climate change.
- **Poorer people** are often forced to live in marginal areas because housing and land prices are cheaper there, and it is all they can afford. People who are forced to live on marginal land or land that is more likely to be affected by floods or droughts have less capacity to modify their living conditions to adapt to climate change, and less capacity to migrate to less vulnerable areas.
- **Poorer people** are more susceptible to diseases that are spreading into new areas in response to climate change because their resistance is reduced by poor diets, and they are often unable to afford vaccinations or adequate medical care.
- **Women** suffer the impacts of climate change more than men because in most parts of the world, women are more impoverished than men, and have lower incomes (or no income). Whereas men in most societies are engaged in the commercial economy and are more likely than women to be employed, women in developing countries are more likely than men to be subsistence food producers who do not earn an income for their work, and who must try and cope with changing temperature and rainfall patterns with few financial resources to assist.
- With little or no control over finances and family assets, **women** in developing countries that are affected by climate change are usually under-represented in community politics, and therefore have little influence on decisions that might help adaptation to the impacts of climate change.
- **Women and girls** bear most of the work of carrying water to homes in developing countries, and as climate change dries up streams, lowers the groundwater and causes prolonged droughts, this laborious work becomes even more burdensome.

6.10 Poorer people suffer from rising food prices more than wealthier people because food costs a larger proportion of their total income. This food stall is in La Paz, Bolivia.

6.11 In many low-income countries, most houses do not have piped water. It is usually the job of women and children to carry water from streams or wells to the house, as seen here in Sanga, Mali.

- Similarly, carrying fuelwood is regarded as **women's** work in many low-income countries. As climate change degrades the vegetation cover in some semi-arid environments, women and girls must walk ever-increasing distances to find enough fuelwood for their needs. As a result of having to spend more time and effort gathering fuelwood, women have less time to complete their household responsibilities, earn money, engage in community life, learn to read or acquire other skills, or simply rest. **Girls** in some societies are kept home from school to help gather fuelwood, thus perpetuating a cycle of disempowerment. When climate change forces women and girls to search for fuelwood over longer and longer distances, women and girls become more vulnerable to injuries from carrying

heavy loads over long distances, and they are more likely to be exposed to risks such as sexual harassment and assault.

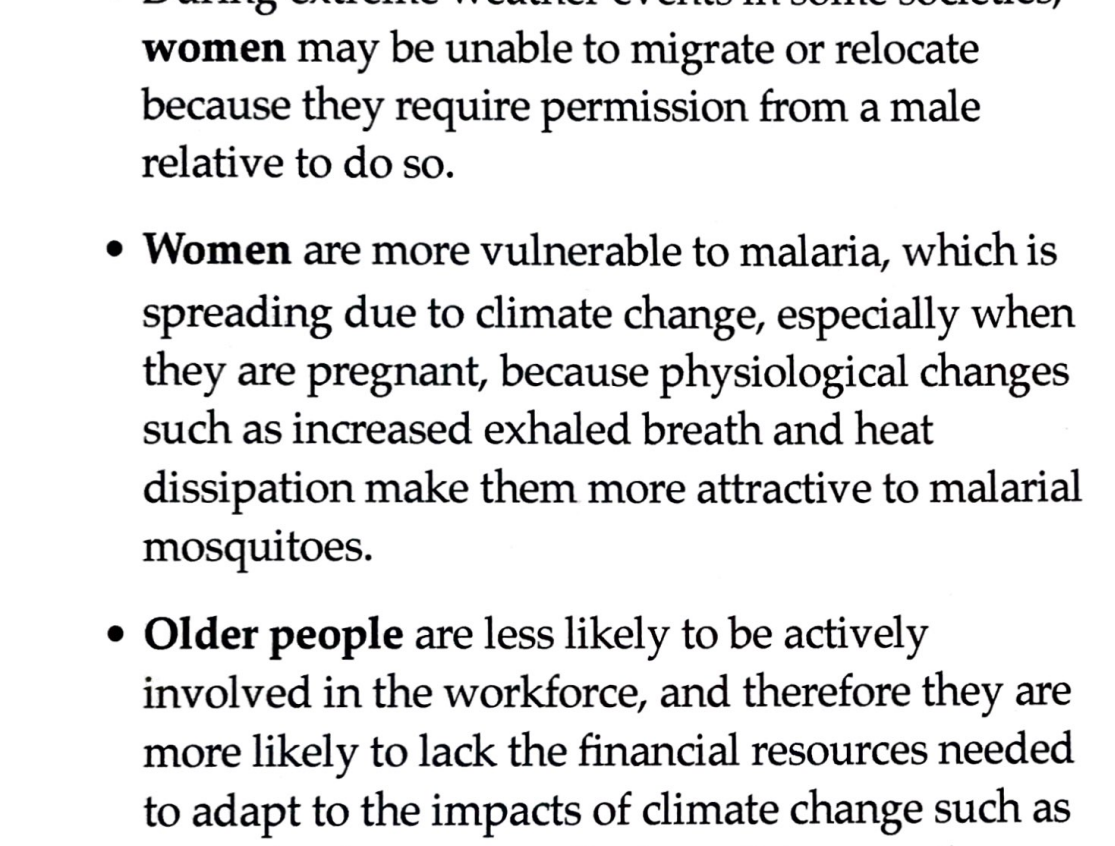
- **Women** are less likely than men to have received an education than men in developing countries, so they have less access to information and services that might help them understand and cope with the impacts of climate change. This challenge applies to all people who have not received a full education.

- In some societies affected by climate change, **women's** traditional clothing impedes their ability to run or swim as they try to escape a disaster such as a wildfire or a flood that was caused by climate change.

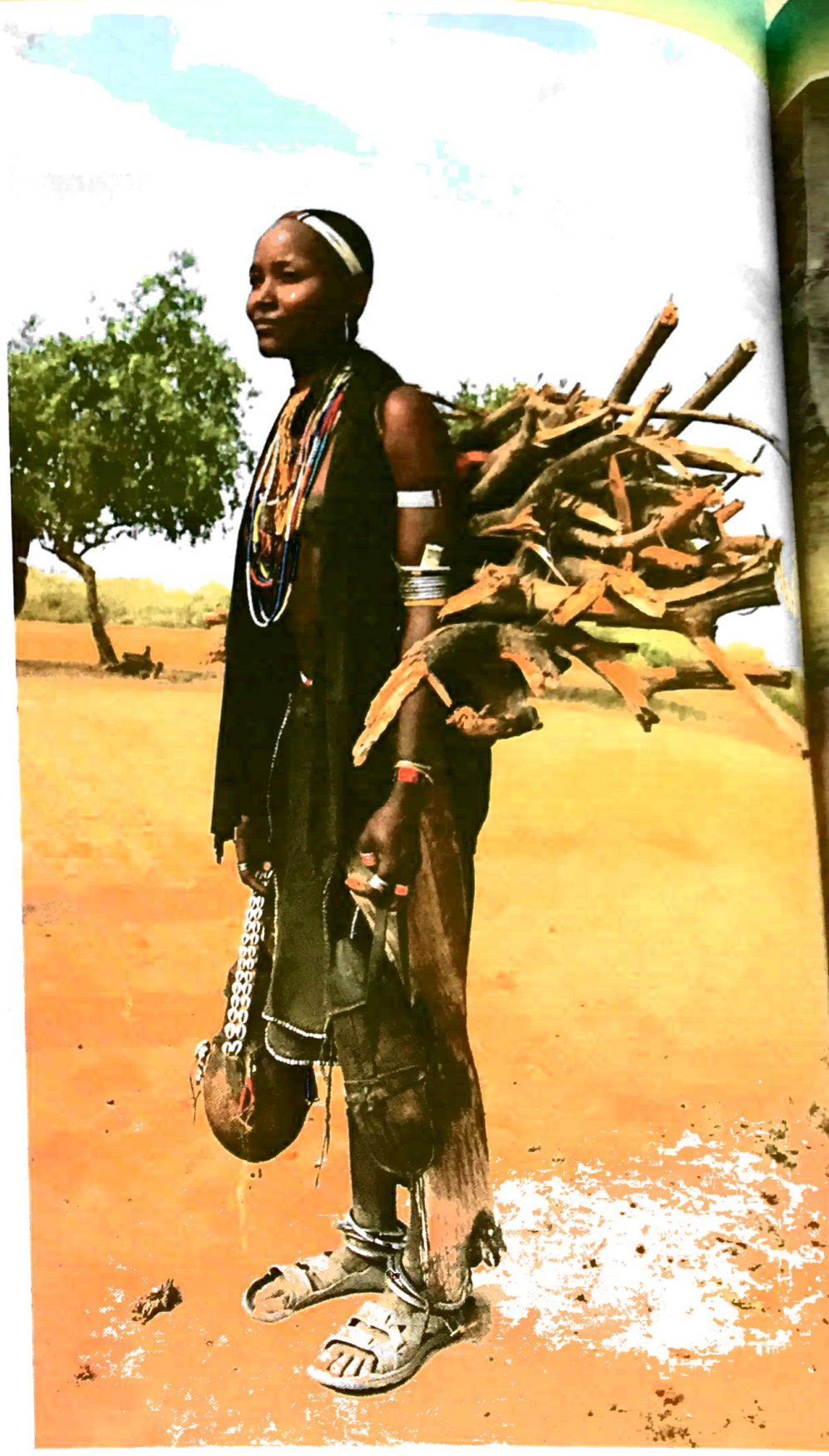
- During extreme weather events in some societies, **women** may be unable to migrate or relocate because they require permission from a male relative to do so.

- **Women** are more vulnerable to malaria, which is spreading due to climate change, especially when they are pregnant, because physiological changes such as increased exhaled breath and heat dissipation make them more attractive to malarial mosquitoes.

- **Older people** are less likely to be actively involved in the workforce, and therefore they are more likely to lack the financial resources needed to adapt to the impacts of climate change such as rising food prices, medical conditions, or the need to relocate their home.



6.12 Women are disproportionately affected by climate change in semi-arid environments because they do about 80% of the farming work. These women are pounding grain in Gogoli, Mali.



6.13 In many poorer countries, women spend long hours carrying heavy bundles of fuelwood over long distances. As climate change affects vegetation cover, women are being forced to travel ever increasing distances. This woman is bringing fuelwood to her village about 70 kilometres east of Turmi, Ethiopia.

- Many **older people** suffer the impacts of climate change disproportionately as their frail bodies struggle to cope with the stresses of heat waves and the increase of pollutants and vector-borne diseases that accompany climate change.

- Like older people, **children** are especially susceptible to the spread of vector-borne disease such as malaria and Lyme disease, both of which are expanding as a result of climate change, as well as seasonal allergies, air pollution, malnutrition and excessive heat.

The **strength** of the impact of climate change on a population depends on a combination of natural and human factors that vary in their significance

6.14 Children in poorer communities are especially vulnerable to the impact of climate change because they are often seen as having a lower priority when food becomes scarce. These children are sharing food in Hukuluak, a small village in West Papua, Indonesia.

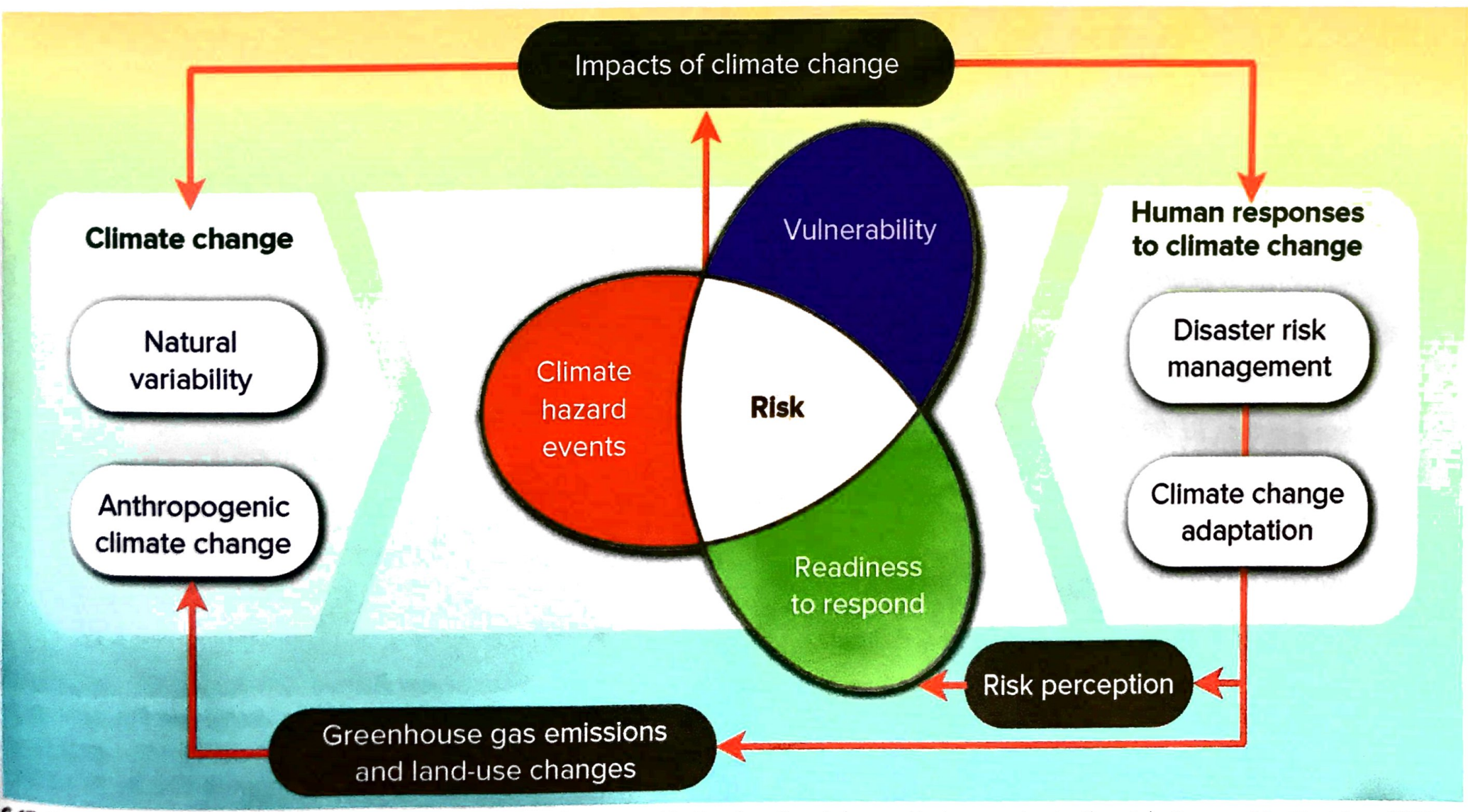
different parts of the world. Figure 6.15 shows these factors, together with the feedback loops that help to perpetuate the impacts.

Starting at the left hand side of figure 6.15, we see that the major force affecting **climate change risk** is the nature and extent of climate change, which has two components – **natural climate variability** and **anthropocentric climate change**. As the ND-GAIN analysis above showed, the strength of climate change risk depends on two counteracting forces, **vulnerability** (which raises the risk) and **readiness** to respond (which mitigates the risk). These counteracting forces are shown at the centre of figure 6.15, where the **balance** between them determines the **extent of risk** faced by people during a climate hazard event.

When a climate hazard event occurs, its impact has two sets of **consequences**. On one hand, the hazard event can be a force that **changes the climate** of the area. This happens, for example, when part of an ice sheet melts and reduces the albedo, causing more insolation to be absorbed, warming the climate and perhaps causing more of the ice sheet to melt, and so on.

The second consequence of a climate hazard event is the impact it has on the human population. **Human responses** to hazard events include **managing the risk** and **adapting** in ways that minimise the future risk. This in turn has two consequences. First, **greenhouse gas emissions** and **land uses** change, and these in turn feedback into the cycle of anthropocentric climate changes. Second, people's **perception of climate risk** changes, which in turn affects their readiness to respond to future climate hazard events.

Risk perception is a significant factor that affects the vulnerability of a population and its readiness to respond to a hazard. In spite of the overwhelming evidence leading climate scientists to conclude that anthropogenic factors are a



6.15 Factors that affect the impact risks of climate change, with the feedback loops that perpetuate the risk. Source: Modified from IPCC.

significant contributor to global climate change, it remains a politically charged **controversy** in some countries. People who deny the significance of anthropogenic climate change will be **unwilling** to commit resources and energy to reducing greenhouse gases or making an effort to minimise climate-changing activities. On the other hand, people who are alarmed by the consequences of climate change will **behave** very differently, engaging in **conscious efforts** to reduce climate change and support political groups that pledge to work towards such goals.

Irrespective of whether a person lives in a low-income country or a high-income country, **risk perceptions** about climate change are affected by many factors, including:

- the amount of **factual knowledge** and **data** a person has on the subject
- the extent to which a person feels **personally affected** or **threatened** by the risks of climate change
- how **immediate** the risks seem to a person, as distant risks are easier to ignore than immediate risks
- the extent to which a person has **control** to avoid or modify the risk rather than just accepting its inevitability
- the extent to which a person is **open to changing** their ideas on the basis of factual evidence.