1 The climate crisis - Why it matters for the built environment

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1.1 Introduction

No book that deals with the matter of buildings can afford to ignore the escalating issue of climate change and its potentially disastrous environmental, economic and social consequences. It is widely acknowledged that the whole life cycle of a building, from its location through to its construction, use, alteration and ultimate destruction, has a major influence on the climate, primarily, though not exclusively, through its contribution to carbon emission (Clayton et al., 2021). If the principles of the circular economy (Geissdoerfer et al., 2017; Kirchherr et al., 2017) are accepted, then some key factors for buildings can be elicited as critical:

1. Initial resource use should be minimised, allowing maximum reuse of materials.
2. The building should be designed to support minimal (or no) carbon use in construction and operation.
3. The building life should be maximised through low-resource intensity retrofits to sustain its longevity for the optimal period.
4. Demolitions should be done in a way that circularity can be achieved through material reuse and, where this is not possible, recycling.

This book deals primarily with the third point: the importance of the retrofit process in lengthening the building life, reducing operational carbon use and supporting social change – all within an economic framework that supports, rather than denies, such processes.

This may sound overambitious, even idealistic, but, we argue, delivery on this is ‘mission critical’ to any realistic possibility of achieving the targets for zero-carbon economies that are being progressively set out and accepted by many corporates, institutions and governments around the globe. In so doing, we are acutely aware that even accepting that climate change is anything more than a natural phenomenon is not universal. However, as the Paris Agreement, referred to as the Paris Accord (UNFCCC, 2020), testifies, the prevailing majority view is that it is real, it has a strong anthropogenic component and the response must be one of both mitigating future changes to stay with global temperature rises of 1.5 degrees Celsius and of adapting to what is already inevitable and locked in.

The urgent need to accept that human actions are resulting in climate change and that it is possible to take effective behaviour change action, both collective and individual, has proved extraordinarily difficult. Even now, as the Covid-19 health pandemic takes its toll globally, the reluctance to accept that it will not be a return to ‘business as usual’ is proving to be an unpalatable message, primarily for economic reasons. The Covid-19 pandemic is something that is portrayed vividly with images of ventilators and human suffering in every country. It is far harder to engender and maintain actions relating to climate change that, for most, seem distant – or transient (Clayton et al., 2015). In December 2021, the World Meteorological Organization reported a new record temperature of 38 degrees Celsius in the Arctic (WMO, 2021); whilst the scenes of wildfires in Australia and California created shocking news images in 2019 and early 2020, the concept of availability heuristics (Mase et al., 2015) instilled collective myopia unless the image was constantly made vivid and relevant. It is the mindset so produced that Ord (2020) means that we are not adept at anticipating and acting on catastrophes for which we do not have precedents; therefore, he argues, even when a threat is very real and clearly explained by scientists, we have great difficulty in believing it will happen until it does. Ord (2020) argues that climate change is one, but only one, such existential threat.

Through the chapters that follow, we lay down the challenge of what it will take to make buildings capable, so supporting the moves to a zero-carbon global society in which temperature increase can be capped to 1.5 or, at worst, 2 degrees Celsius. The challenge will require concerted, sustained and collaborative efforts by all stakeholders: policymakers, building owners, building occupiers, the design and construction industry and financiers. Some 15 years ago, Stern (Stern & Stern, 2007) predicted that the financial costs of not dealing with the matter of climate change immediately would be enormous.

Using the results from formal economic models, the Review estimates that if we do not act, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year, now and forever. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20% of GDP or more (Stern & Stern, 2007).

Alternatively, if mitigation and adaptation measures are adopted, much of this economic downside could be lessened, though not totally avoided, to around 1% of global GDP (Stern & Stern, 2007). However, opinions were divided on the validity of conclusions drawn. Eventually, the Paris Agreement, an international treaty on climate change, was adopted in 2015. It covers climate change mitigation, adaptation and finance.

Regretfully, such warnings and the science from which the economic models were built were not heeded, and since that time, both the severity of the issue and the potential costs have escalated – and continue to escalate to the point when 33 countries and 1,863 jurisdictions/cities have recognised and declared a climate crisis (Climate Emergency Declaration, 2020). However, the debates continue to this day, and the most recent UN Climate Change Conference, also referred to as the COP26, took place in Glasgow in November 2021. Recent weather events have placed extreme weather and its social, economic and environmental impacts at the forefront of many people’s minds. Examples of these events are the 2021 wildfires in Canada, the 2020 bushfires and droughts in Australia, and the 2021 floods in Germany. Though the nature of the crisis and its physical manifestations are complex, they are explored within this introductory chapter.

The climate crisis is not reserved for economic consequences. They may be almost unimaginable, but the social costs of dislocated communities and the attendant poverty and sickness and premature death are far, far higher (Tol, 2002). Such costs will fall, inevitably, upon poorer nations and poorer communities, whilst those living in richer states and countries may have the ability to buy their way out of the immediate impacts, at least in the short term (Stern & Stern, 2007). However, not completely, as the changing climate presents risks that are now feeding through into regulatory frameworks, which will doubtless impact individual and collective freedoms.

This chapter sets out some of the latest thinking on climate change scenarios, including information from the Intergovernmental Panel on Climate Change (IPCC), which points to the inevitable and potential physical consequences: from the impact of rising land temperatures to rising sea levels, floods, droughts, fires and storms (IPPC, 2007). It explores the social consequences of species extinction, disruption to food chains and mass migration. Collectively, these potential consequences, if they come to pass, present an existential risk.

Collectively, these events present challenges to every level of the built environment, from city design to transport infrastructure and, the subject of this book, to the level of how we can adapt and use individual buildings to help mitigate some of the most severe consequences. In so doing, it accepts that mitigation of climate change, whilst laudable, and to date, the preferred policy approach is an inadequate response and requires greater thinking and action around adaptation. In spelling out the challenges, this chapter sets the scene for the book. Before detailing the size of the challenge, it is important to spell out the contribution that buildings make to carbon emissions. Estimates vary, but most agree that they represent around 40% of emissions (Wilby, 2007). Some of this relates to construction – but much is as a result of the way that buildings are accessed, operated, managed and used, and, at the end of their life cycle, demolished.

Before going on to detail what the latest thinking is on climate change scenarios, it is important to understand the types of carbon emission, known as Scopes 1, 2 and 3. Scope 1 emissions are produced from manufacturing processes, such as from cement manufacture, and emissions from the burning of diesel fuel in trucks and fugitive emissions, such as methane emissions from coal mines, or the production of electricity by burning coal. Another summary is Scope 1 covers direct emissions from owned or controlled sources. Scope 2 emissions are indirect emissions from the generation of purchased energy from a utility provider. In other words, it includes all greenhouse gas (GHG) emissions released into the atmosphere from the consumption of purchased electricity, steam, heat and cooling. Scope 3 includes all other indirect emissions that occur in a company's value chain. They are a consequence of the activities of the company but occur from sources not owned or controlled by the company. Some examples of Scope 3 activities are extraction and production of purchased materials, transportation of purchased fuels and use of products and services.

1.2 The climate crisis

In a 2020 report, Bill Gates and Melinda French Gates stated, '*There is no such thing as a national solution to a global crisis*'. Said in relation to the Covid-19 pandemic, it holds true for climate change. Like the virus, climate change does not adhere to borders, and neither should our solutions. The climate crisis affects us all.

Recent climate changes have been widespread and are affecting every region. Although different regions are experiencing different combinations of changes and impacts, the changes are unprecedented, intensifying and becoming more frequent. As global warming increases, the changes in the climate become larger. Evidence suggests that climate extremes such as heatwaves, record-high temperatures, disruptive precipitation patterns, wildfires (Lyster, 2017), sea-level rise and ocean acidification (Whyte, 2019), and droughts and floods are all consequences of anthropogenic climate change (Ide et al., 2020). Such events pose a threat to human security, food chains, health and disease, access to water, biodiversity (Ide et al., 2020) as well as our cities (Lyster, 2017). A number of these changes are unprecedented, including the rate of sea-level rise and glacial retreat, and irreversible in our lifetimes. This means there is a need to implement adaptation and mitigation strategies, as well as increased efforts to slow irreversible changes.

a) IPCC climate change scenarios

The IPCC report (Rogelj et al., 2019) set out mitigation pathways compatible with 1.5 degrees Celsius temperature increase in the context of sustainable development. Limiting warming to 1.5 degrees Celsius will mean reaching net zero carbon emissions globally. To achieve this, mitigation pathways under the IPCC incorporate energy demand reductions, the decarbonisation of electricity and other fuel sources and some form of carbon storage or sequestration. Average global temperatures are already 1.1 degrees Celsius warmer than temperatures in 1850–1900. The world is currently projected to achieve a global temperature increase of 2.7 degrees Celsius, reduced to 2.4 degrees

Celsius if all the Nationally Determined Contributions under the Paris Accord are achieved. This would have a monumental impact.

In their 2021 report, the IPCC modelled five shared socio-economic pathways (SSPs). These used low, intermediate, high and very high greenhouse gas scenarios to predict the impact on global warming (Table 1.1). Under these scenarios, four of the SSPs saw a global temperature increase in excess of 1.5 degrees Celsius relative to 1850–1900 temperatures, only the very low GHG scenario (SSP1–1.9) predicting a 1.4 degrees Celsius increase as the ‘best estimate’ in the long term, but with an overshoot to 1.9 degrees Celsius in the medium term. For the pathways that temporarily overshoot the 1.5 degrees Celsius scenario, large-scale carbon emissions removal measures are relied on, but these currently remain unproven at scale and therefore represent significant uncertainty and risk.

Table 1.1 Changes in global surface temperature adapted from IPCC (2021)

Scenario	Greenhouse gas levels	Near term (2021–2040)		Medium term (2041–2060)		Long term (2081–2100)	
		Best estimate (degrees Celsius)	Very likely range (degrees Celsius)	Best estimate (degrees Celsius)	Very likely range (degrees Celsius)	Best estimate (degrees Celsius)	Very likely range (degrees Celsius)
SSP1–1.9	Very low	1.5	1.2–1.7	1.6	1.2–2.0	1.4	1.0–1.8
SSP1–2.6	Low	1.5	1.2–1.8	1.7	1.3–2.2	1.8	1.3–2.4
SSP2–4.5	Intermediate	1.5	1.2–1.8	2.0	1.6–2.5	2.7	2.1–3.5
SSP3–7.0	High	1.5	1.2–1.8	2.1	1.7–2.6	3.6	2.8–4.6
SSP5–8.5	Very high	1.6	1.3–1.9	2.4	1.9–3.0	4.4	3.3–5.7

Even the ‘low’ scenario (SSP1–2.6) is likely to see a temperature increase of 1.8 degrees Celsius. In contrast, for the ‘very high’ scenario (SSP5–8.5), temperatures could increase by 4.4 degrees Celsius, but as much as 5.7 degrees Celsius at the top of the range. Such temperature increases would have catastrophic effects.

There are a number of barriers to achieving these SSPs. These include a lack of global co-operation, a lack of governance in relation to energy and land transformation and increased resource-intensive consumption (Shukla et al., 2019).

b) The socio-political consequences

There are a number of socio-political consequences arising from climate change. It is now accepted that some negative effects from climate change will be unavoidable. The societal and financial consequences of anthropogenic climate change have become known as ‘loss and damage’, which was included in a clause in the Paris Accord (COP21). ‘Loss’ refers to an irreversible change, and ‘damage’ suggests the potential for repair. However, this could be a matter of life and death for some nations, with countries such as Kenya already experiencing drought, crop failure and starvation, and other nations such as Tuvalu experiencing sea-level rises.

In the context of the adverse effects of climate change, it is those disadvantaged groups that have been shown to suffer disproportionately. This not only leads to greater social inequalities, but it can also increase the susceptibility to the damage resulting from climate change and reduce the disadvantaged group’s ability to recover from such damage (Islam & Winkel, 2017). However, great care is needed when designing interventions. Sources of vulnerability can be reinforced, redistributed or created through interventions aimed at climate change adaptation and reductions in vulnerability (Eriksen et al., 2021). Such 'maladaptive outcomes' can be driven by what Eriksen et al. (2021) describe as a 'shallow' understanding of the 'vulnerability context', inequitable stakeholder participation, adding adaptation to existing development agendas and a lack of critical engagement on defining success.

Climate change has been identified by the IPPC as having the potential to become a significant contributory factor in exacerbating the scarcity of natural resources such as freshwater (Bernstein et al., 2007). Shukla et al. (2019) suggest that limiting global warming to 1.5 degrees Celsius compared to 2 degrees Celsius may reduce the proportion of the world's population exposed to increased water stress resulting from climate change. Although it is estimated that this reduction can be as much as 50%, this can vary significantly between regions.

c) Species extinction

Humans depend on a broad and complex range of ecosystems. Species extinction represents a threat to food security and health, with a loss of diversity in our diets linked to health risk factors (UN Action, 2019). Healthy forests and woodlands clean and cool the air; mangroves provide protection to tropical coastlines against storm surge damage. Changes to these ecosystems will have a profound effect on society (Ide et al., 2020). Protecting and restoring nature is beneficial for people and climate change.

Nature is not only essential for human life, but it is also recognised as important for the quality of life (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, IPBES, 2019). Globally, biodiversity is declining at an unprecedented rate, and the rate of species extinction is accelerating (IPBES, 2019). Although climate change is only one pressure on our wildlife, it is recognised as playing an important role. Indeed, without careful management, rapid climate change is likely to contribute to the extinction of critically endangered species and to other species becoming even rarer. Bernstein et al. (2007) estimated that globally a quarter of mammals and 12% of birds are at significant risk of extinction. Carbon emissions have led to increases in seawater acidity, known as 'ocean acidification'. Climate change–driven ocean acidification is resulting in rapid changes to global ecosystems and a threat to marine life (Greenhill et al., 2020). Biodiversity loss cannot be resolved without addressing climate change, and climate change cannot be resolved without addressing biodiversity.

The need to protect and restore nature and ecosystems, including forests, was incorporated under the Glasgow Climate Pact at COP26. This inclusion is fundamental and complementary in limiting global temperature rises to 1.5 degrees Celsius. Through COP26, although over 130 countries have pledged to halt and reverse forest loss and land degradation by 2030, previous COP pledges to reverse biodiversity loss have been largely unfulfilled, and no mechanism was in place to enforce such pledges.

d) Disruption to food chains

Agriculture, forestry and land use globally account for 23% of anthropogenic greenhouse gas emissions (IPCC, 2020). However, this sector also supports global food security and millions of jobs. For example, in India, the agricultural industry employs over half of the workforce (Guntukula, 2019). Changes to our climate will impact our food chains, and there is a need to adapt our agriculture and food systems both nationally and globally, particularly in relation to food security, global population growth, political turbulence and shocks such as the Covid-19 pandemic (Wheeler & Lobley, 2021).

For some regions, the impacts resulting from climatic changes are not all negative. For example, in the UK, it has led to the opportunity to introduce crops such as grapes that were previously not viable due to local climatic conditions (Wheeler & Lobley, 2021). Some lower latitude regions have seen reduced yields in crops such as maize and wheat (IPCC, 2020), whereas higher latitude regions have experienced greater yields of these crops (IPCC, 2020), resulting from extreme temperatures (Wheeler & Lobley, 2021; Guntukula, 2019; Ayanlade et al., 2017) and heavy rain (Wheeler & Lobley, 2021; Guntukula, 2019). Agricultural impacts are not reserved to crop production – livestock could be impacted by changes in the climate, including lower availability of quality food for the livestock, lower livestock weights, lower fertility and increased livestock mortality (Wheeler & Lobley, 2021).

In addition to such stresses, the IPCC (2020) also reported increases and decreases in agricultural pests and diseases. Such strain on global food production capacity is likely to have an effect on global food availability. For those with limited resources, their climate change resilience is likely to be limited. In their study based on Nigerian farmers, Ayanlade et al. (2017) found that due to their limited resources, smallholder farmers are particularly vulnerable to climate change, limiting their ability to be climate resilient.

Analyses by the IPCC (Rogelj et al., 2019) have indicated that when limiting global temperature increases to 1.5 degrees Celsius compared to 2 degrees Celsius rise, smaller net reductions in crop yields were achieved, particularly in sub-Saharan Africa, Southeast Asia and Central and South America. That is, the smaller the temperature increase, the smaller the proportion of crops likely to be lost.

e) Mass migration

Changes in climatic conditions, including extreme weather events, can magnify migration within and between countries (IPCC, 2020). Such events may lead to food chain disruption, community displacement (e.g. due to flooding) and threatened livelihoods and negative economic impacts. It can also result in increased stressors for conflict. The impact of extreme weather events on economic outputs, including agriculture, has been found to increase the likelihood of conflicts and war, particularly in developing countries (Koubi, 2019). This can trigger mass migration resulting from rising sea levels and extreme weather events such as droughts (Koubi, 2019).

1.3 The built environment – from city scale, precinct to building scale

The built environment comprises various scales from city scale, which includes all built forms, and infrastructures above and can accommodate hundreds of thousands to tens of millions of people. The precinct or suburb scale is a smaller group of buildings accommodating a few thousand people, whilst the building scale may accommodate a few hundred people in the case of a high-rise residential building to a single person in a small house. Collectively, 40% of global GHG emissions are from the built environment, and therefore the built environment significantly contributes to climate change. Most building stock predates our awareness of climate change, which dates from 1987 and the Bruntland Report (Keeble, 1988). As such, it incorporates technologies from medieval to contemporary periods, materials that have been in use for centuries, to recently invented materials such as plastics. The stock includes low-technology buildings such as naturally ventilated low-rise buildings compatible with the local climate to provide comfortable accommodation to high-technology buildings utilising the latest AI and computer technologies to optimise user comfort and convenience. These high technologies can also optimise energy and water utilisation. Depending on scale and technology, there are possibilities to adopt sustainability and resilience measures at all three scales, from city to building level.

1.4 Transport, water and energy infrastructure

In order to function, the built environment and urban settlements are supported by transport, water and energy infrastructure. As settlements have grown in size and density, so too have the complexity and technological sophistication of these systems. These systems result in GHG emissions through fossil fuel petrol and oil consumption in cars, lorries, trains and planes. Water is consumed in sewerage and potable water supply to buildings and industrial production. Finally, the energy infrastructure is typically electricity generation based on fossil fuels, coal and gas. It does not need to be this way.

Transport includes road, rail and air transport, and for coastal and river-sited settlements, ferries and boats. All these forms of transport largely use fossil fuels for their power source, which results in substantial GHG emissions. Car ownership has grown significantly over the last few decades and is the norm in many countries and cities. Houses are developed on the basis of the need for car ownership to get to and from work, education, health, retail and leisure activities. Where compact settlements diminish the need for car transport, we have opted for sprawling urban development. Public transport systems, trains, buses and sometimes ferries allow for more people to be transported from place to place with typically lower GHG emissions per person per kilometre travelled. However, cities vary in their management and governance, with many places preferring private transport over financial and policy support for efficient, reliable and safe public systems. Other sustainable transport options include bicycle tracks to encourage people to travel safely and the adoption of electric vehicles, which requires local governments and councils to incorporate sufficient recharging stations for owners (Greene & Wegener, 1997; Zhao et al., 2020). Of course, electricity generation should be fossil free; solar and wind are suitable sources of power. There are forecasts for autonomous vehicles, which will be available via a phone app or similar, so users can travel from location to location without the need for car ownership and the real estate that comes with it, a garage. It is estimated that autonomous vehicles will be in use for up to 22 hours per day compared to private cars, which tend to be used less than 1 hour per day currently in most cities (Kim, 2018). If adopted en masse, autonomous vehicles could mean far fewer vehicles are needed than we currently have. This would extend the life of existing roads, tunnel and bridge infrastructure. In many cities, there is extensive disruption when existing transport infrastructure is upgraded to facilitate the transportation of greater numbers of vehicles. Extra lanes are added to existing motorways and roads, and new roads, tunnels and bridges are constructed to link new and existing suburbs. In terms of sustainability and resilience, built environments that offer a diverse range of public and private transport options are desired (Newton & Rogers, 2020). Local governments and councils are encouraged to adopt electric vehicle recharging infrastructure and to consider changes in planning that encourage less private vehicle ownership.

In 2020, GHG emissions fell an estimated 2.4 billion tons for the year, a 7% drop from 2019 and the largest recorded fall, which was triggered by global Covid-19 restrictions on travel and business-as-usual activities, according to research from the University of East Anglia, the University of Exeter and the Global Carbon Project (Le Quéré et al., 2020). Forty per cent of the fall is attributed to reductions in transport/travel alone. The researchers stated emissions were likely to rebound in 2021 if pre-2020 Covid-19 conditions returned and urged governments globally to prioritise transition to clean energy and policies that tackle climate change in their economic recovery plans. A decline in transportation activity drove the global drop in carbon emissions. The US had the largest drop in carbon emissions, 12%, followed by the European Union, 11%. India saw a drop in emissions of 9%, and China had a drop of 1.7% (Le Quéré et al., 2020). This is an excellent example of an acute shock to the resiliency of a system. Some supply chains to cities and urban settlements were disrupted as a result of the restrictions. The major impact was the reduction in business and holiday travel, which led to the positive impact of lower GHG emissions and the negative impact of job losses in some industries. It is a good example of the complex nature of sustainability and resilience, whereby both positive and negative impacts arise from events.

With water infrastructure, in some areas, lack of water is the issue, whereas, for others, excess water is a problem. Ageing water infrastructure can deteriorate over time, resulting in the loss of potable water through leaks. Clearly, effective maintenance and repair of existing systems are necessary to minimise loss. New developments should adopt the principles of Water Sustainable Urban Design (WSUD) – that is reducing flows and systems that deliver water. In buildings these include designs with rainwater harvesting for watering green spaces, lawns, greens roofs and walls. Internal designs include water recycling, whereby greywater (i.e. water from baths, sinks and showers) is reused to flush toilets and water gardens. It is possible to recycle water and to clean grey and blackwater (water from toilets) for reuse; however, currently, it is very energy-intensive, and if the energy source is fossil fuel based, it is not sustainable. This may change in future if non-fossil fuel renewable energy sources are used. In terms of resilience, if resilience is bouncing back from adverse events, the adoption of renewable energy ensures recycled water is not more harmful to the environment. For water-starved areas, rainwater retention and storage, the adoption of low water consumption technologies and reuse of water are all practical measures that ensure scarce resources last longer.

Energy infrastructure currently comprises electricity power stations powered by gas and coal, which results in large amounts of GHG emissions. The sustainable and resilient alternative is to use renewable energy in the form of wind and solar power. Depending on the location, some areas receive more sunlight or wind than other areas. This infrastructure can be located outside of the settlements or on buildings, or a combination of both. In order to make the energy supply more resilient, low-energy designs and retrofits to building envelopes in the form of insulation and reflective finishes, double or triple glazing specifications should be adopted to ensure the lowest possible demand on the sustainable renewable energy infrastructure (Ander, 2014 ; Bulut et al., 2021).

1.5 The response

This section of the chapter explores both the degree of response that is needed, if not demanded by our current circumstances with respect to climate change, and also the degree and quality of response to date.

1.5.1 The response that is needed

It is often argued that increasing regulation is the answer. Enacting high minimum standards levels the playing field with all stakeholders equally affected and ensures best practices are adopted. Others argue that a voluntary or market lead approach delivers greater innovation, as stakeholders compete to be the most sustainable. Trencher et al. (2016) explored innovative policy practices to advance building energy efficiency and retrofitting: approaches, impacts and challenges in ten C40 cities in the US and Asia-Pacific. They found mandatory and voluntary policy models with impacts and challenges and concluded innovation occurred without regulation or new policy invention and, by necessity, as generic models were adapted to local circumstances (Trencher et al., 2016). The sample revealed comprehensive regulation in Asia, experimentation with benchmarking in the US and voluntary approaches in Australia. Overall, environmental impacts emerged slowly and had attribution challenges. There was limited evidence of benchmarking programme effectiveness in reducing energy consumption in the short term but some indication of mid-term outcomes. The cap-and-trade model stood out by fostering large, sustained and attributable GHG emission reductions and retrofitting. Cap and trade is a term for a government regulatory programme designed to limit, or cap, the total level of emissions of chemicals, such as carbon dioxide. Proponents of cap and trade claim it is a viable alternative to a carbon tax. Trencher et al. (2016) found that the market and social impacts were highly significant, and there is a need to consider non-environmental impacts in policy evaluation. They conclude the complementary potential of voluntary and regulatory approaches to advancing energy efficiency and climate resilience needs to be explored further, as well as the potential for benchmarking programmes to transition to models mandating performance improvements, such as cap and trade (Trencher et al., 2016).

Another way to label this argument is ‘the carrot or the stick’ approach. Some argue that free markets will deliver greater results than mandated lower standards (Heffernan et al., 2021). In their analysis of policy pathways to an environmentally sustainable rental housing sector, Heffernan et al. (2021) reviewed international mandatory and voluntary approaches. Carrot policies included tax incentives, rebates and grants. Cusp policies, which were neither carrot nor stick, included loans, energy arrangements and improved rental rights, whereas the stick policies are minimum standards and mandatory disclosure (Heffernan et al., 2021). Minimum performance standards, rebates and tax incentives were found to be the most effective policy solutions identified, and the authors conclude policy mixes should include carrot and stick policies. Within the built environment, the sector, be it social or rental housing or commercial property, is influential with regard to whether a carrot or stick, a mandatory or voluntary or a hybrid policy is most effective. There is no one size fits all.

What is needed is collaboration. There is also a discussion to be had around needs and wants. The response to climate change and a stock of mostly inefficient ageing buildings, which predate minimum energy standards or sustainability, is largely overlooked. We need to act now whenever the opportunity arises to improve the sustainability, operational energy efficiency and resilience of our building stock. We may not want to do this. The question we need to ask ourselves is: for those owners who do not want to improve their existing buildings, how can we create circumstances to enable this to happen?

The November 2021 Paris COP26 ended with a global agreement to accelerate action on climate this decade, where COP agrees, for the first time, a position on phasing down unabated coal power (United Nations Climate Change Conference, 2021). Organisers claimed the COP26 summit brought parties together to accelerate action towards the goals of the Paris Agreement and the UN Framework Convention on Climate Change. Others, however, lament yet another lost opportunity to take effective action (The Guardian, 2021). They assert that limiting the 1.5 degree temperature increase is now no longer possible, and we are more likely to experience a plus 2 degree increase. There is evidence, however, that the longer we procrastinate and delay action, the more likely younger people will experience despair and anxiety about the future they will inherit.

1.5.2 The response to date: the scale of the problem for existing buildings

The existing stock of buildings contributes a substantial amount of GHG emissions and represents an excellent opportunity to make a significant reduction to GHG emissions if operational energy is reduced and materials with high embodied carbon are avoided. The opportunity to retrofit buildings occasionally arises during the life cycle, as the fabric or components of the building wear out to the point where replacement is necessary. Therefore there is a limit to what can be delivered through sustainable building retrofits if a business-as-usual approach is allowed to continue. To date, there is no mandatory requirement to undertake sustainable, energy-efficient building retrofits imposed on owners.

Interestingly, the impact of Covid-19 in 2020 and 2021 has required many people to work from home to prevent exposure to the virus whilst travelling to and from the workplace or being exposed in the workplace. There is now extensive debate about whether people will return to a five-day working week in a workplace (Savills, 2021). Many speculate that commercial buildings will be under-occupied and/or vacant. If this is the case, then some owners will seek to sell or convert or retrofit their stock to attract occupiers or buyers. They may adopt sustainable, resilient retrofits to increase their attractiveness to the market. There is a concern in the office sector that air-conditioned spaces may enable transmission of Covid-19 particulates from one area to another. The question arises: can we safely occupy spaces at the same density level as pre-Covid-19? Tests are being undertaken to look at different space plan layouts to ascertain pathways for air flow and particulates so that healthy building retrofits can be proposed. These two factors may create a market for increased building retrofit in the short-term future, which would create a unique opportunity to embrace low-carbon resilient, sustainable retrofits to mitigate the effects of climate change.

1.6 Summary of the challenges faced

This book is structured in three parts. Part 1 explores The Why – the challenge of climate change and the overarching need for extensive change. In Chapter 2, Sarah Sayce and Sara Wilkinson examine 'The philosophy and definition of retrofitting for resilience'. Retrofits are defined and distinguished from other forms of building alterations to differentiate a retrofit for resilience against a normal cyclical undertaking to bring a building back to extant occupational functional standard. The timing of retrofit is discussed, and 'deep' and 'light' retrofit approaches are defined. The chapter discusses what makes a 'resilient' building distinct from an 'environmentally friendly' or 'sustainable' one and the extent to which the terms are complementary. It argues that, if building resilience is to be achieved, sufficient to assist in meeting climate mitigation targets, not only is retrofitting buildings simply a necessity, but it is also a desirable social outcome, conserving as it may do the maintenance of the place, memory and culture. The chapter explores the extent to which retrofitting to preserve – or conserve – the social value of the building and its context is a philosophical, economical or legislative matter before highlighting the issues of the redevelop/retrofit decision. In conclusion, the chapter emphasises the paucity of the business-as-usual approach and outlines the radical alterations needed to our current conceptual understanding to deliver the necessary changes.

In Chapter 3, titled 'An inadequate building stock', Sara Wilkinson and Sarah Sayce describe the challenges facing the existing stock. The inadequacy most explored is the impact of age and associated energy inefficiency. This is a challenge that currently is unmet. However, retrofitting for low energy is only part of the picture: water conservation, flood protection and the ability to withstand fire are important criteria for resilient, sustainable buildings. As the health and well-being agenda gains traction and research connects chronic and fatal conditions with pollution and building defects, the quality of buildings is further brought into focus.

In 2020, a fatal and hitherto unacknowledged risk came to the fore: the transmission of disease within buildings through heating ventilation and air conditioning (HVAC) systems. Covid-19 showed transmission of the virus through HVAC systems was possible. This risk in some countries mandated office workers to operate from home to reduce exposure and transmission risk. Working from home worked well for some, and there are ongoing discussions about the viability of the return to work in offices post-pandemic and the benefits of allowing people to work from home. Even if a return to offices takes place, the type of space and the way it is operated will likely change, accelerating trends already identified (Harris, 2020). In the short term, this may lead to large office vacancies as leases terminate and leaseholders seek smaller demised spaces; in the longer term, buildings which cannot 'flex' to meet changing demand may become economically 'stranded'. Almost inevitably, there will be growth in 'inadequate stock'. Chapter 3 examines the mismatch of buildings to the social needs of communities: be that through the shift in transport means, such as the introduction of electric (or hydrogen) and, in time, autonomous vehicles, and the need to accommodate greater densities of population and to feed them locally. By outlining the drastic, radical changes needed, the chapter concludes that collectively this creates a multifaceted challenge to adapt and improve existing buildings.

The final chapter in Part 1 is titled 'Understanding Vacancy in the office stock'. Dr Gill Armstrong argues that given the uncertain impacts of Covid-19, the need for greater vacancy understanding is particularly urgent. Current predictions are for high levels of commercial building vacancy and an increased risk of premature obsolescence. This chapter makes a case for a more nuanced understanding of vacancy as an evidence base for mitigating obsolescence and building urban resilience. An analysis of vacancy data challenges the accepted wisdom of building urban resilience by converting vacant office buildings to new uses. The chapter offers suggestions on how to advance vacancy knowledge and describes a tool for policymakers to quantify vacancy, known as Vacancy Visual Analytic Method (VVAM) (Armstrong et al., 2021). Finally, this chapter highlights the usefulness of vacancy as an essential evaluation tool in policy development to address chronic stresses and acute shocks experienced by cities.

Part 2 explores The What – setting out what is needed to deliver the changes identified in the why part of the text. Jeroen van der Heijden sets the scene in Chapter 5 titled, 'A governance response: from coercion to persuasion to embracing diversity?' van der Heijden claims that seeking to achieve retrofits, government responses can and have been coercive, persuasive or both, and range from punitive tax regimes and statutory requirements to 'nudge' techniques and voluntary programmes. This chapter analyses a range of measures in different jurisdictions and across the spectrum of interventions (such as taxes, certification requirements, statutory obligations and economic incentives). It assesses whether such measures are sufficient in light of the great urgency of climate change and awareness of health and well-being in the light of Covid-19. It argues that not enough is being done to shift the pendulum from coercive to persuasive techniques and suggests ways in which governments should seek higher levels of effectiveness through an overhaul of the building regulatory system. This overhaul would involve combining coercive and persuasive interventions and targeting different groups of property owners and users with tailored regulatory and governance interventions.

Chapter 6, 'Financing Retrofits', written by Zsolt Toth, Ursula Hartenbeger and Sarah Sayce, examines the ways financing building retrofi ts is evolving to assist owner-occupiers and investment owners to gain finance from either public or private financiers, or both. It concludes the situation is changing rapidly, and arguments previously made that funding was unavailable have started to be overcome. However, it concludes that more needs to be done and posits some recommendations to aid both the speed and quantum of progress.

In Chapter 7 , 'Technological Solutions', Sara Wilkinson and Sam Organ explore innovations in technology that could bring significant change to the carbon footprint of existing buildings to address the critical issues set out in Part 1 . Extreme times demand consideration of new approaches, such as the end of fossil fuels as primary energy sources. Wilkinson and Organ argue this is already happening through a combination of investments (public and private) and the impact of legislation and policy. In evidence, they refer to the UK's national electricity grid experiencing 18 days of fossil-free energy generation in April 2020 (The Guardian, 2020). They ask, 'can buildings derive sufficient energy from non-fossil sources, and will it need rapidly accelerated rates of retrofitting to achieve the change from fossil fuels and a reduced carbon footprint?' Other benefits such as bioremediation of greywater in buildings are described. Innovations in sensors, technology, artificial intelligence and robots, they claim, may facilitate greater adoption of green infrastructure, which, if adopted 'en masse' in city centres, mitigates the urban heat island effect. One method of distinguishing innovations is whether they are considered low or high tech: that is, whether they have little or no reliance on computerised technology (low tech); or whether features such as computer technologies, sensors or artificial intelligence (AI) are integrated into a building ('high tech') for performance optimisation. Drawing on innovations from a range of disciplines, this chapter sets out new technologies, new ideas and new ways of retrofitting existing buildings to deliver more sustainable and resilient outcomes.

In Chapter 8, Hilde Remøy and Sara Wilkinson focus on repurposing and adaptation. Social and technological change will always affect buildings and how we design and use them. An example is the advent of driverless vehicles and a sharing economy model, which is predicted to decrease car ownership. Currently, most cars globally are in use less than 1 hour per day, so we build structures to park them for 95% of the day. As this decline occurs, large amounts of car parking space will become redundant. Elsewhere the retail sector and the high street are suffering from the advent of online shopping. So, what can be done to repurpose and adapt this stock? Remøy and Wilkinson argue some changes are unpredictable and fast, known as 'acute shocks' in resilience parlance. Others are slow and ongoing or chronic. In 2020 the globe experienced a health shock in the form of Covid, which quickly turned into a global pandemic, a health crisis that spread rapidly and was exacerbated by international air travel. As a result, global travel shut down to essential travel only, with people required to quarantine on arrival in many countries. Soon economic impacts were felt; people were told to stay home and work and not to socialise outside the home. Retail switch to online shopping accelerated to minimise exposure to the virus, and restaurants turned to home delivery models. Socialising at sporting, cultural, music and arts events ceased. In 2021 this is impacting our existing building stock, and the full outcome is yet to be realised; however, we can see from previous changes what can happen and, in this way, explore what might happen in the future. This chapter examines innovative ideas for repurposing and adapting redundant stock for new uses which meet revised needs and demands. For example, urban food production, shared affordable and alternative housing are some options explored.

The last chapter in Part 2 is Chapter 9, 'Heritage: learning from and preserving the past'. Here Sara Wilkinson and Shabnam Yazdani Mehr explain why heritage buildings are important to remind us of our history, and the need to conserve and preserve remains important. There are many ways in which these buildings physically embody resilience, and they can be retrofitted and adapted sustainably. Many heritage buildings adopted what we now consider sustainable materials and technologies as they predate industrialised methods of production and the reliance on high levels of energy and mechanisation for operation, and therefore, there is much to be learned from them. Over time some buildings are adapted and retrofitted within the use, whereas others are converted or undergo adaptive reuse. At this point, issues around the place and location, or 'genius loci' and authenticity, become important. These changes are a result of the prevailing legal, technological, social, economic and environmental drivers prevailing in the location at that point in time. This chapter explores what we can learn from heritage stock to make their retrofit resilient; and what we can learn and transfer into the retrofit of other, non-heritage stock. A model for assessing adaptive reuse of heritage buildings and a checklist for identifying and preserving 'genius loci' in adaptive reuse are proposed.

Finally, Part 3, Chapter 10, concludes the text and sets out a manifesto for change. Building on the preceding chapters, this last chapter presents a manifesto of recommendations for policymakers, educationalists, professional bodies and practitioners. Whilst it may be speculative in some ways, the intent is to underscore the conviction that a business-as-usual model can no longer work; it will argue that the responses to date to dealing with building adaptation are too timid – and that this lack of real commitment and drive could be argued, to quote Greta Thunberg, is 'beyond absurd'.

1.7 Conclusion

This first chapter has set the scene in respect of global climate change causes and the social, environmental and economic impacts and the considerable contribution of the built environment to global warming. It has highlighted the need for more sustainable retrofits to mitigate these impacts and to contribute to lessening waste, reducing building-related water and energy consumption, to adopting a circular economy approach. The rationale for the three parts to the book structure was explained. Part 1 explores The Why – the challenge of climate change and the overarching need for extensive change. Part 2 explores The What – setting out what is needed to deliver the changes identified in the why part of the text, and finally, Part 3 concludes the text and sets out a manifesto for change.

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