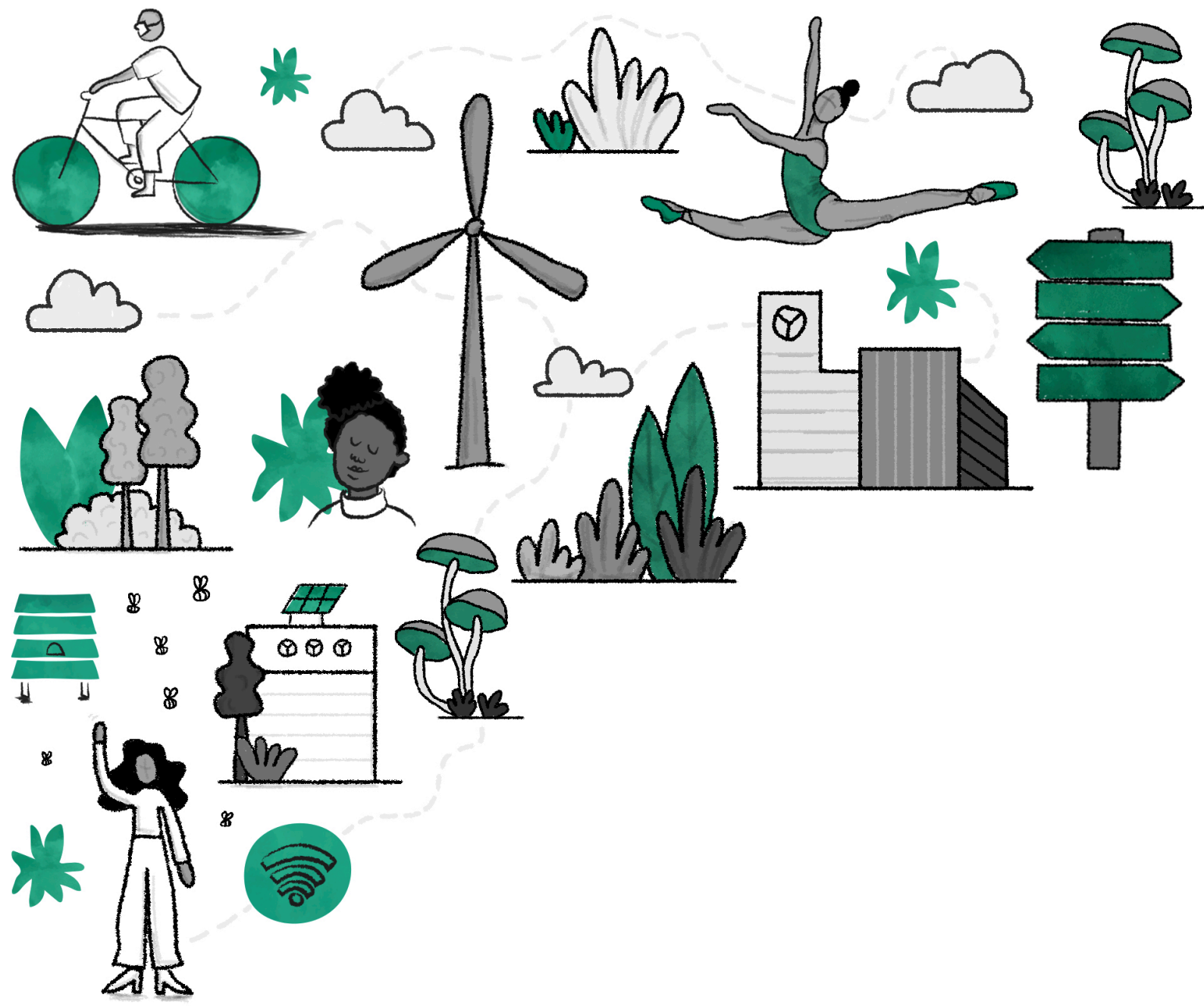

FOUR FUTURES, **ONE CHOICE.**

OPTIONS FOR THE DIGITAL BUILT BRITAIN OF 2040

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Introduction

PROFESSOR DANIELLE GEORGE MBE

PRESIDENT, INSTITUTION OF ENGINEERING AND TECHNOLOGY (IET)

The Institution of Engineering and Technology (IET) focuses on the opportunities for engineering and technology to enhance the physical environments that people need to work, rest and play - offices, homes, services and open spaces.

We know that in the UK life expectancy for those who live in the most deprived neighbourhoods is nine years less than those in the least deprived areas. What does this say about how our homes and physical environment impact on our health and wellbeing, and what can we do to improve this?

This book explores some of the broad spectrum of actions that will be needed over the next 20 years if we want to close this gap and make our built environment greener, cleaner and safer. It is imperative that the industry works together to achieve the United Nation's (UN) sustainable development goals and keep us within targets for carbon emissions, all while ensuring people are supported through the likely long-term economic impact of the COVID-19 pandemic.

To deliver these benefits we need data that's perpetually accessible while also being securely managed. Simultaneously, to deliver wider social, economic and environmental benefits, we also need data to be open. This doesn't mean free; the openness of data is about its interoperability and ease of distribution.

I think we can all agree that the year 2020 has been unprecedented - Four Futures, One Choice helps us to imagine the opportunities, as well as the challenges, that this presents to us.

MARK ENZER OBE

CHAIR OF CDBB'S DIGITAL FRAMEWORK TASK GROUP

The scenarios set out in this book – four potential versions of 2040 – explore how the decisions we make today will have a significant impact on our future.

Whatever 2040 brings, there is a common strand in all the scenarios that we can be almost certain about: that greater digitalisation and increased use of technology will have a crucial part to play in our lives. Whether we are faced with a dire future in which the climate emergency has become more acute and there is an ageing and dependent population, or a more hopeful future where we have managed to limit global temperature rise and are beginning to achieve the sustainable development goals, there can be real benefits of using data for the public good. And the National Digital Twin (NDT) is intended to do exactly that.

The NDT is envisaged to be an ecosystem of digital twins, connected via secure and resilient data sharing across organisational boundaries. Its promise is to unleash value by enabling better decisions—in use, operations, maintenance, resilience, planning, investment and more—across the built and natural environments. But this technology needs to be guided by appropriate values.

That's why in 2018, the Centre for Digital Built Britain (CDBB) published the Gemini Principles to be the conscience of the NDT and of the information management framework that will enable it. The Gemini Principles are deliberately simple and enshrine the intention that all digital twins have clear purpose, must be trustworthy and must function effectively.

The choice is ours – to use technology for good, not ill. By making the right choices now, we can look forward to a transformed built and natural environment in 2040 that is served by an industry that is highly literate in using data for the public good.

PREFACE

WHAT IS A DIGITAL BUILT ENVIRONMENT?

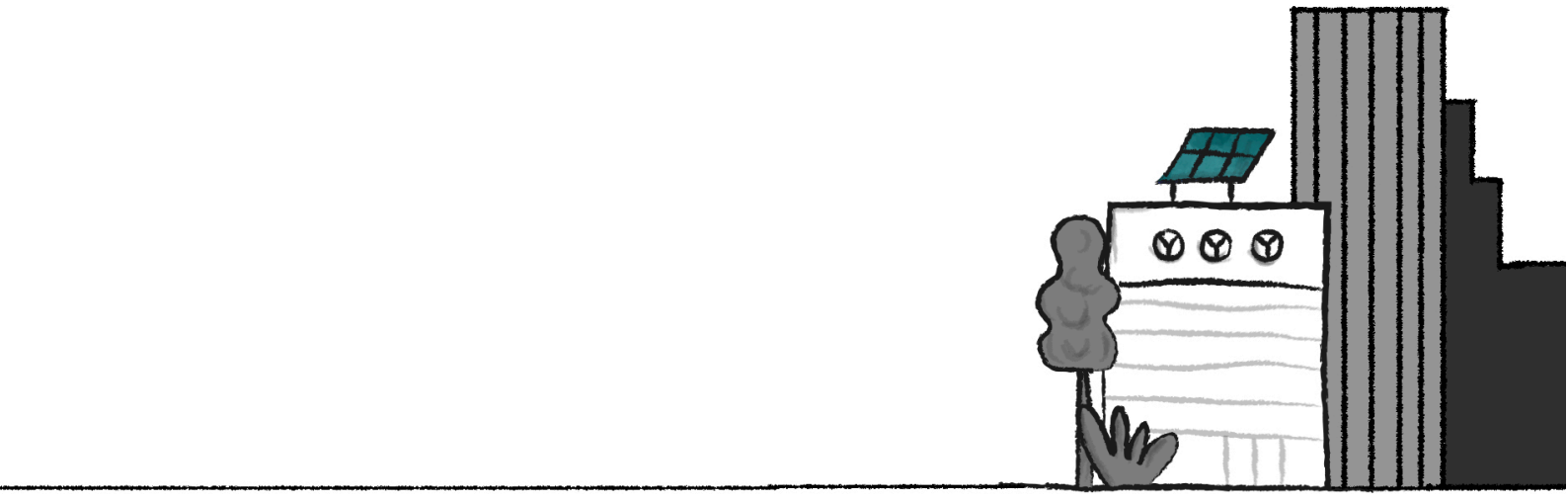
This book is about the **built environment**, but what does that mean?

It's the buildings and places between where all of us live, work, play, learn, heal and travel. It's the stage on which the dramas of our lives play out. If it's doing its job well maybe you don't even notice it, but if it works against you it's often all you can think about.

It's the country's **economic infrastructure** – power lines, rail, roads, broadband, and all the other essential pieces that enable a country to create financial value. It's also **social infrastructure** – schools, colleges, hospitals, care homes, and all the places where we do our socialising and cultural activities.

It's made up of sectors that have an outsized responsibility when it comes to the future of this planet, creating and managing built assets (bridges, roads, homes, office buildings, airports, etc.) that will last decades, even centuries, and are responsible for roughly 40% of the UK's carbon footprint[1].

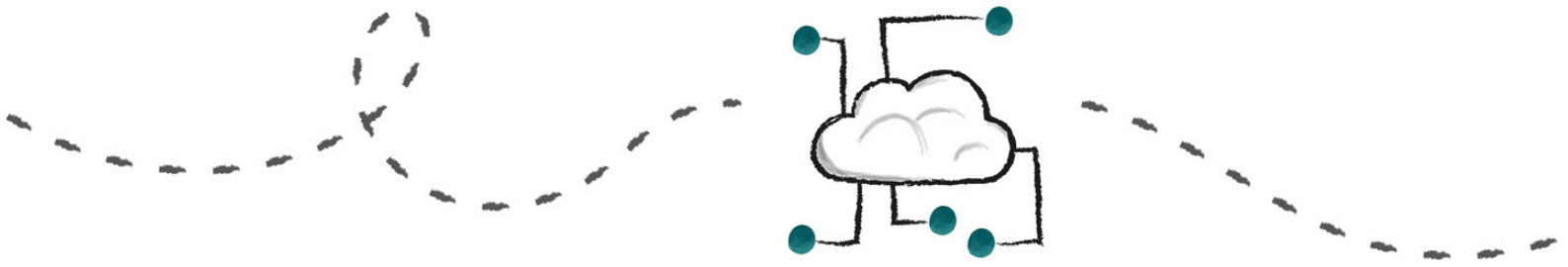
This book is also about **digital technology**. You might have heard about 'smart cities', places where digital devices talk to each other to find out how the city is being used, and to make it run more smoothly. And you might be thinking that this book – a book about the future of the digital built environment – will tell you all about driverless cars and robot baristas, drone delivery services and traffic lights that automatically change for emergency vehicles.



THE ANSWERS LIE WITHIN THE DATA

But we, the authors of this book, haven't laid out a future that's dependent on any of these smart devices. That's because they're not essential components of our collective digital future, or the smooth functioning of our society and economy. Even though we see their value and potential, we frame the focus on data, because digital technology and any of these smart devices relies on data to function. It's how Google knows that your favourite restaurant is full and how the maintenance crew of the aeroplane you board know when it's time to tune up the engines. In fact, Sir John Armitt, chair of the National Infrastructure Commission, has said that, 'Data is now as important to UK infrastructure as concrete or steel.'[2]

That's right, data: that thing the pop-up windows on websites keep asking you about; that thing the Test and Trace apps need in order to let you know whether you've been exposed to COVID; that thing your kids keep running out of when they stream videos without connecting to WiFi. Like the built environment, data is so pervasive that you might not notice it until it starts working against you. When data works against you, you might find your neighbourhood is underfunded or over-policed. You might find your educational opportunities are lessened. That means that in practice, data isn't neutral. Like any other tool, it can cause harm when used with the wrong intentions. In the future, as now, how data and digital technology are used in the built environment impacts all of us, and all of us have a role in deciding the outcomes we want.



THE VIRUS THAT SHOOK THE WORLD

Thinking back to February of 2020, when a group of researchers sat together in Cambridge for the workshop that began our work on this book, the world felt like a very different place than it does just 11 months later. We had gathered to discuss what the built environment of Britain might look like in 2040, and the biggest factor on our minds then was the climate crisis. When we thought about how climate and changing demographics might impact the built environment in the UK, we considered a world where telecommuting and flexible working patterns might be the norm. We thought about what gradual changes to healthcare might happen over 20 years. We imagined ourselves deeper into the climate emergency, wondering what such a situation would do to the most vulnerable among us.

But shortly after starting work on this book, we learned first-hand just how quickly things can change as COVID-19 wreaked havoc around the world and so much that we considered dependable unravelled. We retreated to our individual homes and had to continue our project remotely over the internet, suddenly inhabiting a version of the future we had just been exploring.

It also became clear that as a global population we were going to have a high price to pay for ignoring the early warning calls from many experts who warned that our lack of preparedness for a global pandemic would result in catastrophic failures to react in a timely and effective manner. Unfortunately, it's in parallel with the lack of response to the warning signs pertaining to the climate crisis as well, and yet despite the early signs and warnings, there seems to be a consistent failure to acknowledge and take action. As with COVID-19, we may well find ourselves worryingly underprepared when the effects of the climate crisis come knocking at the front door. COVID-19 showed us the importance of planning for the unforeseeable by considering what might have happened had we just been better prepared. In order to be more prepared in future, as an industry and a society we need to learn how to make decisions based on long-term values, not just short-term targets in order to protect ourselves against, and aspire to, futures we can't accurately predict.

The infrastructure we commission today, especially with the added pressure of recovery from COVID-19, will lock us into a pathway with set carbon emissions for decades. We have to think carefully about the decisions we make in the short term, and understand how they will impact a complex system of interdependent factors. In short, we need to be guided by good data as well as good principles.

WHO IS THIS BOOK FOR?

This book is for you, **construction industry leaders and manufacturers**, who can choose business practices that use resources and data responsibly. It's for you, **policymakers**, who can hold us accountable for the carbon we emit and protect future generations with legislation for sustainability and resilience. It's for you, **teachers and academics** who can discover, communicate and inspire with new ideas and new ways of seeing the world. It's for you, **parents, friends, neighbours** who are worried about the future, and are able to express your opinions through engaging in democratic processes such as voting in local elections and challenging policies.

Each one of us makes decisions every day – and each decision we make impacts upon the future we define for ourselves and for our loved ones, therefore it's important to consider how our values are reflected in those decisions. No matter how big or small the decision, its impact ripples out from our sphere of influence to the wider world, and these decisions are cumulative. This is why we need to consider how our values and our decision-making affects others, not just today and for our immediate families and networks, but for tomorrow and the generations that will follow. The aim of this book is to give you a glimpse at four possible futures. Although none of them are certain and perhaps none of them will materialise, they give you an opportunity to consider which version of the future best aligns with your values and hopes, and will ultimately help to inform your decision-making from this day forward.

Which future will you choose?

KEY TERMS

These terms are defined according to their use throughout this book, not necessarily their most exhaustive or popular definitions.

ASSET

While in general assets may be any resource with value to an organisation, we often use 'asset' as shorthand for 'built asset': individual buildings and built infrastructure systems, like a road, a bridge or a pipeline. Where appropriate, qualifiers are added, for example 'digital asset', to identify other types of entities that have a recognisable value.

BUILT ENVIRONMENT

All forms of buildings (residential, industrial, commercial, hospitals, schools), all economic infrastructure (above and below ground) and the urban space and landscape between and around buildings and infrastructure[3], as well as the services and activities provided through these spaces and assets.

CARBON SINK

A carbon sink is a natural or artificial reservoir that captures and stores morecarbon than it releases. Examples include forests, oceans, soil and potentially timber buildings. We need these reservoirs to capture existing atmospheric carbon at the same time as we need to reduce our carbon emissions to turn off the tap and stop pouring in more carbon.

CYBER-PHYSICAL SYSTEMS

Systems that include integrations of computation, networking, and physical processes with feedback loops where physical processes affect computations and vice versa[4]. An example of a Cyber-Physical System is a Digital Twin, where a building has a virtual model that is populated by sensor data from that building, and uses computation to alter the state of the building – like opening the windows or turning down the temperature.

DATA

Data is a very complex term to define because it does not exist independently of the ideas, instruments, practices, context and knowledge used to generate, process and analyse it[5]. However, many accept that data is the elements extracted through observation, computations, experiments and record keeping[6]. They include network, asset, weather and organisational data[7]. This book will refer to personal data when it means data about an individual, but otherwise personal data is excluded from our usage.

ECOCIDE

In environmental justice, ecocide is the criminalised activity of substantially harming or destroying ecosystems in their entirety or by harming individual species. At time of writing, 10 countries have criminalised ecocide, but the effectiveness of these laws depends on the ability and willingness to enforce them.

INFRASTRUCTURE

This book uses the word infrastructure to describe the structures that underpin, organise and enable social functions. Individual units of infrastructure are known as assets. It is sometimes subcategorised into economic infrastructure, the networks of built assets that enable the creation of value like energy, ICT and water, and social infrastructure, the assets that enable social services and connections, such as transport networks, hospitals and schools.

INTERNET OF THINGS (IOT)

This phrase refers to networked infrastructures that interconnect physical objects and allow for the management of the data they generate[8]. A common example of IoT is a home energy monitor connected to an app on your phone, or a voice activated system in your house that allows you to play music or dim the lights just by speaking a command.

INTEROPERABILITY

The ability for a system or a product/service to work with other systems or products/services without the special effort of the user[9].

FLOURISHING

In the context of infrastructure systems for human flourishing, this has been defined as 'the ultimate good that people aim for, both as individuals and as society', relying on 'external conditions that are beyond the control of individuals but are related to the choices we make.'[10] This can include material or psychological benefits to human societies, sustainability and connectedness.

SUSTAINABILITY

This book tends towards the definition of sustainability given by the British Standards Institution (BSI), the UK's official body for the production of technical standards, the 'state of the global system, including environmental, social and economic aspects, in which the needs of the present are met without compromising the ability of future generations to meet their own needs'[11]. According to this definition, sustainability has three dimensions: environmental, social and economic.

RESPONSIBLE ARTIFICIAL INTELLIGENCE (AI)

AI systems that are sensitive to human values and considering accountability, responsibility and transparency as part of their design[12].

UNCERTAINTY, AXES OF

Axes of Uncertainty are tools for scenario development that help us avoid over – or under – estimating the degree of change, exploring a wide spectrum of outcomes and confronting the uncertainty about which one will come to pass[13].

VALUE

Value is derived from a set of desired outcomes (financial, social, environmental, etc.) that can be implicitly or explicitly understood. It is a complex topic that is best defined in relation to specific frameworks, contexts and stakeholders.

UNPRECEDENTED TIMES

The Boy Who Cried Wolf is an old tale cautioning children about the danger of lying about important things, but it can also tell us something about human responses to repeated warnings. Tell the villagers over and over again about a wolf attack that never comes, and they start to become complacent. They will not listen or prepare the necessary defences for when there is inevitably an attack. Preparedness for disasters and events that are uncommon will naturally lose prioritisation over more commonplace problems.

Take, for example, the state of California, which, prior to the Coronavirus pandemic had amassed a huge stockpile of general emergency equipment, mobile medical equipment and 'health surge capacity' against fires, earthquakes, mass illness and other worst-case scenarios. However, as potential pandemics – avian flu, SARS, Ebola, MERS – came and went with the people of California largely unscathed, this stockpile was dismantled to save the state money[1], and the capacity to deal with worst-case scenarios diminished. Once COVID-19 took hold, a study estimates that the shortfall cost the state $93 million USD and potentially dozens of lives[2].

The arrival of 2020 has brought with it some of the most turbulent global events experienced in generations. Global pandemics, political unrest and environmental disasters have all combined to make 2020, for the majority, the very definition of 'unprecedented times' as multiple problems converge[3] into complex and urgent crises.

In Britain alone, at the time of publication, the measurable effects of the COVID-19 pandemic have yet to be determined. However, early predictions are that the impact on the economy, society and the built environment will be sizeable and most likely long-tailed. In parallel, the planet has reached a tipping point with the global climate crisis, experiencing several significant events within 2020 alone that present deep and urgent concern – notably reports that the Arctic is undergoing 'an abrupt climate change event'[4]. Scientists are now extremely concerned that, in the absence of significant cuts in emissions, the global climate will rapidly become unstable and present a situation that we, as humans, have limited capacity to ameliorate or adapt to.

Where the negative events that have blighted us thus far in 2020 are classed as 'unprecedented', it is worth remembering that unprecedented need not only have negative connotations. The UK is also in an unprecedented time for making positive, and remarkable improvements. What if COVID-19 is not our worst-case, but rather a potent lesson on how to prepare for the complex crises of the future[5]? We have an opportunity to build back better – to learn from the past and present in order to be able to shape a future that can allow us all to flourish.

> These are unprecedented times and we have a window of opportunity to make the most of them.

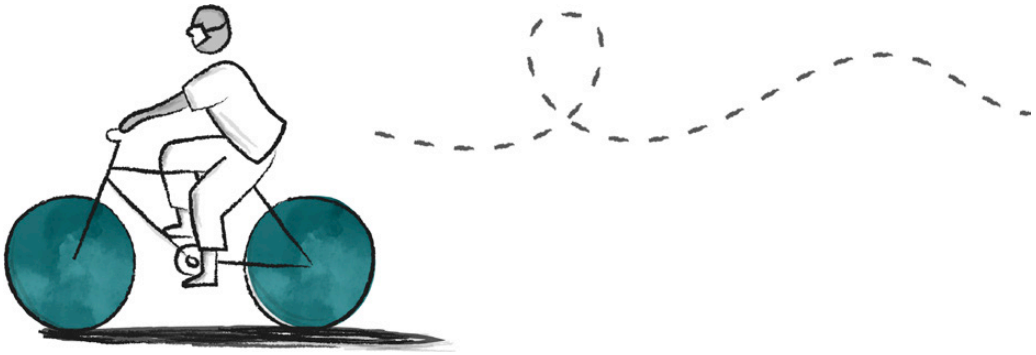
The next 20, 10, and even two years will be filled with decisions that determine our ability to adequately address these crises. Agreed in 2015 to address interconnected problems of poverty and environmental destruction, the UN's Sustainable Development Goals (SDGs) are for the most part set to be achieved by 2030[6]. The UK government has committed to net zero carbon emissions by the year 2050[7]. In 2018, the Intergovernmental Panel on Climate Change (IPCC) released a report warning of the urgency of the next 12 years in keeping global heating under +1.5°C above pre-industrial levels[8], setting a ticking clock on dramatic restructuring of global economies and consumption patterns.

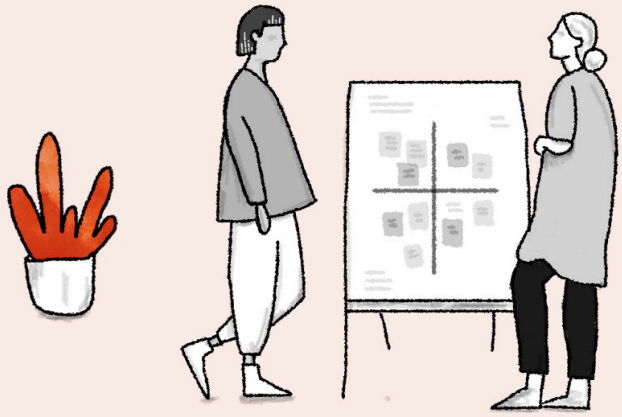
In our collective economic and social recovery from the pandemic, we can look for opportunities to make better decisions in support of these urgent targets for society and the planet. At the beginning of this critical decade, future studies and scenario planning give us a lens to view, with clarity and detail, what Britain might look like in 2040, depending upon the decisions that are made now in these unprecedented times of opportunity. While the outcomes of decisions are not guaranteed, exploring future scenarios may help identify the direction we would prefer to take and ultimately which actions we should take.

The SDGs take into account that the world is so full of complex and interconnected systems and that it is impossible for a single person, or even an entire academic discipline, to understand all of the causes and effects in play. In the same vein it's no longer sufficient to merely decipher the real wolves from the false alarms. The 'wolves' themselves come in many different forms and in addition people may misread the warnings or misunderstand where the biggest threats lay. What if the wolves attack the village and what if they don't? What if our stockpile of food runs out when the wolves are here, and we can't go out to collect more? What if the wolf population moves on and our crops are eaten by the rapidly multiplying rabbits they used to eat? If nations and supply chains have broad resilience to potential future scenarios, reliance on warning systems and their validity would be less vital[9].

Data, and especially predictive modelling of data, presents an opportunity to predict future events and build resilience for our built environment by analysing the past and present, but decision makers must understand the limits of this approach. The Boy Who Cried Wolf is also a tale about human behaviour in response to incomplete information: people look for patterns in the past and assume they know what is coming next. This kind of thinking diminishes uncertainty and ambiguity, certainly, but is it realistic to think this way? This fails to identify the need to prepare for unprecedented events.

This book will help you picture different future scenarios that are plausible and consider how to move the country, your sector, or your organisation toward a more just, sustainable and resilient future. By imagining what the built environment of the UK will look like in 20 years' time, collectively we have a chance to make better decisions about how to shape it.





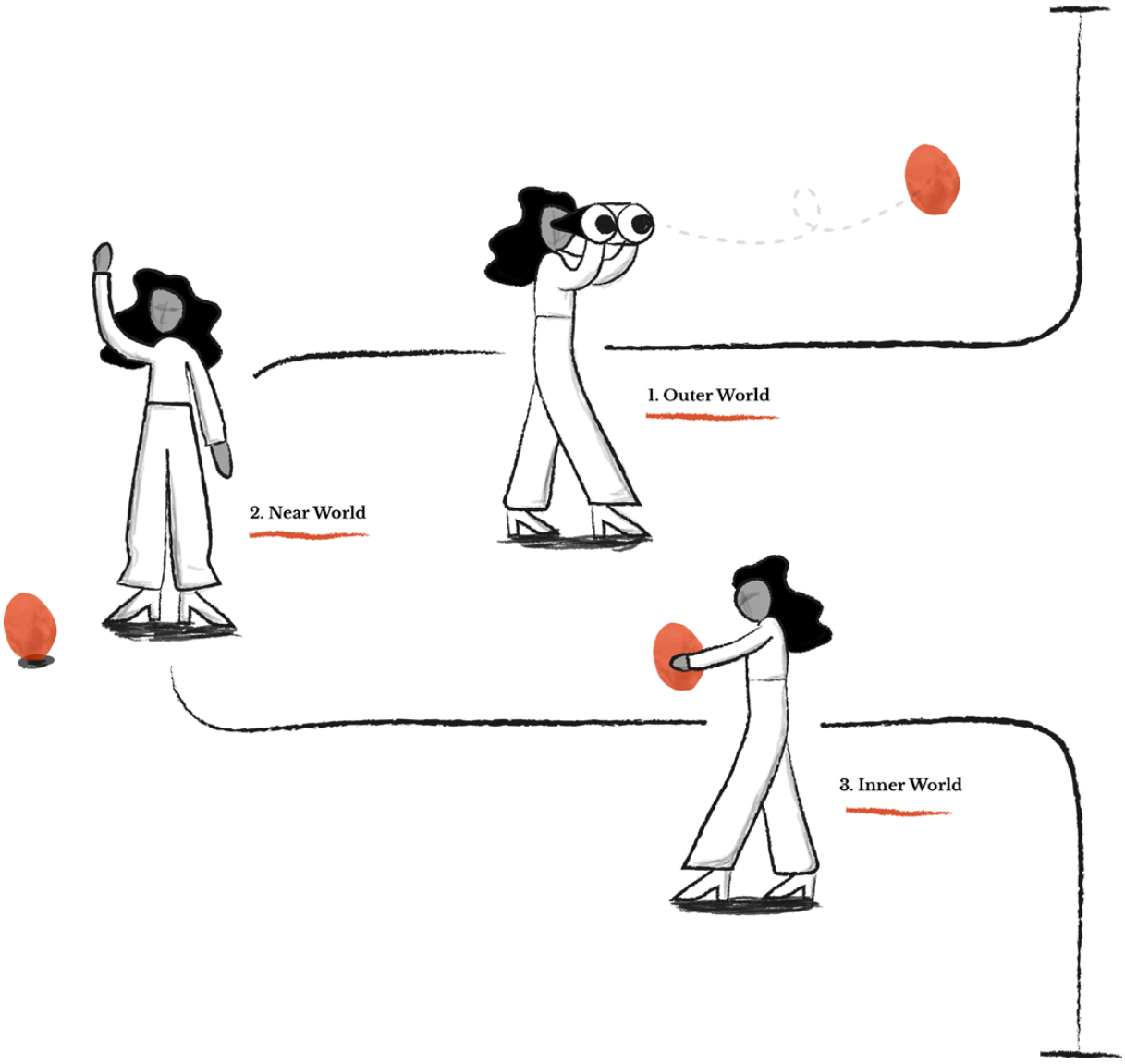
02

Meeting of Minds

THREE WORLDS FRAMEWORK

Now more than ever, the world we live in is a complex place. Digital technology has enabled global connections between people and businesses, adding to the interdependence of ecosystems, climate and the natural world. As individuals, the decisions we make can feel like a drop in the ocean, lost to the vast, interconnected systems in which we operate.

The 'Three Worlds Framework'[1] helps us understand how to make decisions about the future in our complex world. The framework highlights the three worlds in which we as individuals or organisations can have an effect or are affected by – the Inner World, Near World and Outer World.



When developing a strategy for the future, it seems natural for many organisations and the decision makers within them, to adopt an inside-to-outside (Near World to Outer World) perspective as we inherently assume that it is better to think first about that which we will have greater control over – our Near World – in order to influence that which we have less control over – the Outer World. A similar pitfall is believing that the past is a useful barometer for the future.

In reality, the opposite is true. Future events unfold in response to the ever-changing context of the wider world. An organisation can create a seemingly watertight strategy for future growth based on how they have succeeded in the past, but if, for example, a global pandemic suddenly emerges onto the scene, or a vital resource runs out unexpectedly, then that strategy will almost certainly become irrelevant. This is why forewarning from exploring potential scenarios in the wider world can help forearm decision makers against what may arise in the future.

As you read through the scenarios in this book, consider how you might work towards your best-case scenario while preparing for the worst, but also consider what future you want to live in. Consider the Outer World whilst you think about how the types of decisions you can make today might impact your Near World – your family, friends, business partners, supply chains, clients. It may be a drop in the ocean, but that drop could ripple out to change the course of history.

WHAT ARE SCENARIOS?

Scenario planning is a well-established method in the future studies discipline[2]. It explores tools for managing future uncertainty[3], providing an internally consistent view of what the future might turn out to be: a set of possible future outcomes[4]. Rather than relying on a single forecast or prediction that might provide a false sense of certainty, scenarios demonstrate 'how—and why—things could quite quickly become much better or worse'[5] and therefore expand our understanding about the range of plausible future outcomes[6].

Leaders can use scenarios to make decisions based on very different potential worlds. For example, Royal Dutch Shell has famously used scenarios to develop a business plan that will be agile in the face of different futures for oil and gas availability and energy markets[7]. In this case, considering a range of possible scenarios enabled decision-makers to develop an adaptable strategy and be better prepared for unexpected changes, such as the oil shock when oil-producing countries imposed an embargo in October 1973.

Scenarios can also be a powerful tool for creating a common vision of the desired future state. Leaders often leverage a positive vision of the future to spur action, whether it's because:

- the alternative is unthinkable, such as when Winston Churchill said: 'Victory at all costs, victory in spite of all terror, victory however long and hard the road may be'; and

- or the goal so audacious, such as when John F. Kennedy said: 'We choose to go to the Moon in this decade... not because [it] is easy but because [it is] hard'.

Looking at the Outer World scenarios we have provided in this book as our Four Futures, which do you want to live in? Which do you want your kids to grow up in?

Do these scenarios make you want to act differently in any way?

WHAT AREN'T SCENARIOS?

Scenarios are **not** a prediction, forecast or a crystal ball. The Britain of 2040 may end up not bearing a resemblance to any of the visions we present, this is largely due to the fact that despite knowing that the climate is changing, we can't be sure how long it will continue to do so at its present speed. Equally, we know demographics of the population are shifting, but we don't know what trends will continue, especially in light of global pandemics that seem to affect certain demographics with differing levels of mortality. Scenarios are not a guaranteed outcome, they're a tool for imagining what could be so we can make decisions based on those plausible circumstances and be prepared for the unexpected. We can't predict the unpredictable, but we can imagine what the future might be like based on what we know.

Scenarios are also not a menu of operational options created from an inside-out perspective as opposed to the Three Worlds Framework that we have described at the beginning of this section. They are not the strategies, but they can provide insights upon which we can build more effective and resilient strategies. The scenarios are not static, the trends change constantly so the scenarios should be reconsidered and updated at different periods of time.

OUR AIMS

The overarching goal of this study was to provide answers to a focal question:

What might the built environment in Britain look like in 2040?

In considering what Britain[8] will look like in 20 years' time, it is important to note that 2040 sits 10 years after the deadline to achieve the Sustainable Development Goals (SDGs), 10 years before the net zero carbon target set for the UK in 2019[9], and within the timeframe in which 70% of UK population growth is projected to be among people over 60. This makes it a compelling time period to consider, as well as being an acceptable timescale for scenario planning where the future is not too close to be considered a continuation of today's events, hence predictions; or too far to be considered plausible, hence becoming a science fiction.

Beyond answering the focal question, this book also aims to:

- Build consensus on a desired outcome of a digital built Britain in which the SDGs are met using digital technology; open, interoperable and secure data; and aligned policy solutions;
- Advocate for decisions that will create a resilient and sustainable digital built environment; and
- Guide practitioners in industry towards a COVID-19 recovery centred in a green information economy.

OUR RESEARCH STORY

On a chilly February morning in 2020, a group of 12 interdisciplinary researchers from the University of Cambridge[10] and four members of staff from the Centre for Digital Built Britain (CDBB)[11] gathered with their two expert facilitators for a workshop at the Howard Building at Downing College, Cambridge. Near strangers from different departments of the University, all studying different topics and with different preconceived notions, we mingled quietly over tea and coffee before adjourning to the Assembly Room, where we were to begin our explorative journey together. As we took our seats the sky outside the tall windows was dark grey and ominous, yet the enthusiasm in the room was as energising and bright as the yellow painted walls around us.

The two-day workshop gave us sufficient time to build a common understanding about the scenario planning methodology and to accommodate all the activities. The scenario planning activity used the Track, Analyse, Imagine, Decide, Act (TAIDA) framework[12], described below[13].

WORKSHOP DAY 1: TRACK AND ANALYSE

We began by learning about future studies as a methodology from our experienced facilitator, who talked about how scenario planning has been used in research and business contexts, and the essential components that we were about to experience first-hand.

This was followed by discussing the Focal Question[14]:

> What might the built environment in Britain look like in 2040?

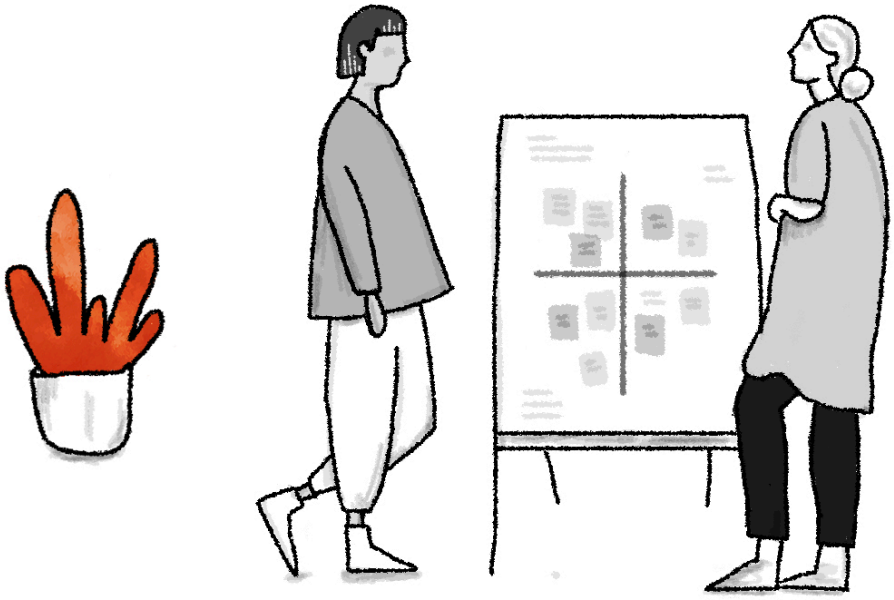
As it turned out, our disciplinary differences led us into a spirited debate about whether 'cities' or 'built environment' was the more inclusive term. We agreed that either way, we were discussing the buildings, infrastructure, services, social activities and resources that make up life in Britain and weaves together cities, towns, utilities, transportation, schools, housing, food production and many other threads into a complex, interconnected tapestry – the system of systems on which everyone in the UK relies.

Following this activity, we identified influencing factors in a trend spotting activity, using paper templates[15] to jot down our ideas about technology, social movements, demographics and other trends[16]. We initially discussed our influencing factors within small groups and then converged the groups' feedback, resulting in a list of influencing factors. We prioritised these according to their relevance and impact on the built environment, strategically choosing factors to include in our scenario discussions.

WORKSHOP DAY 2: IMAGINE AND DECIDE

The second day began in a similar fashion to the first, though conversation over tea and coffee flowed a little easier with a day of initial introductions and collaborative exercises behind us. Back in the grand Assembly Room, we listened to a short series of lectures on scenario building with axes of uncertainty[17], example scenarios, and storytelling.

We then gathered in small groups around flip charts and, using the influencing factors, wrote down the themes of what we had used and discussed the day before, and looked at how they may be used to create axes of uncertainty. The scenario axes technique is one of the most common and useful techniques to align divergent views on how the future may unfold. This technique enables exploration of the unknowns in a structured and coherent way[18]. We would pick two factors at a time, place each on an axis, and consider the implications of those factors in the year 2040 to see if any combinations were worth exploring in more depth. Each small group then presented its preferences to the wider group and we all discussed each of them in depth, with input from everyone asking for more detail or questioning each other's assumptions around aspect such as the role of the night-time economy or immigration rates, ICT connectivity or remote working etc. By the end of this process, 48 different scenarios were constructed from 12 axes of uncertainty.



At the end of the exercise, we walked around the room with coloured dot stickers and placed them on our preferred axes. Through this process, and with objective of the research clear in our minds, we collectively agreed on a final set of two axes:

- Whether by 2040 we will be on target with the Sustainable Development Goals (SDGs), and

- Whether the demographic dynamics of the UK population will be weighted toward the working age population or older adults by the same time.

Using these two axes of uncertainty we were able to construct our four scenarios, our Four Futures. Then we discussed the outcome of each factor in each scenario in groups (see Appendix 2). Our final activity was to describe the scenarios in narrative form, telling each other stories to help envision and illustrate the futures we had imagined together.

WHY THESE UNCERTAINTIES?

We wanted to create future scenarios that include everyone, are interesting to a wide range of stakeholders and relevant to any age group. Our target audience was us: our friends, family, colleagues, people that we love and respect, but also people who plan policies, build infrastructure, develop algorithms and shape the future.

Our shared interest in the climate crisis provided one of the primary uncertainties that will develop over the next 20 years and a focus throughout the workshop. However, environmental sustainability is interconnected with so many other factors, and we needed a metric for understanding sustainability, so we chose the **SDGs** as the first of our uncertainties.

The SDGs[19] comprise 17 goals for the year 2030 selected to transform the world to a more just and sustainable way of life for all. They envision a world where the built environment is a platform for the flourishing of society and the natural world. For the purpose of this book, our focus is Britain's future, but the SDGs are global, and they are interdependent with each other, meaning that all of the goals would need to be achieved everywhere to secure a sustainable future. Failure or success in reaching these goals would create very different worlds, and either of these outcomes is plausible.

THE UNITED NATIONS 17 SUSTAINABLE DEVELOPMENT GOALS

We were also interested in the demographic trends that would shape the future of the workforce and have a direct effect on the planning and implementation of the built environment. Specifically, the **dependency ratio** is a key uncertainty, because this would impact requirements from the built environment in terms of who we build for and how we build, how services should be delivered and how the workforce and work patterns could be organised. The dependency ratio is a measure of the number of dependents aged between zero to 15 and those over 67, who depend on the working-age population aged 16 to 67[20]. It highlights the relative economic burden of the workforce and has ramifications for taxation, welfare support and public spending[21]. Similar to the SDGs, the dependency ratio would contribute to a range of plausible outcomes for the use of digital technology in the built environment.

We considered age demography to be an uncertainty because, prior to COVID-19, it was perceived wisdom that the UK would experience an ageing population, with more than 70% of population growth between 2014 and 2039 projected to be among those above 60 years of age[22]. Various factors could change the dependency ratio, however, from public health crises that disproportionately affect older adults, to global migration patterns and refugee resettlement causing an influx of working age adults. We chose to explore how this ratio interacted with the success or failure of the SDGs by creating an axis of uncertainty, assuming the extreme end of each spectrum using the following metrics:

- **Success in achieving the SDGs:** Here success is defined as implementing the SDGs to at least 80% of set targets, while limiting global heating to no more than 1.5˚C above pre-industrial levels;

- **Failure in achieving the SDGs:** Failure is then defined as implementing the SDGs only up to 20% of set targets, while global heating is set to exceed 1.5˚C above pre-industrial levels;

- **High dependency ratio:** The number of dependents (ages 0-15 and 68 plus) is greater than the number of people in the workforce (ages 16-67); and

- **Low dependency ratio:** The number of dependents (ages 0-15 and 68 plus) is less than the number of people in the workforce (ages 16-67).

These created four very different scenarios for us to explore.

AFTER THE WORKSHOP: RE-ITERATE AND ACT

The narratives we developed on Day 2 of the workshop became the basis for our next goal, writing an academic journal article on the topic. We planned to meet regularly to discuss the paper and assign work, using the CDBB office as a central meeting point.

However, shortly after we held our workshop, it became clear that our plans were about to change significantly. Everyone was glued to the news about COVID-19, and it rapidly changed from being a far-off problem to something that everyone was talking about. In early March 2020 we met remotely, with two of us in the CDBB offices, and everyone else dialling in from around Cambridge and beyond. It was our first taster of the world to come. In some of our scenarios in the workshop, we had predicted greater use of remote working in 20 years' time. We had imagined it as a gradual process. Yet here we were, less than a month later, struggling to save our project over bad connections and microphones dropping in and out, while people in Spain and Italy were being forced to stay at home to save their medical services from collapse.

We discussed our options. Should we scrap the project in light of the lockdown that seemed increasingly likely? Would focusing on age demographics perhaps be too sensitive, given that the virus at that point seemed to impact older adults almost exclusively? We paused to think about it, but ultimately agreed that our work was more important and relevant than ever.

> Understanding and planning in the face of uncertainty was at the front of everyone's minds, as suddenly the only certainty was that the world was going to be very different. We did not know how, but we knew that there would be important decisions to make through lockdown and beyond that would shape the future of this country.

In the subsequent weeks, as Britain entered a lockdown and the co-authors of this work retreated to our respective homes, we quickly became accustomed to remote collaboration – analysing the evidence from the workshop[23], co-editing a shared Word document and discussing the draft via email and virtual meetings. First, we revisited the factors that we had discussed in the workshop. We knew we needed to place greater emphasis on the impact of COVID-19 and the predicted economic crisis on the course of the future. Each of us took responsibility for one or two factors and wrote about it, eventually resulting in more than 50 pages on the different factors, why they are important, and descriptions of how each impacts the four scenarios. These were gradually edited down to the more concise and coherent narratives you can read in the following section.

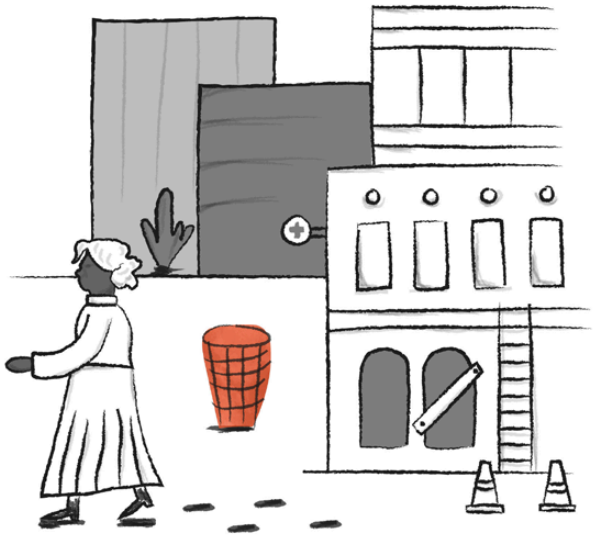
We also realised that it was not enough to simply outline the future scenarios. At this crucial point in time, when so much is at stake for the built environment, the economy, the climate and the people of the UK, we felt it was our responsibility to proffer guidance and suggestions the built environment sectors and policy makers might use to get to a future where digital technology supports and enhances sustainability and equality.

This was our opportunity to act and communicate our timely insights to the built environment sectors, decisions makers, academics – and to you.

High Dependency Ratio

SCENARIO C

Resigned To Our Fate



SCENARIO A

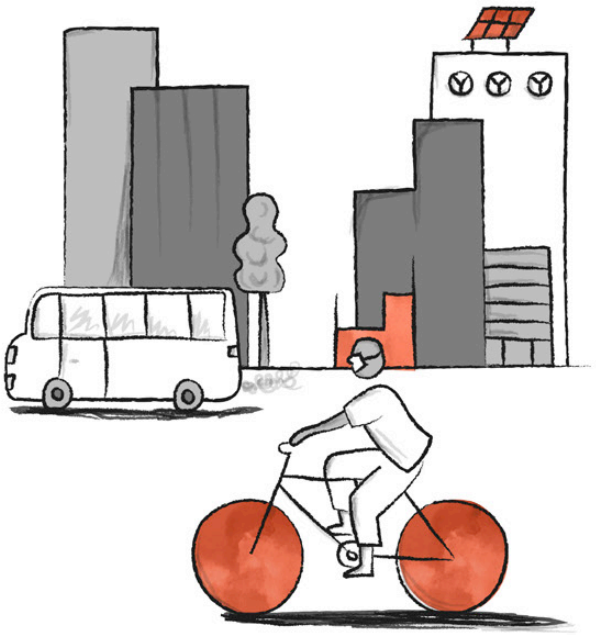
A Legacy Of Hope

Sustainable Development Goals Failed

Sustainable Development Goals Succeeded

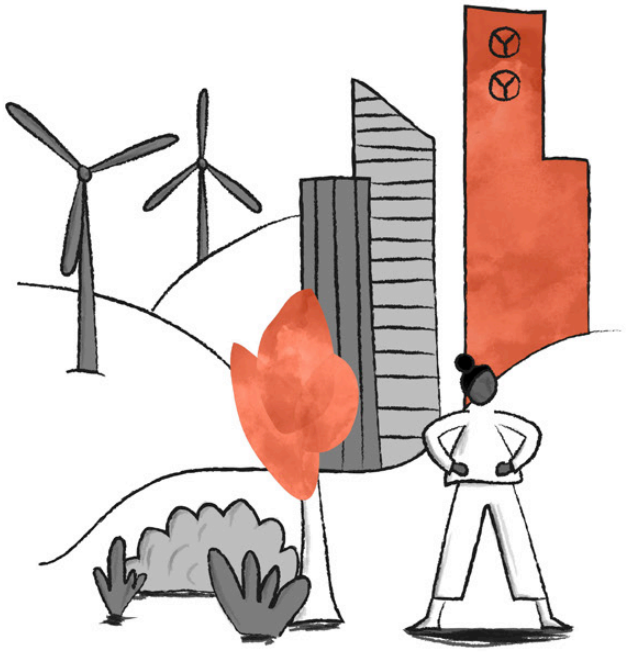
SCENARIO D

Too Little Too Late



SCENARIO B

Generation Zero



Low Dependency Ratio

OUR SCENARIOS

To make the scenarios memorable as our Four Futures, we gave each one a descriptive title, a narrative, and hero characters. These are summarised below and described in depth in the Four Futures section.

SCENARIO A – A LEGACY OF HOPE

Scenario A represents the world of 2040 where the SDGs are on target, the global temperature has stabilised just below 1.5°C warmer than pre-industrial levels, and an ageing population has led to a high dependency ratio.

SCENARIO B – GENERATION ZERO

Scenario B represents the world of 2040 where the SDGs are on target, the global temperature has stabilised just below 1.5°C warmer than pre-industrial levels, and the population is younger with low dependency ratio.

SCENARIO C – RESIGNED TO OUR FATE

Scenario C represents the world of 2040 where the SDGs are not on target and far from achieving their targets, global heating is accelerating, and the population is ageing with high dependency ratio.

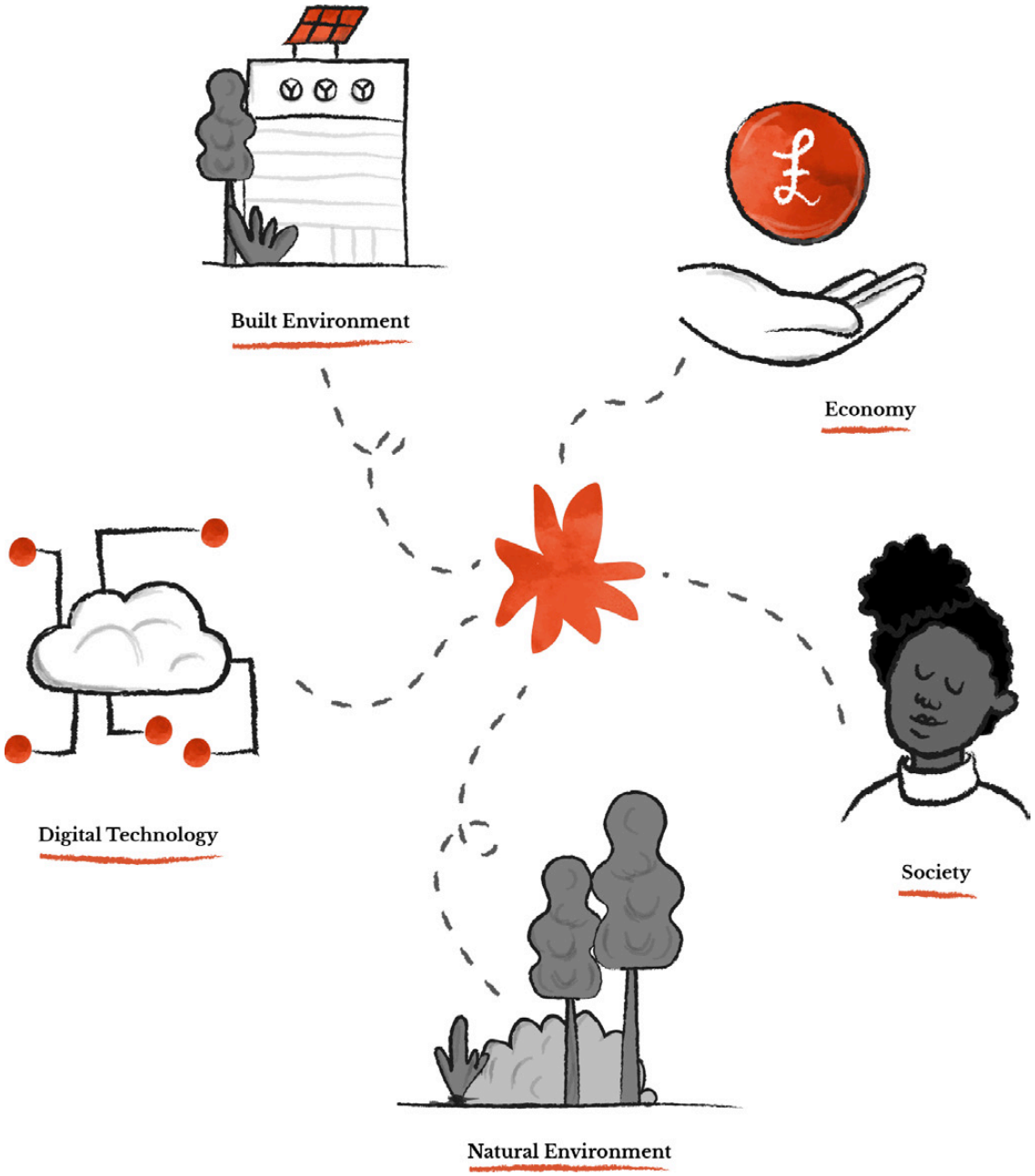
SCENARIO D – TOO LITTLE, TOO LATE

Scenario D represents the world of 2040 where the SDGs are not on target and far from achieving their targets, global heating is accelerating, and the population is younger with a low dependency ratio.

As we explored the influencing factors and trends[24] that might be at play across these four futures, we made the assumption that digital innovation would continue no matter what, but that it would be deployed based on the priorities of society – or the market – depending on the context of the wider world, making these scenarios a useful tool for exploring what will drive innovation in the near future[25]. Where there are urgent social needs – runaway climate change, a shrinking economy, public health needs, social unrest – digital solutions will spring up to support them. **If we meet these challenges, we have more opportunities for digital innovation to enhance services and infrastructure performance instead of just reacting to crises.**

DIMENSIONS

Of course, the influences on the wider world are more complex than these two uncertainties alone. For that reason, we considered how a range of other dimensions of the built environment, natural environment and society might look. These dimensions functioned as the central themes we used as we explored each of the scenarios. Each of these dimensions had multiple influencing factors, and the relationship between these is explored in Appendix 2.



BUILT ENVIRONMENT

In the Four Futures, we thought about how the built environment might look to an observer. What would be the same and what would be different about it? What would it be like to live in a city? How would people organise themselves within the built environment?

There are tremendous opportunities across the built environment sectors to transform the future of the planet. Decarbonising these sectors would eliminate 40% of the UK's carbon emissions[26]. There are also tremendous risks in getting it wrong. We considered various types of infrastructure[27] including housing, transportation, utilities (water, waste, telecommunications) and health care facilities, as well as the sectors that design, build and operate these structures. Infrastructure that performs well is vital to the health, prosperity and wellbeing of a society[28], and built environments can shape cultural identities and opportunities.

DIGITAL TECHNOLOGY

We were particularly interested in how digital technology would shape life for people in the UK[29]. We considered how pervasive technology would be, how open and secure data would be, the strength of data protection for individuals and how engaged with digital technology the majority of citizens would be. We also explored how advanced digital technology in the built environment might be, from wearable health sensors, to driverless cars[30], to digital construction, to smart cities[31]. This turned out to be a key variable between the scenarios as we considered increasing digitalisation to be inevitable, but the nature of its development depended on the economic situation and the pressures facing society.

ECONOMY

The shape of the economy in the future is an uncertainty weighing on many minds during the COVID-19 pandemic, and it would be incredibly difficult to predict the state of the recovery next year, let alone 20 years in the future. We considered different approaches to recovery: austerity versus investment, an emphasis on job creation and deregulation post-Brexit to draw businesses to the UK. Each of these approaches was considered in the wider context[32] of the scenarios.

NATURAL ENVIRONMENT

In two of our scenarios, the SDGs have been met, which means that runaway climate change is more likely to have stopped. However, even the best-case scenarios science can provide still feature difficult times ahead in terms of resource scarcity, global heating, biodiversity and other global issues. In the scenarios in which the SDGs have not been met, we based our scenarios on the predictions of the IPCC and the scientific community for 2°C. We considered how resource pressures (air[33],water[34], food and soil[35], energy [36], minerals and materials [37], temperature, extreme weather and other factors[38] might impact people in the UK, especially vulnerable populations, and discussed how digital technology was being deployed to help. We also considered the ecosystem services – the intangible benefits – that the natural world provides, and how those might impact social wellbeing.

SOCIETY

While society is impacted by all of these other dimensions, the way that people vote[39], interact, work, play and the makeup of society all impact how we will organise the built environment, digital technology and the economy. In this area, therefore, we considered governance[40], work patterns, where people live and how they travel, and demographics. This helped us imagine what life might be like for someone living in Britain in the year 2040 in the four different scenarios.

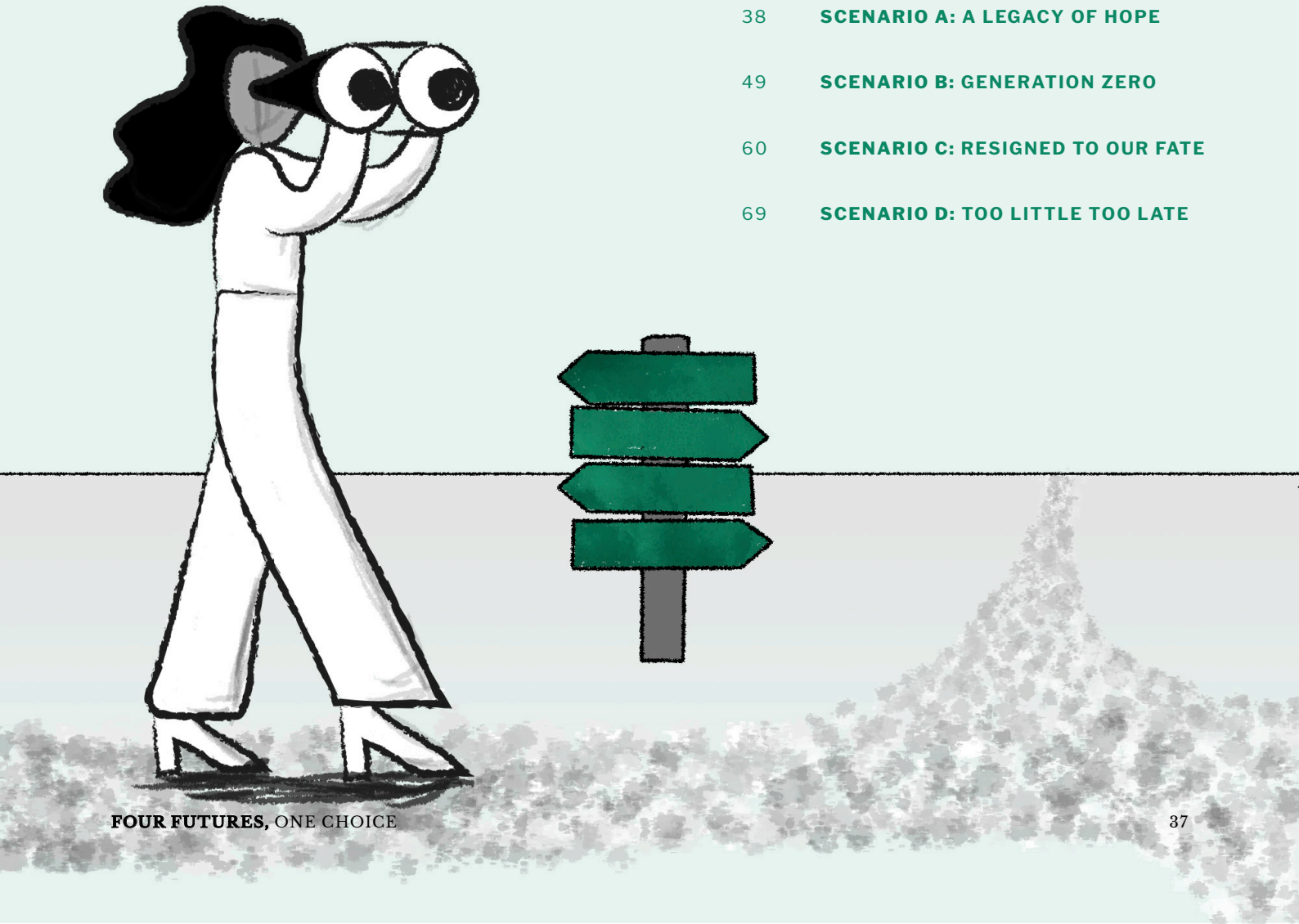
FACTORS

We created the four future scenarios by considering more than 30 different influencing factors that shape these dimensions. More detail about these factors, their relationship with different dimensions and different outcomes of the influencing factors can be found in Appendix 2.

Exploring the different outcomes of these dimensions and factors helped us build a picture of what the **four futures** might look like, which we could then craft into a narrative, and use to build consensus on a **desired outcome** and advocate for decisions that will create a resilient and sustainable digital built environment.

03

Four Futures



A LEGACY OF HOPE

SCENARIO A

SDGs achieved

Digital technology supporting a shrinking workforce

High dependency ratio

The UK, and much of the global community, has met most of the SDG targets and the global temperature has stabilised below 1.5°C warmer than pre-industrial levels. This has been achieved in the face of changing demographics; an ageing population has meant new challenges. Digital innovations have proven instrumental in supporting public healthcare, wellbeing, a shrinking workforce and rapidly decarbonising the UK while building better infrastructure that allows communities to flourish.

In the UK, birth rates have continued to slow over the decades – thanks to increased prosperity and access to education, family planning and medical care – while at the same time life expectancy has continued to rise as a result of better healthcare, cleaner air and decreasing inequality. Migration has also decreased following a global decline in unrest in the last 10 years. Climate refugees are still arriving in Europe and North America as the climate crisis continues, but better management of refugee resettlement processes, aided by international co-operation, means that the UK is just one of many destinations for people whose homes or livelihoods have disappeared due to natural disasters, sea level rise and climate change. As a result, the population of the UK is shifting towards a higher percentage of retirement-age adults than at any previous time.

While dangerous environmental tipping points have already been set in motion, swift and decisive actions taken by political leaders, activists, corporations and citizens in the 2020s to reduce greenhouse gas emissions were successful in keeping the average global temperature stable. While there are positive stories in environmental news these days, such as species returning from the brink of extinction and global tree cover growing every year, much has been irrevocably lost and global heating is still wreaking havoc on the climate[1]. The extremes of weather marking this period of global heating pose problems for vulnerable people, including older adults. However, the country is on track to reach its goal of Net Zero emissions, and in order to do so, has transformed its social, economic and environmental infrastructure. It is also on target with regards to the SDGs, and, as a result, some benefits to the environment and the public have already been realised.

The prevailing feeling among the older generation has been a desire to leave the world better for future generations and, while there have been challenges in achieving that, a unifying vision of a sustainable future has mobilised many changes in the built environment and wider society. These changes seemed to happen rapidly at first, as we became accustomed to flying less, telecommuting more and consuming more thoughtfully. Digital technology and data were instrumental in bringing about these changes, enabling us to maintain a high quality of life while consuming less. Throughout this process, the people and businesses of the UK have placed greater value on lower-carbon activities, such as creative pursuits, sharing and repairing economies, careers in caring and spending time in nature with the people we love. For now, we can feel proud that we have left natural resources in a slightly better state than we found them for future generations, as well as a blueprint for a more sustainable way of life.

BUILT ENVIRONMENT

Perhaps no sector rose to the occasion presented at the beginning of the 2020s as much as the tightly interlinked built environment sectors. Aware of their position as one of the largest contributors to carbon emissions and spurred on by new, more rigorous carbon taxing, industry leaders undertook a digital transformation to decarbonise, and to plan a more efficient built environment that coexists in a balance with people and nature. The sectors in post COVID-19 and post-Brexit Britain quickly set into motion mechanisms to evaluate and apply environmental strategies that were best suited for its independent vision. Chief among these, was a commitment to lower carbon materials[2].

Today, while retrofitting existing infrastructure is almost always favoured over new buildings, equal emphasis is put on using building materials like engineered timber, and all infrastructure projects are evaluated for their usefulness as carbon sinks[3] and material banks[4]. Mined materials, like iron ore for structural steel, are carefully monitored as they are manufactured, used and remanufactured, with greater transparency about supply chains ensuring that the UK is not simply exporting its environmental footprint onto other countries. Water is also carefully managed by decision makers who are supported by AI such as digital twins, as droughts have become a common feature of the global environmental crises[5].

Investment in public spaces and services has revitalised cities and towns across the UK, following changes to public procurement[6]. Although much of the infrastructure that existed at the beginning of the century is still here, its function has often changed: some multi-storey car parks have been repurposed as urban vertical farms, many lay-bys are now also electric vehicle charging points, city streets have been transformed into bike and pedestrian friendly community corridors, and motorway building has given way to improved long distance rail networks[7]. Office buildings that stood nearly empty 15 years ago have been transformed into affordable housing[8] and co-working hubs, where remote workers can hire desks – or whole offices – by the hour. Most urban roofs have the latest specially engineered urban wind turbines[9], solar panels or bee-friendly gardens[10], making the best possible use of urban space for generating energy, growing food, supporting wildlife or creating communities.

In the social housing sector, homes are designed to enable customisation and upgrades, with ICT-connected study and workspaces designed into units to facilitate remote working and learning, and modular construction enabling easy reconfiguration as households change. Near these new social housing areas are communal workspaces and large parks that encourage wildlife and recreation[11]. Large scale projects like transport hubs have also changed remarkably during the last 20 years, with more space given to pedestrians and bikes over cars, and indoor spaces that incorporate passive and active environmental strategies for optimum daylight, increased air flow and comprehensive monitoring for energy and occupancy all made seamless by the Internet of Things[12].

The most notable difference is how much greener cities look today. The value of public access to nature was made apparent during the 2020 pandemic, as those who had green spaces near them could benefit from regular outdoor exercise, while others were not so lucky. This corresponded with the health outcomes of those communities who lacked green spaces to exercise and congregate[13]. Local councils, led by the national government, prioritise and subsidise green spaces in new builds and redevelopments, as well as adopting measures to limit car traffic, especially in areas with schools, hospitals and shops.

Urban households are using public and shared transport more often, and most do not own a car[14]. The increased capabilities around data and resulting advancements in artificial intelligence solutions enable the wide adoption of autonomous vehicles. Autonomous car parks are generally underground and allow the much smaller fleet of autonomous and electric vehicles to be charged, cleaned, serviced and updated, leaving street-level real estate free for new parks, gardens and playgrounds. Many local councils are reporting an increasing sense of community now that their cities prioritise people over cars. Long-distance travel is mainly done on high speed trains, whereas the short distance mobility solutions are either autonomous vehicles in different forms such as buses, pods or e-scooters and e-bikes. Most of these solutions are designed and developed to serve the older population, include embedded health monitoring services, emergency support systems and have the ability to contact health professionals according to users' health and needs.

DIGITAL TECHNOLOGY

Lower demand for consumer products has not meant a decrease in the development of digital technology. In fact, technology has played a significant role in achieving the SDGs. Connected systems of systems are supporting the analysis and optimisation of assets in numerous areas. For instance, digital twins have massively contributed to monitoring and tracking the trade-offs between the built and natural environment, following energy and material use through a network of smart meters and automating processes across agriculture, manufacturing, infrastructure and supply chains to reduce their environmental footprints. The built environment is highly connected through digital technologies, data and information and suffused with sensors, actuators and human-computer interfaces.

At the same time, robotic workers are contributing to the ecosystem of connected systems[15]. The digital boom, and the accompanying volume and transparency of data, has been credited with helping to meet the SDGs despite the shrinking workforce. Connected digital twins and cyber-physical systems are autonomously analysing and optimising processes for greater sustainability. Humans use VR not only to remotely monitor and control assets but also to do dirty and dangerous tasks through the medium of industrial robots. All of these robot-human interactions are also informed by responsible AI. The underlying philosophy of this digital transformation, 'data for the public good'[16] and 'AI for good'[17], has been used in different ways, suited to the local context[18].

There is still plenty of work that requires human intervention, including collaborations between responsible AI and human stakeholders to make better decisions about, for instance, health care[19], land use management and operational performance. Review boards with diverse representatives ensure that decisions made by responsible AI do not unfairly disadvantage certain groups[20]. Digital access and tailored products and services – informed by big data and AI – are expanding the access to banking and financial services for all, including vulnerable populations. The 'Responsible AI' initiatives have pushed for the development of AI ethics, policy and law. Transparent data has been transformative in our ability as a country to support vulnerable and underrepresented groups[21]. More and more public services, such as transportation, healthcare and housing, use digital interfaces. Many in the older generations honed their digital skills around digital communication starting from the COVID-19 crisis, but there is still a small digital skills gap related to age, ability[22] and socio-economic background[23]. In 2028, the Government launched the 'Internet for All' campaign, getting ICT connectivity and training to every household in the UK, which has significantly narrowed both the digital exclusion and educational attainment gap between prosperous and deprived households and regions.

The bigger challenge to digital engagement has been ensuring data privacy, both through technology and through more robust governance. While the population in general has a high level of digital competency and literacy, many still mistrust private corporations and the Government with their personal data. This trust has had to be built by ensuring digital technology is ethical, responsible, safe, secure and resilient by design. After the pandemic in the 2020s we started to see increasing trust in experts and technology after a dramatic decline. Today, well-defined policies, rules and data-related laws are followed by technology companies throughout the whole life cycle of the data, from collection, sharing, integrating and storing, to analysing and implementation of responsible AI solutions. The underlying philosophy of this digital transformation, 'data for the public good'[24] has been used in different ways, matched to the local context, and has targeted investment in communities to bring maximum benefit for the lowest cost.

Amenities are close by to residential areas, centred on community hubs that have been developed based on crowdsourced data. That data has been provided by the communities themselves for the purpose of community-led design and the design ideas are suggested by human-AI collaborative work. As a result, people feel safer, walk more, and enjoy a greater sense of pride and belonging in their communities, and greater trust in AI to benefit their lives.

"I've been working in construction since 2024, and it's changed a lot over the course of my career. Now I'm using a digital twin to monitor the safety and productivity of my crew, and to get accurate measurements as we go. We're using modular timber frames that have been built offsite, saving time and materials, and saving the client money. The digital twin will be handed over to the building operator and they can see exactly how we built it and monitor the air quality, light and temperature, occupancy, recycling rates per office and all kinds of things. I like that I can go home at night and tell my kids that the building mummy is working on is trapping carbon in its walls and helping the climate recover."

Samira, Digital Construction Project Manager

ECONOMY

The GDP is in a long decline[25], and by traditional measures this would be an economic depression. However, today our economic models value the natural environment and human wellbeing alongside economic growth. The increasing dependency ratio means that human labour is more expensive compared to using automation, and many businesses have invested in automation to address the labour shortage, maintaining productivity with a smaller workforce who work alongside robotics, AI and other forms of automation[26]. As a safety net, the UK provides everyone a regular payment to meet basic needs such as healthcare, education, and housing. This has had the unexpected benefit of making the creative and caring sectors – teaching, medicine, elder care, mental health care, fine arts, urban design and so on – available and attractive for people who no longer need to worry about the low wages that historically went with such work. People are pursuing work that they are passionate about and that makes the UK a better place to live.

The COVID-19 lockdown proved that many people can work remotely and reduced the need for commuting to large, central offices. As a result, people have less need to live near their workplace and many businesses are opting for an office-less model. In this model, professionals work from home or at neighbourhood co-working hubs, further driving the decreasing reliance on individual car ownership[27].

Focusing on the SDGs, and a reduction in the extraction of raw materials due to a decline in private investment for new developments, governance measures have helped to control the supply of construction products. Another important factor that enables us to live in a more sustainable world is the mindset shift towards a more sustainable construction and building demand, which leads us to employ new ways of managing existing buildings and infrastructures. Digital technology in the built environment, then, is supported by new ways of doing business and new measures of value and success.

Today we do not only monitor our built environment for profit and economic gains but have more inclusive economic models that do not overlook the value of the natural environment. The smart built environment has been driven by a culture of openness as the economic downturn of the 2020s has stretched into a longer-term recession, meaning that smaller businesses and local authorities have been able to benefit from the expertise of their industry leaders. Data is no longer a commodity to be hoarded, but a resource to be shared.

NATURAL ENVIRONMENT

Natural resources are recovering from decades of depletion through a combination of policy, corporate responsibility and public buy-in. Air quality is steadily improving as we have adopted the dual strategy of reducing emissions and capturing the carbon already in the atmosphere. Widespread tree planting efforts have increased tree cover in the UK to double the amount in 2020, capturing and sequestering 37-50 million tonnes of carbon dioxide equivalent per year[28]. This has been one small part of a wider rewilding movement that has seen public and private landowners allowing natural ecosystems to manage themselves unimpeded, aided by the selective reintroduction of species of flora and fauna to areas from which they had previously disappeared. This has coincided with a strengthening of environmental protection legislation, meaning that polluting industries have had to either change their practices or lose their businesses.

Improvements in the management of fishing and water sources through strict legislation and publicly supported conservation efforts have seen the fish and aquatic flora populations off our coasts come back from the brink much more quickly than we could have predicted. Through better data, data sharing and science communication, we are learning which human activities have had the most detrimental effect on our most delicate ecosystems. We are now able to address these problems head-on to help nature recover. Ambitious targets set for major sectors and for the natural environment in the 2020s have shaped the balance between the built and natural environment as we know it today.

With fewer privately owned vehicles in general, but more electric vehicles, the energy grid has had to adapt to the large changes in transportation, work and living habits. The UK has abandoned coal and other fossil fuels for energy and now relies entirely on clean sources, such as solar, wind, tidal and the still-controversial nuclear option. Campaigns against nuclear power are still going on, but this year has seen the greatest share of UK energy coming from renewable sources yet. As a result, one of the largest sectors for jobs growth over the last 20 years has been the green energy sector[29]. Recently developed microgrids allow cities to create some of their own energy in their own way, making the entire UK grid more flexible and resilient. Of course, this has also been made possible through gains in energy efficiency of consumer products, buildings and infrastructure and processes. Decreasing demand at the same time as developing green energy sources has kept the UK on track for its zero-carbon emissions target for 2050[30].

SOCIETY

Recently there has been a challenge in funding the healthcare, housing and pensions of the growing population of older adults. Some viewed the climate change mitigation budget as a negotiable cost to help pay for this, but ultimately lost out to those who recognised the need address both simultaneously. As a result, nursing, care work and other careers that support vulnerable adults are now a more attractive profession since people going into these careers have their financial needs met and they are assisted by a range of new digital care devices. Smart homes and robots for healthcare and wellbeing support some of this population, empowering older adults to maintain independence and higher quality of life[31]. Internet of Things applications are also very common for outpatients during rehabilitation and they are used to provide constant monitoring of patients' progress and emergency healthcare[32]. Loneliness and neglect are still a problem for some older adults, but that is on the decline as the needs of this demographic are more visible, and the built environment is being configured for better mobility and sense of community for all.

In the face of growing evidence that migrants do not take jobs away from British nationals but rather create new markets[33], among a host of other benefits, Britain has become more open to immigration, both socially and legally. The 'hostile environment policy'[34] was officially ended in 2023, as the Ministry of Housing, Local Communities and Governance set up a challenge fund to promote the benefits of cultural diversity in cities across the UK. As climate refugees from countries impacted by drought, famine, sea level rise and conflicts over resources look for places to settle, the UK has been among the countries willing to open its doors, acknowledging its large role in global heating in the past and the resulting economic advantages from which it benefited. However, there has not been the influx of refugees and immigrants anticipated by the critics of this policy. Indeed, the rate of immigration has risen by less than one percent over the last ten years. The UK is just one of many countries around the world in which refugees can settle thanks to global coordination and collaboration on this issue, and international conservation efforts are working to protect the front lines of the climate crisis.

Taking the steps necessary to meet the SDGs required courage and conviction on the part of policymakers in the 2020s. A key piece of legislation was the adoption of the Wellbeing of Future Generations Act, pioneered in Wales (2015), across the rest of the UK. This provided a new lens through which to view all policy decisions: With an ageing population, what kind of future do we want to leave in legacy to our children and grandchildren? This mindset has shaped the policy landscape ever since, led by our Future Generations Commissioners for each country of the UK. This Act opened the door for other legislation[35], such as a Green New Deal, stronger environmental protection and ecocide laws, higher taxes for polluters[36] and supply chain transparency laws that have impacted the way we eat[37], the way we work[38], the way we build our communities[39], the way we travel[40] and our fundamental values as the word 'sustainability' has taken on a new resonance with the people of the UK.

"I was made redundant from my office administrator job in 2021 when the company was losing money from the pandemic. Luckily, I was able to pursue my passion and retrain as a care home attendant and eventually a registered nurse working with patients in their homes. My IT skills from my previous job came in handy as the Internet of Things (IoT) for home health care took off. Now I can look after more patients, even when I'm not in the room, through mobile apps and wearable sensors in their homes. I love that they're able to be safe and independent at home for longer now that we can use technology to support them remotely."

Patricia, Elder Care Specialist

HOW THE UK GOT HERE:

- [x] Future Generations Act UK passed.
- [x] Creation of green jobs and social support to help the economy recover from COVID-19.
- [x] Greater investment by NHS and the private sector in Internet of Things for home health care for older adults.
- [x] Greater investment in digital technology for monitoring the impact of climate change on the built environment.
- [x] World-leading ecocide law passed, which includes transparency of supply chains.
- [x] Development of meaningful sustainability standards for the built environment lifecycle, high industry compliance with new low carbon construction and procurement policies and standards.
- [x] New build projects are evaluated for their whole life carbon footprint as well as their efficacy as carbon sinks.
- [x] Increasing digitalisation of many professions to support a smaller workforce in maintaining productivity.
- [x] On track to reduce the UK's carbon emissions to Net Zero by 2050.

GENERATION ZERO

SCENARIO B

SDGs achieved

Digital technology making life easier

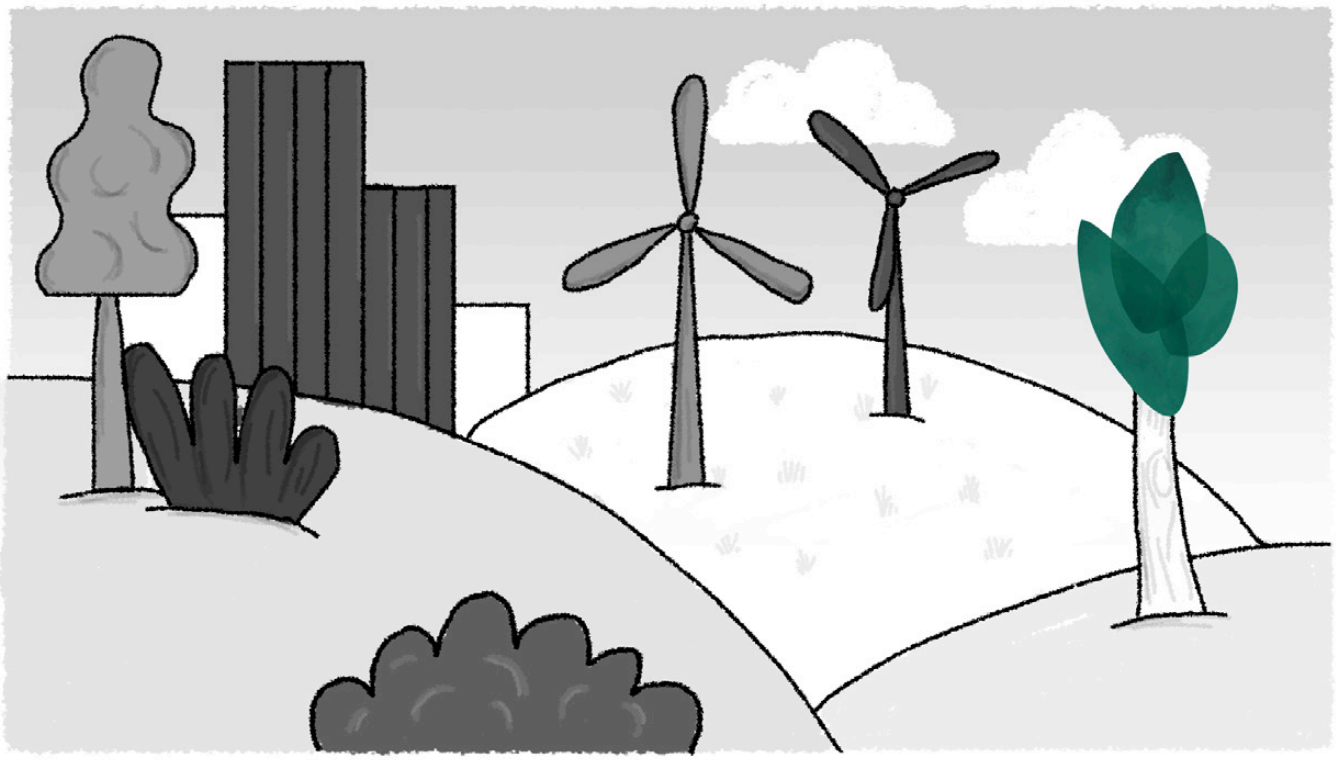
Low dependency ratio

Climate activist Greta Thunberg turns 37 this year. She is widely regarded as the representative of a generation that inherited a desperate situation and turned it around. Thunberg in Sweden, Varshini Prakash in the USA, Sohanur Rahman in Bangladesh, Leah Namugerwa and Vanessa Nakate in Uganda, Eyal Weintraub in Argentina, and millions of other young people around the globe brought attention to the climate crisis and pressured decision-makers to act in enough time to avoid the worst-case scenarios for climate change. As this generation entered adulthood, they led social and economic transformations that have resulted in the UK, and many other countries around the world, meeting the SDGs and global zero-carbon targets. Now known as Generation Zero, they have fuelled the energy and hope that has ushered in a green information economy.

Today's workforce is stable and this is not because of birth rates, but because the UK has opened its doors to immigrants and climate refugees, many of whom are of working age and have contributed their skills and effort to our green digital revolution. Without this influx, the UK working population would be entering a decline, but by introducing diverse skills and ideas from around the world, the built environment sectors have seen a significant and rapid transformation.

While many worried that automation would lead to unprecedented levels of unemployment, the built environment is both powered by a skilled workforce and supported by automation. More people than ever are now in employment, a change that happened rapidly in response to the Green New Deal and other post-recession measures. The challenges of sustainable digital transformation have drawn Generation Zero into careers in the built environment sectors. They are the products of an undergraduate curriculum focusing on digital literacy and sustainability across disciplines. The stable workforce has enabled an increase in green building and infrastructure projects, such as the change to resilient micro-grids running on 100% renewable sources. This generation is comfortable working alongside AI as partners in decision-making and, thanks to the undergraduate curriculum, continuing professional development and lifelong learning, is highly literate in using data securely for the public good.

Generation Zero have already seen their share of unprecedented events, from climate crises, the COVID-19 pandemic and the ensuing economic recession, to a vast reconfiguring of society and the economy around sustainability and social justice. This has made them more empathetic to others, and more resilient in the face of uncertainty. Rather than focusing on what has been lost to climate change, or what has been sacrificed from our former lives, Generation Zero reminds us that we must do what is necessary to ensure a better future for everyone.



BUILT ENVIRONMENT

Our cities have been reinvented, with timber structures[1] gradually overtaking concrete, glass and steel in new builds[2], and green pocket parks and forests, wildflowers, urban farms and rooftop gardens all around. Almost no one owns a personal car[3], and electrified public transport networks and car sharing serve the communities that need them the most. The housing crisis has been addressed by creative retrofitting of existing buildings to affordable, green, smart homes. A conscious move by the UK government and industry two decades ago towards explicitly procuring for environmental and social value was key in encouraging the use of digitally assisted construction using natural materials in infrastructure projects and ensuring the capture of excess carbon dioxide from the environment.

Today, Buildings as Material Banks (BAMB)[4] ensure that all building elements can be dismantled and recycled in a circular economy model, meaning that some new building projects will work out to be carbon negative over the whole life of their constituent materials. Novel methods and forms are being developed to ensure that new buildings are green, smart, resilient and beautiful to look at. Resource efficiency over the whole lifecycle of the built environment has been one of the most exciting and rewarding design challenges of the modern age. Younger generations have embraced this challenge wholeheartedly, pioneering new technologies and rediscovering historical practices that enable us to live within the planet's means.

Given the carbon footprint of materials and construction, the greenest building is the one that already exists. This means that refurbishing existing buildings and changing their use where needed is the first solution before creating buildings from scratch. Repurposing office buildings into affordable housing has been an effective response to the growing trend for working from home, and the need to provide affordable housing near to commercial districts. The vertical space of former multi-storey car parks makes for excellent urban farms, pop-up markets and food truck venues. Outside of cities, former brownfield sites have seen redevelopment into 'smart villages', connected hubs that help local communities plan their own resilience strategies[5] based on evidence and insights provided through their local planning portal.

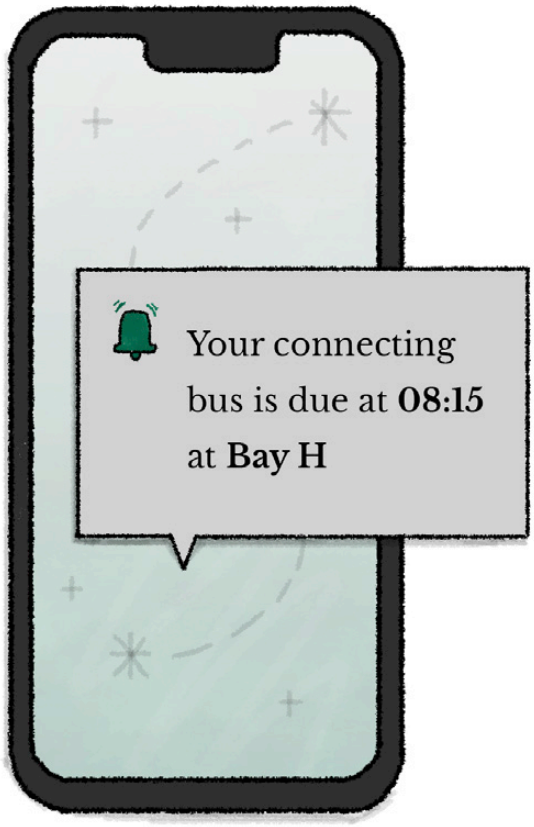
The increase of young adults within the urban population[6] has resulted in higher demand for open, green spaces and leisure amenities in city centres[7]. Cycling is common, with most commutes and short trips being made by bike thanks to safe and extensive cycle and pedestrian infrastructure. This has boosted businesses in city centres, helped combat loneliness, health problems and improve air quality.

Environmental improvements in city centres have encouraged developers to invest in these areas, which in turn have led to more young professionals eager to live in these sustainable cities[8]. The Internet of Things has transformed other modes of mobility in cities. Smart transport platforms predict our needs, tailored to our preferences, physical abilities and priorities, enabling us to shop, work and stream entertainment while we travel, with robust authentication protocols keeping those remote connections secure.

The grid has had to adapt to the large changes in transportation, work and living habits. The UK has abandoned coal and other fossil fuels for energy and now relies entirely on clean sources. Microgrids allow cities to create some of their own energy in their own way, making the entire UK grid more flexible and resilient. The energy sector has been a source of growing jobs throughout the transition to a green economy.

With pervasive IoT, work can happen seamlessly anywhere – including on smart public transport systems and in open spaces – with robust authentication protocols keeping remote connections secure. On integrated regional and national Mobility-as-a-Service platforms, we can plan and customise our journeys according to our preferences and abilities, and have those preferences automatically applied, even when travelling to a new city.

The passive infrastructures of yesterday are now constantly sharing relevant information, indicators, and news with passengers and service providers. For instance, autonomous vehicles and roads, trains and railways are sharing real-time information with each other and AI algorithms are proposing solutions, changes, schedules related to these conversations. These communications and suggestions are working seamlessly with human decision-makers as well as community input on larger or more permanent changes.



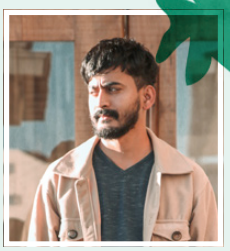
DIGITAL TECHNOLOGY

Pervasive use of secure, connected digital twins helps model infrastructure use and give early insights into potential issues with performance, health, accessibility, inclusiveness and environmental cost. Given the extensive use of IoT, AI and big data in infrastructure, the guiding principles of 'Data is the answer, but what was the question?'[9], 'data for the public good' and 'AI for good'[10] ensure strategic use of digital information for decision making. Digital technology and data massively supported the achievement of the SDGs and radically transformed every sector towards a zero-emissions, green information economy, with changes to the natural environment carefully monitored and the impact of human activities digitally modelled to help us make decisions that are better for people and the planet[11].

A huge proportion of new value created in the economy and society is now based on digitally-enabled platforms and services. Thanks to new policies and frameworks that led to upskilling and market reforms, the majority of the public are engaged with and literate in data and digital technology. Personal digital twins populated by wearable devices and AI have transformed the way the NHS works and the services it provides by enabling earlier and higher-performance diagnosis of a range of diseases. Citizens track their health and other metrics on apps[12] and also benefit financially from the value of their data by receiving compensation when they opt to share it. Organisations with data and digital technology embedded in their business models also benefit, particularly where they have reached secure data sharing arrangements with others. The value of data is leveraged at a scale we could scarcely have imagined in the 2020s, thanks to greater openness and collaboration along supply chains, and better management of physical assets and processes using technologies such as cyber-physical systems and digital twins.

Reversing the climate crisis and ensuring social equality have also involved big data and smart solutions. The SDGs have been met through a combination of efforts across multiple sectors, enabled by technology. AI, sensors, robotic and synthetic biology are improving crop productivity, circular economy and resilience across the UK. Renewable energy mini grids have become the cheapest and most resilient solution, and both centralised and decentralised energy systems are fully monitored through digital twins and IoT.

Across all assets, the 'golden thread of information' suggested by the Hackitt Review[13] is managed securely and with appropriate data sharing permissions, in interoperable formats – meaning that critical information about buildings and infrastructure is available to the right people at the right time. In this way, the built environment is data-informed, cyber-physical systems driven, well-managed, performs well over its whole life, and contributes to human flourishing[14]. As Generation Zero became voters, they helped enact better governance for secure data capture and sharing, meaning that the principle of 'data for the public good' is now firmly embedded in legal frameworks[15].



"When I was a kid my dad was a bus driver, and he always worried about what I would do for a living when I grew up since he thought most jobs would be automated by now. There is a lot more automation, including in the transport sector. But as it turns out, you still need people to design how those systems work, to make decisions about how they operate, and to be there in case things go wrong. I was always more of a creative type, but I also like solving problems, so I've found a really good balance in my job as a user experience designer for the National Mobility Platform. I had to learn a lot about data and algorithms in my degree, but the curriculum was really well tailored to the way I think and I like knowing how the system I'm designing for works. It helps me think about who might be at a disadvantage so I can design ways to make public transport more accessible."

Tariq, user experience designer for MaaS platform

ECONOMY

Presently we are in a period of relative prosperity[16], and while GDP is high, it is a lesser measure of public good compared to others in which we have excelled. Valuing nature, cultural assets and people for the intangible value they provide to society has marked a huge shift from the days when GDP was the primary measure of success[17]. It is less lucrative to be a CEO of a major corporation these days, but the benefits to society of capping CEO pay, closing tax loopholes, progressive carbon taxation[18] and paying key workers fair wages are undeniable. With more economic equality everyone's health outcomes, crime rates and reported levels of happiness have all improved[19].

The traditional built environment sectors of the past are now primarily dominated by a much younger workforce and have become intertwined with the green information economy and digital ways of working. This way of thinking and working serves to solidify the economic resilience of such sectors by diversifying their revenue streams into information economy and circular economy models. The built environment is now at the cusp of new value generating functions in a flourishing green information economy, and capturing, storing, transporting, analysing and reporting data outputs crucial to the continued achievement of the UN's second generation of SDGs.

The development of a thriving circular economy – based on products designed for reuse, and the development of markets for post-consumer materials – has reduced reliance on extractive industries for materials such as plastics, concrete and metals. It has forced a change from business models based on planned obsolescence to a thriving repair economy, and consumers that value long-life products over disposable trends. Similarly, the buildings and infrastructure under construction now are designed for long life, reuse and remanufacture, protecting the environment and freeing future generations of the demand for new steel, concrete and other materials.

NATURAL ENVIRONMENT

Natural resources are recovering from decades of depletion[20] through a combination of policy, corporate responsibility and public buy-in. First, air quality is steadily improving, thanks to the well-executed dual strategy of reducing emissions and capturing the carbon already in the atmosphere wherever possible. Widespread tree planting efforts have increased tree cover in the UK to double the amount in 2020, and this has been one small part of a wider rewilding movement that has coincided with a strengthening of environmental protection legislation. Reducing water waste in sectors like clothing manufacturing, construction, and landscaping have protected our increasingly strained supply of clean water. Meanwhile, improving soil quality and agricultural practices have become a priority as the UK increasingly grows its own food. Educating farmers and gardeners and putting in place standards and legal codes to protect air, water and soil quality have helped ensure a stable food supply and better public health into the future.

Environmental regulations were a core part of the post-Brexit agenda for the Environment Agency, but it was the national lockdown for COVID-19 that provided the catalyst to reset regional and national policy to address the climate emergency. As the skies temporarily cleared of pollution from air and car traffic, people realised that clean air was worth fighting for. As part of the recovery from the COVID-19-related financial crisis, we brought in Green New Deal style legislation that has ensured more green jobs, especially in parts of the country that were struggling before the pandemic, meaning both the climate and the economy were able to recover after that global crisis. The economic and environmental crises of 2020 converged with a greater awareness of social justice, and data turned out to be a large part of the solution to all of these problems.

SOCIETY

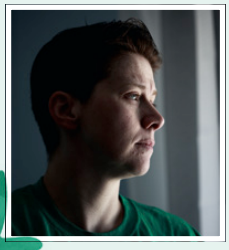
Meeting the SDGs required an infusion of courage and conviction in the 2020s on the part of policymakers. A key piece of legislation was the adoption of the Wellbeing of Future Generations Act, pioneered in Wales (2015), across the rest of the UK. This provided a new lens through which to view all policy decisions: we want to be the last generation to inherit a planet in crisis. It has shaped the policy landscape ever since, led by our Future Generations Commissioners for each country of the UK[21].

According to a recent study from UCL, people born after 2010 were twice as likely to report a sense of social cohesion than their contemporaries who could remember life before the 2020 pandemic. The analysis pointed to several reasons for this, including greater transparency, more investment in communities and a shrinking gap between the wealthiest 10% and the poorest 10% in the UK population. The report suggested that social programmes and the Universal Basic Income scheme contributed to a sense among young people, adults without a graduate degree, older adults and people with disabilities that their lives mattered to others in society, whether they were in work or not. The dual crises of the pandemic and the climate emergency seemed to contribute to a sense that everyone was in it together and needed to collaborate to meet the challenges we faced.

Our current Prime Minister was elected into office at age 34 and is a modernist. Since coming into office three years ago, she has shown a commitment to realising the five pillars of our Modern Industrial Strategy, particularly unleashing the power of responsible AI and big data. Tech companies and providers of cloud services are now effectively regulated, and 90% of the British public now possesses all of the crucial digital skills set out by the 2037 update to the National Digital Strategy (UK Government, 2017). Following the widespread digital connectivity and access to the internet across the UK, and after witnessing successful policy solutions to large-scale problems and transparent reporting from the government, more young people have taken keen interest in democratic decision-making.

Housing for vulnerable people has been one of the success stories of the green information economy. A public housing audit was commissioned immediately after COVID-19 and found that in areas where more people of colour and council housing tenants died, 80% of the housing stock was structurally or environmentally unsound, unhealthy, and/or energy inefficient[22]. Most of these dwellings have since been refurbished where possible and new social housing is built to environmental, health and safety standards, facilitated by digital compliance checking and community involvement.

Using a mixture of retrofitting and modern methods of construction, we have been able to create more structurally sound, environmentally sustainable and affordable homes in cities and towns facing an acute housing shortage and housing unaffordability, guaranteeing housing and social services for all. With greater economic equality and access to services, the wider population's health outcomes, safety and reported levels of happiness have improved[23].



"I'm a city planner in Leeds, which was not a job I thought I'd be interested in when I was at Uni studying economics. I really loved sandbox style video games like Minecraft, though, and as planning became more digital, I started to think it might be a lot of fun. I use a planning portal that connects to the National Digital Twin when I'm exploring different decisions I could make. I'm able to tweak parameters and see the environmental footprint, impact on transportation, hospitals, schools and community spaces that my decisions would have. There's a process in place where I post potential projects and their impacts on our local Digital Democracy Portal, get feedback from the community and then take that on board as I iterate the project. There are certain requirements that the automatic compliance checker needs me to meet in terms of environmental footprint and community engagement before I can progress it, but I can also set my own requirements. All of the procurement stuff is handled digitally, and all of the relevant information is passed on to the contractors and operators of assets, so everyone is being checked for their actual environmental performance throughout the lifecycle of that asset. It's really cool to know that projects I'm commissioning are actually carbon neutral over their lifespans, and that I have the support of the local community."

George, local planner

HOW THE UK GOT HERE:

- [x] Future Generations Act UK passed.
- [x] Creation of green jobs and social support to help the economy recover from COVID-19.
- [x] Early investment in digital technology for construction, aligned with data and AI for the public good principles, connected digital twins balancing trade-offs between built and natural environment.
- [x] Widespread adoption of IoT throughout the built environment to provide better services for all people with better resource efficiency.
- [x] Ending hostile environment and welcoming climate refugees to boost workforce and economy.
- [x] Thanks to government income support, citizens are able to retrain in digital skills, or pursue volunteer and creative career opportunities, adding value to the economy
- [x] New build projects are evaluated for their whole life carbon footprint as well as their efficacy as carbon sinks.
- [x] Increasing digitalisation of many professions, and new well-paid opportunities in design, programming, caretaking etc., assisted by automation and IoT.
- [x] On track to reduce the UK's carbon emissions to Net Zero by 2050.

RESIGNED TO OUR FATE

SCENARIO C

SDGs not achieved

Digital technology focused on predicting failures

High dependency ratio

In the 1980s the world missed its best opportunity to answer the alarm call from scientists about human-driven climate change[1]. By the end of the 2020s, we had missed our final opportunity to slow runaway global heating. We chose business-as-usual over working toward the Paris Climate Agreement and the SDGs, and not even the global pandemic of 2020-21 was enough to catalyse people into collaborative action. In order to pay for the economic recovery after that event, austerity was extended in the UK and the regulatory environment developed to make the UK more attractive to businesses, eroding employee rights, environmental protections, and the social safety net in return for short-term gains.

With an ageing population – due to slower birth rates and low levels of immigration – there is a reluctance to change business models and behaviours. As a society we are beginning to accept more extreme weather, resource scarcity, public health crises and the collapse of ecosystems as a frightening, inevitable 'new normal'. A privileged minority can afford to insulate themselves against the changes – moving to areas that are less impacted by air pollution, flooding and frequent wildfires, for example – while the rest of the population is becoming increasingly vulnerable to these and other dangers[2].

The result is that the UK has failed to meet both the SDGs and its own targets on the way to net zero carbon emissions by 2050, and global heating is set to rise by nearly 2°C before the end of the century[3]. With 10 years left to meet the zero carbon target, the built environment has a growing percentage of energy coming from renewable sources, new building materials in use, greater availability of electronic vehicles, and a wider selection of green products on the market. Consumers support sustainable options where they are available and affordable, and innovations in this area have landed well. Greenwashing is prevalent, however, as the economy is still largely organised around a linear extraction, use and disposal (or cradle-to-grave) model.

The news is not entirely bleak: faced with worst-case climate scenarios, several entrepreneurs have donated billions of pounds into research and technology developments in the interest of geoengineering projects such as re-freezing the Arctic. This research is promising, but the fact remains that humankind is now faced with the difficult, dangerous and expensive task of trying to design ourselves out of a problem we might have been able to prevent only two decades ago, with a shrinking workforce able to address it.

BUILT ENVIRONMENT

In the built environment sectors, business-as-usual is shifting gradually toward digitally-enabled decarbonisation, but the lack of a mandate for rapid adoption of digital technology and modern methods of construction has led to slow uptake beyond a few industry leaders and key sectors[4]. Important steps towards the development of integrated and sustainable infrastructure were made in the early 2020s. However, the economic depression channelled financial support towards the recovery of certain parts of the economy, such as air travel and hospitality, rather than green transformation. Concrete and steel continue to be used widely in new buildings and infrastructure projects[5], which are more prevalent than retrofit. As a result, sustainability targets have not been met, and the digitalisation of infrastructure remains limited outside of health care, energy and telecommunications.

Remote working rose rapidly in the early 20s and has continued to climb, driving the creation of smart microgrids, currently underway to help deal with rapid changes in energy use. The promise of autonomous vehicles – that they would be pervasive in the built environment – has not materialised. The will and financial support were not behind the massive undertaking to develop a workable solution to the numerous challenges of creating a market-ready fleet of autonomous vehicles[6]. However, there is undeniable pressure for greener transportation solutions. Although more commuters are choosing high-speed electric-powered trains as an option for long-distance travel, electricity production in the UK is still not carbon free, and carbon footprint of travel remains too high to slow global heating.

The rapidly changing climate is taking its toll on the built environment, with frequent flooding, landslip, windstorms and droughts causing numerous problems for the performance of assets and services, and knock-on effects in complex systems. Planning at the national and local levels has had to focus on repairing infrastructure and reacting to threats rather than developing a new, resilient built environment, affordable housing and other priorities that were left behind in the 2020s.

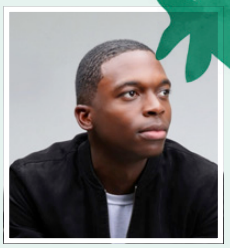
DIGITAL TECHNOLOGY

The high dependency ratio of the population and the frequent occurrence of extreme weather events renders a large part of the population highly vulnerable. In the last 20 years, the technology sector has been called on to address this challenge. Efforts are oriented towards negating the deterioration of the natural environment and supporting the medical sector, as well as monitoring and predicting the worst disasters, from fires to flooding, so that people can better prepare for them. In particular, live feedback devices, sensors, AI and IoT technologies are used pervasively in this capacity. As a result, there has been a steady increase in smart home applications and data-centric operations in the built environment. Services, including the NHS, are increasingly automated and many users miss human connection, but most are becoming accustomed to interacting with screens and other media for automated services.

The widespread adoption of digitisation, automation and robotisation supporting the increase in efficiency and acceleration in production. Technology is now an integral part of the operations of the built environment, offering the means to address and overcome the high dependency ratio of the population. Supplementing the shrinking workforce with automation was unpopular at first, as there were fears that it would replace only blue-collar jobs. But automation also supplemented some of the administrative and decision-making jobs of white-collar workers.

The management of data and information by many of these systems is done in proprietary silos. These silos are managed and integrated by corporations without full transparency and this leads to not trusted digital services. Corporations have unprecedented access into private data and can buy and sell data freely to their partners. While AI and the data economy have been disrupting many industries for a long time, the privacy, safety and trust to these applications are still not guaranteed. Unexpected accidents related to the AI-driven machines are not happening as often as the 2030s, but the broken trust caused by these incidents is not fully restored. Trust in digitalisation among people of colour and poorer people is especially frayed, as algorithms developed by and for institutions dominated by white people replicate many of its biases. Without proper regulation, the dream of 'data for the public good' or 'AI for good'[7] has turned into 'data for the profit of the few'.

This is compounded by the lagging digital skills of the public, who are unaware of how their data is being used and how technology might be used to manipulate them. The lockdown of 2020 drove more people than ever to engage with digital technology as working remotely became normalised in many sectors. However, the UK has not achieved its target of eliminating the digital divide isolating older adults from digital services. This divide is compounded when age or disability intersects with another form of systemic disadvantage, such as social background or ethnicity[8].



"I have always been interested in using technology to help people. That's why I specialised in IoT for home medical care. I programme the user interface to make sure it's accessible and shows the sensor data in ways that everyone can understand. It means that older people with health issues can stay at home longer without in-home carers, and early studies are showing it helps outcomes by detecting things like stroke and heart attacks early. It's a good job and I'm proud to do it. But I do sometimes worry that even with my salary, I'd struggle to help my grandmother pay for the whole smart home set up if she ever needs it."

Wes, software engineer for at-home medical sensor manufacturer

ECONOMY

Economically, our GDP is in the early stages of recovery from a lengthy depression beginning in 2020 with the continuation of austerity[9]. Recently, private sector incomes and spending have been rising, leading to higher tax revenues. This has in turn stimulated the ability of the government spend in order to help address our current challenges, but it remains to be seen how effective this investment will be.

The shortage of young workers to fill new positions across all sectors has required organisations to move from human labour toward automation in recent years. Investment in the Internet of Things has led to greater data capitalisation. It is unclear if this will cascade into a positive net effect by creating a digital single market. Data management is still largely siloed, and sharing between partners is achieved through complex, bespoke arrangements, so the value of data has still not been fully realised[10].

Digital skills in support of automation are a high priority for the education sector, but literacy in these areas still falls along demographic lines. Overall, the job market has been shrinking in tandem with the aging population, but the contraction is most rapid in traditionally working-class roles, and many are not being adequately re- or up-skilled, which in turn deepens economic inequalities.

"I used to think that the problem of climate change was too big for me to do anything about. In retrospect, I wish my peers and I had helped each other modernise rather than trying to 'win' after COVID-19. We might have had a big impact on the current situation. Before I retired, I had to do a lot of change management to modernise our workflows and catch up with the kind of technology that is now required to measure environmental impact."

Josephine, retired CEO of major construction firm

NATURAL ENVIRONMENT

On the global scale, we have reached the first of several environmental tipping points about which scientists have been warning the public since the beginning of the century[11]. The rate of the climate breakdown has accelerated rapidly. We are approaching 1.5° C of warming, and many of the consequences predicted by the IPCC in 2018 are happening as a result. Loss of Arctic sea ice has led to sea-level rise and an existential threat to small island nations and coastal communities around the world. Droughts and famines have become more common and more severe across the world. Two more novel viruses made the leap from animals to humans since 2020, fortunately with less globally significant results, but scientists warn of more frequent pandemics over this century as the relationship between humans and the planet frays further.

The climate crisis has also impacted the availability of natural resources to the UK. The cost of fresh, healthy food has skyrocketed while the cost of fast food is artificially suppressed through subsides, intensifying the food desertification of cities and poorer towns[12]. While effort was made to plant more urban trees in the 2020s and 30s, it has not yet been sufficient to significantly improve air quality. Asthma and other respiratory health issues are endemic in cities and at times masks are required to safely be outdoors due to smog. In urban heat islands in the UK, every summer is deadly to the most vulnerable people in society[13]. However, we lack adequate data to track the real scale of these problems, making it much harder to prepare and problem solve.

Sustainable energy is cheap and prevalent for powering buildings, supplemented at peak demand by nuclear and some coal, but we are still a society that is addicted to the car and the aeroplane, and the switch to fully electric vehicles has been slower in arrival, hindered by lobbyists and the artificially suppressed cost of fuel. Access to fossil fuels from abroad has recently become more difficult as it is becoming a scarce commodity, and this has been one of several drivers of armed conflicts around the world that can directly be tied to environmental crises[14].

UK winters are warmer and wetter than ever, but the demand for water has increased, especially during the hot, dry summers that make groundwater supplies scarce. Cities have been hit particularly hard by this, with supplies of clean water at times becoming contaminated by storm surges and flooding. Marine and coastal resources have also suffered from the warming, pollution and over-fishing of the oceans and seas, and from coastal erosion accelerated by sea-level rise and more severe weather.

SOCIETY

The political divisions exacerbated by Brexit remained in place through the recent economic crisis of the 20s and 30s, fresh in the memories of the older generations of adults. In fact, populism has become more entrenched the more resources became scarce as wealth and power became more concentrated. Fake news online is taking on ever more sophisticated forms and the legislation has never caught up with the problem. Fortunately, the UK did not follow the USA down the path of climate change as a partisan issue, but the political will required to meet the crisis never materialised. In retrospect, we can see that we wasted vital years to manufactured arguments about trade-offs between the economy, trade and the environment that need not have been made. The issues were always interlinked and the solutions may have been too.

Although during the COVID-19 pandemic the Government and everyone across the political divide recognised that the NHS is one of our greatest national assets, the pledges made at the time to adequately fund it have fallen through, and we reverted to austerity after the crisis passed. We have not been able to bring down the number of mortalities from heart disease, Alzheimer's disease or cancer from 2020 levels, and among some demographics the premature death rate is actually on the rise. Our polluted atmosphere has led to a widening disparity in health outcomes, with wealthy people able to afford to move to places with cleaner air and less flooding, while people in polluted cities die of asthma or lose their homes to persistent flooding. Care homes have become overwhelmed with older people who have complex conditions and require specialised services. With shortages in the workforce and budget cuts across the caring sectors, many older people are being served by a mixture of human and digital carers.

Digital technology is also being used to enhance security. However, where privately developed AI has been used in policing, law enforcement and sentencing, it has been shown to target BAME communities with greater police presence and recommended harsher sentences for the same crimes[15]. Unregulated fake news has fuelled divisions between people, with propagandists using highly-realistic DeepFake videos, sophisticated bot accounts, and algorithmically-targeted social media adverts to undermine trust and manipulate public opinion[16].

As a society, we are beginning to recognise that the time in our history at which we were most divided was exactly when we needed to unite to prevent the unravelling chaos of climate change. We ignored the warnings that carrying on with business-as-usual would bring about a dire future. Now our hope for reversing the changes is low and we are resigned to our fate, needing urgently to innovate solutions for our survival.

HOW THE UK GOT HERE:

- [x] Limited investment in bespoke IoT solutions for public good in the built environment, restricted to home health care and climate monitoring.
- [x] Post-Brexit legislation made the UK attractive to businesses, but deepened economic and social inequalities.
- [x] Unregulated digital innovation in silos, no guiding principles for public good applied to the development of IoT and big data.
- [x] Slow progress on climate legislation.
- [x] Austerity to boost post-COVID economy.
- [x] Slow uptake of digital construction beyond a few leaders.
- [x] Not on track to meet 2050 net zero carbon targets.

TOO LITTLE, TOO LATE

SCENARIO D

SDGs not achieved

Digital technology developing in silos

Low dependency ratio

The adult population of working age is larger than at any previous time in the UK's history. With a rush of energy and enthusiasm, the generation that entered adulthood in the early 2020s seemed poised to change the world. Instead, they met entrenched power structures that were resistant to change. Despite a groundswell of support for radical climate policies by young people, the changes made in the 20s and 30s were not ambitious enough to meet the need. This generation entered the workforce in an economic depression and solving the climate crisis became a lower priority than restarting the economy, even as the effects of climate change prolonged the economic downturn. The built environment and legislative landscape of 2040 look very similar to 20 years ago, and the results of decades of exploitative economics are hitting the UK in terms of sweeping resource shortages and extreme climate events.

The birth rate has levelled off, so there are fewer young children now than 20 years ago, and unfortunately life expectancy over all is beginning to creep down as extreme heat and poor air quality take their toll on older adults, particularly where that demographic intersects with other vulnerable identities. The climate crisis has brought many refugees of working age to the UK, but unfortunately there is a great deal of animosity toward these communities as they have become scapegoats for the economic troubles of the last 20 years and climate-related resource scarcity in the eyes of xenophobes and ethno-nationalists.

This young, driven population is working hard to design solutions to the most pressing problems facing the planet. A new generation of architects, designers, civil engineers and data scientists have just begun to create a built environment that is more resilient to these problems[1], but this open and altruistic movement is a small part of the technology sector and they are chasing the symptoms rather than meeting the crises at their root cause. Those that hold proprietary data and technology still hold most of the power in technology, and disproportionately benefit from its value. In some ways, the rush to digitalise for decarbonisation has simply deepened the inequalities and exploitation of the planet because it was undertaken in the same spirit of unregulated competition that fuelled those crises in the first place.

"While we have a lot of freedom to set our own security policy, that actually makes it harder to do business, because so does everyone else. Every new partnership means a massive negotiation between sharing data but doing so securely, and matching up our security policies so that everyone in both firms are on the same page."

Mel, head of digital security for a major London-based tech company

BUILT ENVIRONMENT

Lack of investment and retrofitting over the last 50-60 years have left infrastructure vulnerable to flooding and extreme weather. Smart technology solutions have been deployed primarily at the points deemed most critical, but many assets were missed out of this effort. Several tragic and preventable bridge collapses in recent years have created more pressure to widen digitalisation efforts, and the mandate to digitise for major projects. Although they are late in coming, critical interventions in the infrastructure are being deployed. In addition to structural monitoring, sensors are now providing climate, usage, supply chain and other data to aid in decision-making in most major cities and assets.

Now we are aware of how much we lost by not taking timely actions. Although they are late in coming, critical interventions in infrastructure are in development and will provide live feedback devices and data processing tools that incorporate AI and Internet of Things technologies across the built environment. At the same time, the construction industry is being driven towards a full adaptation of automation and prefabrication. While it is part of a new mandate, these practices will ensure that the construction of new buildings and the retrofit of our existing infrastructure are time, cost and resource efficient, providing better outcomes for the sector, the public and the planet.

A greater share of journeys than ever is taking place by bicycle, especially in the younger adult demographics. Active, green mobility solutions are a growing priority at the Government level. Yet we are still very dependent on our personal cars for travel within and between cities[2]. Electric vehicles are becoming more common, but the charging infrastructure has yet to materialise to make them a viable alternative and autonomous transportation has not lived up to its promises of safety and decarbonisation. The greenest cities are drawing more educated and wealthy workers, while poorer cities are caught in a spiral of falling behind on climate solutions, smart technology and reducing inequality.

DIGITAL TECHNOLOGY

The large and active workforce is formed by a digitally skilled and connected generation that exploits technology's potential to negate the consequences of climate change and improve the living conditions in a highly polluted urban environment. In today's highly connected and engaged society, technological advances are now oriented toward mitigating the extreme climatic conditions. A substantial part of the technology sector is working towards the mitigation of the pollution levels, albeit in parallel rather than cooperatively. AI, data, sensing technologies and extensive research investments are in place to predict extreme natural phenomena. Technological advances and the adoption of smart technologies drive cities to remain competitive and operate in a sustainable manner, but practice is not shared between cities or organisations.

Gradual progress has been achieved in the way the built environment operates and interacts with the users. Smart Internet of Things devices are in place throughout most cities and infrastructure, and some homes. The interoperability between these devices is increasing at different hierarchical levels, ranging from different parts of a single building, to larger system of systems at an urban scale. This enables more data-centric decision-making, which is contributing to recent improvements in the performance and efficiency of buildings, infrastructure, towns and cities. The AI algorithms are developing slowly after the AI winter – where public interest for artificial intelligence appears to wane along with investments made in these technologies among the business and academic communities – and we are working on automating as much as possible to increase the output of the production. Yet, there are big questions about privacy-related issues as we push forward with digitalisation. Due to urgent need of data to manage the consequences of climate change, there is a rush to open personal data to technology companies without much indication of how to protect the privacy and integrity of individuals' data.

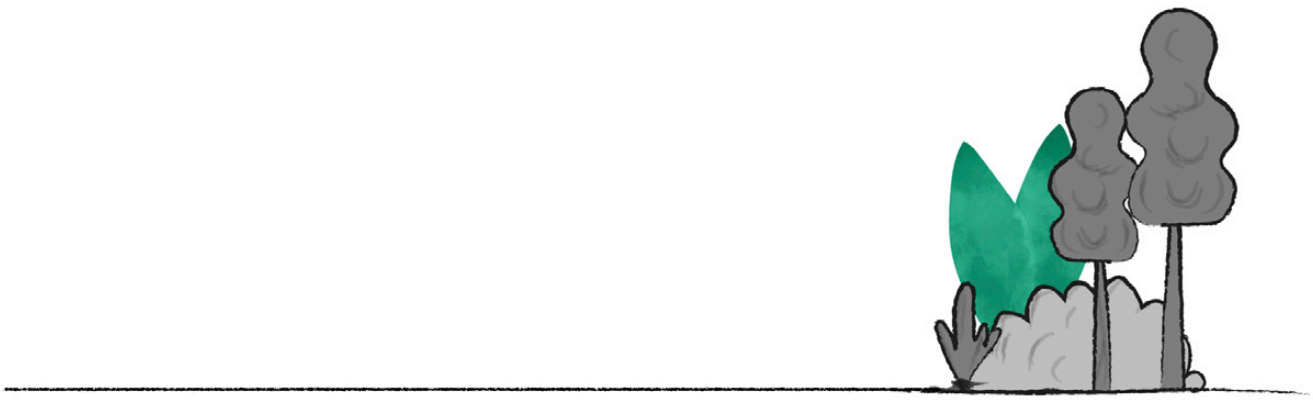
Digital skills and literacies are now embedded in the national curriculum and on-the-job training is available at larger firms within the built environment sectors. This provides employees with an understanding of any data, AI algorithms and robots with which they will be working. However, many think that this comes far too late for many of us. A major focus of the developing digital literacy curriculum has been 'security by design', which teaches individuals to avoid being the weak link in their personal and professional digital security. This is particularly important as teleworking and flexible working hours have taken off[3]. However, rapid advancement in digital technologies is making it difficult for legislators to catch-up. Although most people in Britain are digitally connected, our cyber-security and data protection laws and practices are struggling to ensure that citizens are safe online[4].

NATURAL ENVIRONMENT

The 2020s provided some early glimpses of the resource shortages we are facing as a planet today. From depleted soil and pollinator collapse to food shortages, from a dwindling clean water supply to global shortages of concrete and electronics-grade metals, we are currently paying the price for industrial societies' prior unsustainable exploitation of the planet. Air and water quality are plummeting, and global temperatures are rising every year as ecosystems collapse and certain foods become scarce. This in turn has driven inequality, as only those who can pay the high price-tag for scarce commodities can access them, and global conflicts, as nations and peoples compete over necessary resources.

The main weapon we have at our disposal in this age of climate chaos is data. Various companies have launched advanced observation satellites and sensor arrays, but the competitive race to solve climate change means that data is kept proprietarily. Some nations have the resources to gather data that might be publicly shared, as it was in the past, but a rise of global authoritarianism and climate change denial cut back on the level of climate data collection and sharing by some national bodies. Private companies designing and selling geoengineering solutions have the most complete datasets, and academic researchers need to be funded by these organisations to gain access.

Sustainable energy is cheap and prevalent for powering buildings, supplemented at peak demand by nuclear and some coal, but the switch to fully electric vehicles and the greening of air travel has been slower in arrival, hindered by lobbyists and the artificially suppressed cost of fuel. Even as our carbon emissions have slowly crept down, the ability of the natural environment to absorb excess carbon through forests, ocean plants and peat bogs has dwindled, so that biomass that used to act as carbon reservoirs are now leaking carbon back into the atmosphere.



ECONOMY

In today's economic trough, the GDP is at its lowest point after a long period of decline, falling employment and price stagnation. The combination of a younger population with this economic trough is leading to decline in business earning, redundancies, low credit availability, higher unemployment, and business closures. While this has depressed demand for housing, retail zones, industrial areas, and infrastructures, the built environment business cycle is now beginning its recovery.

The data economy is no longer working for the common good. Instead, it has continued to widen the wealth gap and inequalities where governments have failed to fairly distribute surpluses captured by data monopolies[5]. IT 'superstars' of data economy have introduced new business models to the built environment data domain. They do not seek profits from selling built environment data or services or products but instead profit from business intelligence when combing this big data with streams of other data, especially location and social data. Continuing the powering of unregulated profits from targeted advertising based on big data-based business intelligence, the consumer protection continues to weaken[6].

"It's frustrating researching climate right now. All of the best data belongs to a few big private organisations, and to get access to the data you need to work with them. But of course, they don't like it if you draw links between the ways they do business and the climate crisis. They tend to favour geoengineering solutions to our problems, rather than reimagining their own business models to make the world better for everyone."

Adrienne, lecturer in climate science at a UK University

SOCIETY

With a huge rush of energy and enthusiasm, the generation that entered adulthood in the early 2020s seemed poised to change the world. In the last general election, the UK elected its youngest and most diverse Parliament in history, with many of these new MPs tracing their political activism back to those movements in the 2020s. They have led the call for the most progressive climate legislation and finally the established politicians seem ready to listen. Instead, they met entrenched power structures that were resistant to change, and political will was not behind them.

This generation entered the workforce in a deep economic recession that turned to a depression, and their struggle to be heard amid these harsh conditions led to a decrease in activism, even as the effects of climate change became clearer for all to see. Some policy changes have been made: in 2019 the government committed to increasing tree cover by 25% and they met that target; the country is lagging behind its target to make the UK net zero by 2050 also set out in 2019, but progress has been made; and there have been consistent additions to policies to make agriculture, business and infrastructure projects more green. However, this has not happened decisively or quickly enough to meet the scale of the problem.

The data economy does not work for the common good. Instead, it has continued to widen the wealth gap and inequalities where a few data monopolies capture value that does not have a route back to communities providing the data. Private, self-interested behaviour continues to play a pivotal role in generating technological change[7]. Our cities are also becoming increasingly divided as the amount of investment and quality of physical, natural and social infrastructure in areas with large BAME, low income and immigrant populations have fallen significantly below the national average. This has had profound implications on the educational attainment of children who grew up in these communities and neighbourhoods, with even far greater implications for their job prospects and ability to build financial and social capital. It is also a driver of increased violent crime and scapegoating of BAME communities by white nationalist hate groups. Women are still discriminated against in workplaces in terms of their appointment to leadership positions and after the 2020 pandemic, the gender pay gap has begun to widen again after decades of progress.

The efforts toward digitalisation for environment and public good within the silos of business-as-usual have proven to be too little, too late.

HOW THE UK GOT HERE:

- [x] End of hostile environment to encourage immigration that has supplemented the ageing British workforce.
- [x] Widespread investment in bespoke IoT solutions in the built environment, restricting data sharing for public good
- [x] Investment in sensors and modelling of geoengineering solutions to monitor and mitigate climate emergency.
- [x] Digital skills focus in curriculum.
- [x] Unregulated digital innovation in silos.
- [x] Slow progress on climate legislation.
- [x] Austerity to boost post-COVID economy.
- [x] Quick uptake of digital construction among built environment leaders, but without sharing information across the sectors.
- [x] No guiding principles for public good applied to the development of IoT and big data.
- [x] Not on track to meet 2050 net zero carbon targets.

04

One Choice

WHERE DO WE GO FROM HERE?

There are multiple plausible futures that may come about, depending on how certain and uncertain factors come together, but it should be clear that there are warning signs for the future about the decisions we as a society and a nation make today. This section explores how choices made now and during the recovery from COVID-19 can take us in the right direction.

"As we get Britain building again, there will be a natural temptation to go back to the familiar, outdated practices rooted in cost minimisation and risk transfer. We have, as a sector, an historic affinity with cheapness. We tend to see value through the prism of pounds and pence rather than in the much broader sense. This was not sustainable before the COVID-19 crisis and it is far less so today."

Keith Waller, Director of the Construction Innovation Hub[1]

As we mourn our losses and begin to recover from the public health, social justice and economic crises that the COVID-19 pandemic brought into sharp focus, it is widely acknowledged that the UK cannot afford to go back to its previous version of 'normality'. Refrains of 'Build back better' are leading to questions about what the 'new normal' could look like.

As one example, the Construction Leadership Council, whose mission is to provide sector leadership to the construction industry, has outlined a three-phase recovery roadmap that builds to the reinvention of the sector[2]. This may seem intimidating to those just wanting to get back to their routine, but we have an unprecedented opportunity to decide as individuals, organisations and as a nation what future we want to create, while addressing the root causes of the interrelated social, environmental and economic crises. The opportunity is especially profound in the built environment sectors, who are not only responsible for approximately 40% of the UK's carbon emissions[3], but create and manage assets that last potentially for hundreds of years. The decisions taken today – between road or rail, coal or wind, cheap materials or transparent supply chains – could lock us into carbon emissions that will derail the UK's zero carbon ambitions and send the planet deeper into climate chaos.

While the solutions to these problems are complex, they are so interconnected that identifying the right changes may trigger a positive tipping point, for example investment in green transport and decarbonisation of the grid, could have an outsized effect on decarbonisation throughout whole systems[4]. Identifying these positive tipping points will enable rapid progress and better value for money. This approach stands in contrast to a model that prioritises economic recovery at the expense of other forms of value, injecting money into infrastructure projects that will have a large lifetime carbon footprint, opening up precious natural resources to the highest bidder, and removing environmental and employee protections[5]. Build, build, build will see us following the same trajectory that brought about the crises we are in now. **We have to build smarter and better to ensure the future outcomes we want.**

Whatever the demographics of 2040 look like, there is clearly a broad spectrum of actions needed over the next 20 years in order to achieve the SDGs, keep us within targets for carbon emissions and global heating, and save ecosystems from collapse – all while ensuring people are supported through the likely long-term economic depression following the COVID-19 pandemic.

But what can we start doing today? Beyond reducing single use plastics, Meatless Mondays and flying less, what power do individuals have to impact these outcomes?

This is where we return to the Three Worlds Framework (see the Meeting of Minds section). What is within the sphere of your control?

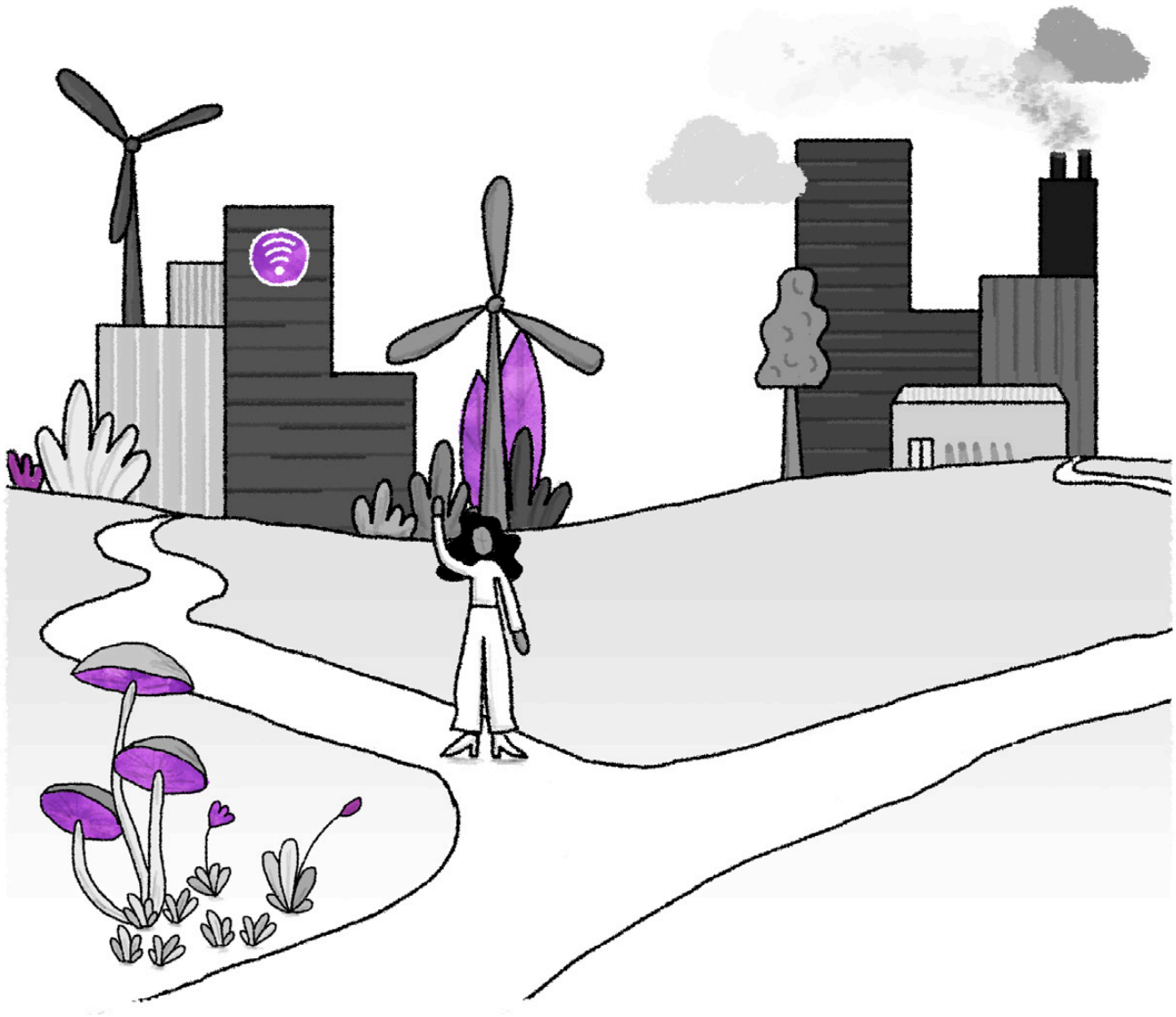
- If you are a **citizen**, you might change the course of the future by engaging with your community and family members on how to reduce your household carbon footprint[6], consider what you buy and what policies you support.

- If you are a decision maker in the **built environment sectors** – a contractor, client, supplier, asset operator, service provider, etc. – you might have the power to choose how you do business and with whom, or to green your supply chain. You might be able to include nature-based green infrastructure solutions, such as wildlife bridges, nature-based flood prevention or pollinator meadows, to mitigate harm in the projects you plan and commission.

- If you are a **policy maker**, you might listen to younger generations, who will have to live with the consequences of your decisions for longer and ensure that those most responsible for climate chaos are held accountable for making it better. You might have the power to help provide broadband access or digital skills education to areas in need. You may have opportunities to amplify underrepresented voices and support marginalised communities.

Below, the text explores actions that may help you create the future you choose, some of which may be out of your sphere of direct control, but you may find you can work toward them in your own way by using the levers at your disposal.

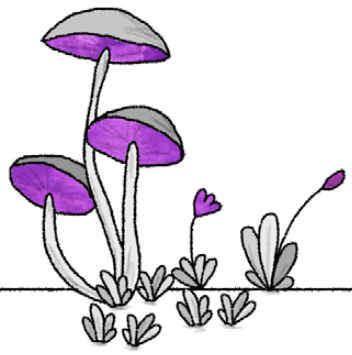
Why not share what you or your organisation is doing to work toward the future you want by emailing **engagement@cdbb.cam.ac.uk** or by Tweeting **#4futures1choice** to **@CambridgeCDBB**?



While we don't know for certain the exact outcomes of our actions, we can be clear about the direction in which we're heading. If we keep in mind the future we want, we will make choices that will lead us in the right direction.

ACTIONS FOR A BETTER FUTURE

The following actions are based on our, the authors', expertise and understanding of the problems facing the UK. These are our suggestions for how to move forward towards a vision of a more sustainable, equal and flourishing future for the UK and the planet, in which digital data and technology are able to enhance beneficial outcomes for the built environment, rather than putting out metaphorical (and maybe even real) fires. In other words, by following these actions, we believe that the UK has the chance to become **proactive** leaders in creating sustainable, liveable digital built environments that exist in balance with the means of the planet, rather than being **reactive** to emerging crises.



THOUGHTFUL INVESTMENT IN DIGITAL TECHNOLOGY AND DATA

In our research, we took greater digitalisation as a certainty; the difference between the scenarios is how digitalisation supported and permeated the built environment based on the economic model, governance and the most pressing needs of society. For example, where the climate emergency had become more acute and there was an ageing population (Scenario C), digital technology had to be deployed primarily to support a shrinking workforce and predict the next disaster. However, this was done in an ad hoc, market driven manner, meaning there was less integration and less benefit to the public good than in Scenario A, in which some of the same demographic pressures were in play.

We explored in the Preface how digital technology relies on data to function, and therefore any discussion of digital is a discussion of data. People tend to see data as rational, dispassionate and neutral, when, really, it's anything but. Already, in the early days of data and algorithm-based decision making, we are seeing the ways that entrenched cultural inequalities and biases are being translated into the digital world. For example, **interaction biases** may be introduced into facial recognition by the data used to teach AI containing unrepresentative samples[7]. **Latent biases** introduce pre-existing human biases into digital systems by making use of historical data, replicating structural prejudices about who is more likely to be a good leader, fit a certain job or commit a crime because that's what the data says[8]. **Selection biases** are created when an algorithm has much more access to information about certain groups, communities or global issues than others, and therefore reinforces stereotypes[9].

The world is made of complex and interconnected systems, and, while data may help us navigate this complexity, our maps often reproduce the biases of their makers. It is not enough to collect data: it must be described, managed, curated and shared in ways that enable others to benefit from it. Therefore, decision makers need to think carefully about what they need to know, express clear information requirements, and enforce standards for data quality to enable the data to be used for making better decisions.

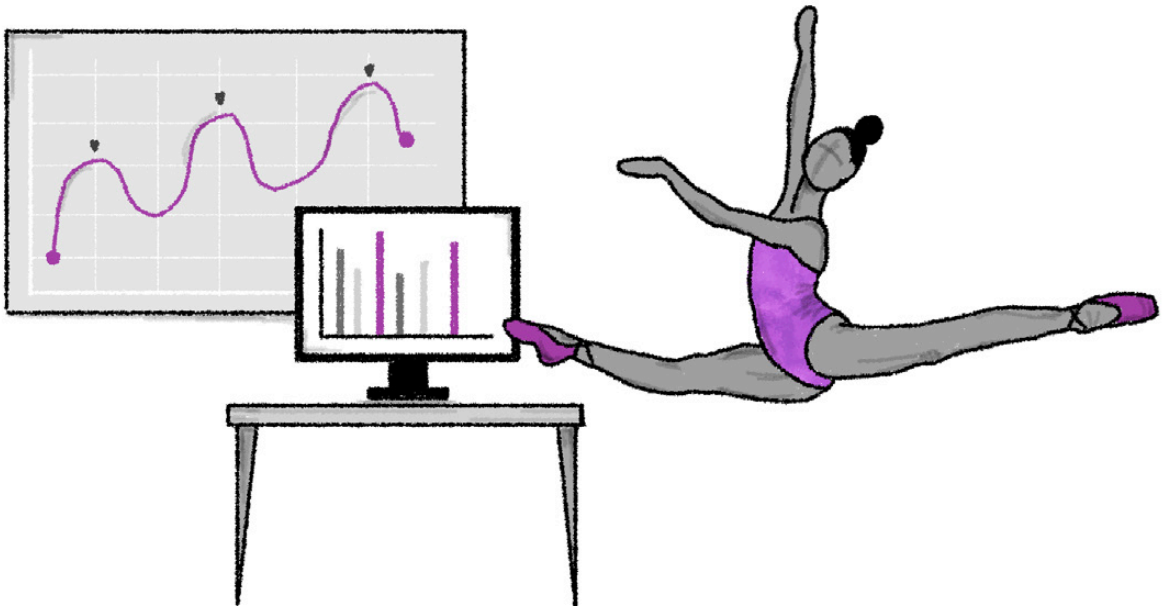
There is also a need to consider how the physicality of technology in the built environment may advantage or disadvantage different users. Designers and planners can seek to create environments that give people **freedom of movement and accessible information**, but it takes a mindset shift to do so. Accessibility to transportation, congestion and pollution may lead to dissatisfaction and social turmoil, ultimately affecting the health and wellbeing of citizens. Public transport stakeholders should work together to build systems-level collaborations, and the state agencies should provide support to improve the attractiveness, capacity and efficiency of public transportation. Today, we have all the technology and tools to make public transportation a compelling alternative option, not only in London but across the whole country[10]. Moreover, the data sharing platforms need to be in place to enable stakeholders to share necessary data to improve these systems.

This drives home the need to put **people and planet first** in decisions about digital technology. Investment in digital technology for its own sake, or for financial value alone, can lead to exploitative, exclusionary systems. It is for that reason that ethical frameworks and standards are so vital to enabling 'data for the public good'[11] and 'AI for good'[12] – frameworks that ask why technology is being used and who benefits[13]. At all levels of data gathering, modelling, and decision-making, the purpose of public good needs to be considered, whether that's ensuring **better inclusion and representation** in data sets, having transparency and review of algorithms, or considering how technology might exclude people with different physical or mental abilities, or levels of wealth and access.

No discussion of sustainability is complete without discussing socio-economic inequality. The same is true of economic recovery: an economic recovery that leaves people behind is not acceptable. Engels' pause is a term coined to describe the period from 1790 to 1840, when British working-class wages stagnated and per-capita gross domestic product expanded rapidly during the technological upheaval of the first Industrial Revolution[14], leading to deep socio-economic inequality. Even though the history showed that eventually Engels' pause came to an end and many people of different backgrounds benefited from the technological advancements in the long run, we know that the majority of those who endured the negative effects of these fast technological changes did not experience any betterment in their quality of life or prosperity. Many believe that the world can be at the edge of another such technological upheaval when faced with the data economy and digitalisation. It is the responsibility of governments, business leaders and anyone in decision-making roles to ensure that the technologies being implemented today benefit everyone equally.

One way of doing that is by ensuring a digital revolution does not mean working class jobs are replaced in great numbers in any region or across the UK. Today, the Fourth Industrial Revolution has already eliminated the types of jobs created for a host of machine operators during the earlier industrial revolutions[15]. The continuation of this trend could result with the displacement and even disappearance of jobs in favour of automation, robotisation and digital twins. Without counter practices to deal with this destructive shift there will be an increase in economic inequalities and resistance to these technologies. Therefore, the industry should firstly identify the purpose and benefits of using these new technologies; and secondly provide necessary education and training to fill the gaps between the future skill needs of the industry and the skillset of the current workforce. **Retaining jobs** for workers who are aided by AI, robotisation or other digital technologies will mean retraining and educating current and future engineers, assembly line workers, contractors and citizens in **digital literacy**, a range of skills and competencies that enable individuals to be critical and effective consumers, producers, users and managers of digital information and digital technologies. **Training, education and upskilling** are therefore a key part of the puzzle of bringing about a green information economy.

Central to the way we train and educate people is the idea of how the job market is configured. The country does not necessarily need people who are passionate about ballet to retrain to become data analysts, but it is important to have creative and data literate people throughout the built environment sectors, and society as a whole. Public literacy in data, technology and critical thinking is part of creating general resilience to shifting job markets. Similarly, creativity is fundamental to the future. Design, caring professions, the arts, and so on make the UK's culture richer and more meaningful, but also creative people in engineering, planning and data science can spot solutions others do not.



Younger generations have different values to their parents' generations, and they are making those values known through, for example, Fridays for Future (2018) and other demonstrations. This is a unique opportunity for today's educators and policymakers to change the current curricula not only towards data, digital technology, and more cooperative and **transdisciplinary education** and research environments[16], but also more ethical, human-centred and sustainable ones. Transdisciplinary curricula would enable young people to explore multiple ways of looking at our biggest crises and design challenges, to learn to work collaboratively and to find new solutions[17].

As we have seen in the Four Futures, when certain factors align, social divisions can widen and as a result the SDGs would be a missed opportunity. Therefore, decision makers should focus efforts not only on creating sustainable and resilient built environments, but also equal, ethical and trustworthy systems to bring them about. It is vital to understand the ethos behind the SDGs: complex, interconnected problems – such as poverty, environmental destruction, air and water pollution, disease and lack of education – require interconnected solutions. In this vital decade, there is a need for **better data** to support these solutions and track progress toward the SDGs. 'The SDGs call for a major effort to **mobilise data and monitoring frameworks** to track the transformations and share lessons on best practice. Outcome data on the SDGs remain incomplete. Filling these gaps will require the integration of official and unofficial data.' [18]

By harnessing data and digital technology, the UK can more easily meet the SDGs by digitalising healthcare, education, finance and other public services. Digital technologies can improve resource efficiencies, support zero-carbon systems and help monitor and protect ecosystems, and these changes need to happen rapidly, but industry and policymakers need to work together towards a unified vision xi. In this unprecedented moment governance, industry and research need to work together to deploy digital technology in ways that provide better outcomes for people and the planet. Digital technology can replicate old biases, but it can also shed revolutionary transparency on human rights and environmental abuses throughout supply chains. Outcome-based decision making using public good as the desired end point, connecting that to metrics and gathering the right data about those metrics could go a long way to helping us solve our planet's most pressing problems.

PROCURING FOR BETTER OUTCOMES

Procurement is a lever that even small organisations can use to make change in their Near Worlds.

For example, when faced with the COVID-related economic crisis that was disproportionately hurting indigenous communities, Tania Pouwhare, Community and Social Innovation Manager for Auckland Council in New Zealand, decided to highlight the underutilized talent of Maori and Pasifika businesses through procurement frameworks. 'We are a small team and don't have macro-economic levers, so we used the levers we did have – influencing the council's purchasing power through requiring employment and other socio-economic objectives in tenders and contracts.' Pouwhare and colleagues created Amotai, an intermediary organisation who could connect buyers to Maori and Pasifika-owned suppliers, and helps buyers draft procurement frameworks that centre justice for marginalised communities as a core value[19]. They began with the desired outcome – to support indigenous communities through their business leaders – and worked back to a procurement framework from there.

In this unprecedented time of economic pause amid converging crises[20], you can take this opportunity to reflect on what outcomes you'd like to see – what type of world you want to leave behind for future generations – and use those to develop the metrics to which you will hold yourself and your business partners responsible. Your values can shape the way you do business, your Inner World, which will alter the supply chains and lifecycle of assets touched by your organisation. This in turn feeds out into the Wider World and shapes outcomes nationally and even globally. You and your strategic partners can exert pressure together and demonstrate good practice through the choices you make starting from this moment.

For example, The Construction Innovation Hub Value Toolkit[21] provides a structured approach to embedding value and outcomes within clients' decision-making frameworks. This is based on a broader understanding of the capitals of value, such as natural, social, human and produced[22]. Each organisation, programme or project will have its own value profile and therefore the relative weighting of importance of these capitals will vary. 'Reinventing'[23] the built environment sectors means changing the relative weights of these capitals, not leaving behind financial value as a goal, but ensuring that other outcomes are given sufficient gravity in project portfolios and organisational strategies.

Trade-offs are an inevitable fact of strategic decision making. If your desired outcomes include zero carbon from new building projects, for example, this might change your ability to meet your economic goals in the traditional ways, by using cheaper materials if you're a contractor, or selling parcels of land for commercial development if you work for a local council. However, using frameworks to articulate clear outcome statements, assigning them metrics, and managing data well will help to navigate these trade-offs and reach positive outcomes.

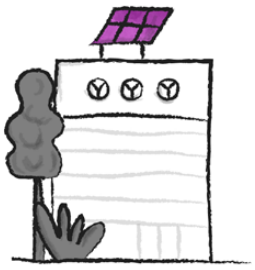
Why not use this as a moment for reflection on the values your organisation wants to cultivate?

PRIORITISE DECARBONISATION AND BIODIVERSITY

Carbon is just one greenhouse gas contributing to global heating as it grows in concentration in the atmosphere. Some authors have used the metaphor of our atmosphere as a bathtub[24], with carbon pouring out of the tap (in the form of burning fossil fuels for energy, transport and manufacturing, as well as other sources) to fill the bathtub, and biomass (trees, plants, algae, etc.) and other carbon sinks acting as the plughole draining carbon out of the atmosphere. If the net amount of carbon drained is less than the net amount pouring into the atmosphere, the bathtub fills – and we are currently nearing the total capacity of the bathtub. This is also sometimes referred to as the global carbon budget. As some of the biggest contributors to global carbon emissions[25], the built environment sectors have a responsibility to both cut net emissions and increase the amount of carbon captured in the materials used. Additionally, the assets created and managed by these sectors are long-lasting, so have a role in dictating future carbon emissions as well.

To stave off environmental destruction and heal the planet, we need to make some big changes in the built environment sectors. These changes will enable us to continue to grow and develop the built environment to support human needs while still respecting the planet's limits. Innovation of new materials, decision models and business models, as well as increasing the energy efficiency of construction and operation processes[26], would have a significant impact on overall global emissions.

Starting at the beginning (and end) of the building lifecycle, we can **prioritise design for reuse and remanufacture**, wherein materials from decommissioned assets are repurposed for future assets. The carbon footprint for reusing steel components, for example, is much lower than for creating new ones. We need to improve our ability to recycle these components safely and reliably, as well as create a market for previously used materials[27]. This would be part of a larger effort to create a **circular economy**, in which buildings, services and consumer goods become less and less reliant on the input of newly extracted or manufactured materials and before a product is created there is an identified route to reuse or remanufacture that product[28]. This emerges from an understanding of the reciprocal relationship between the built and natural environment; it is not enough to model the impact of buildings and infrastructure on natural ecosystems. There is a need to understand the ways in which the built environment relies on natural ecosystems for materials, food, energy, social and cultural services and many other things. Such herculean efforts to make the design decision-making in the built environment more circular also requires close collaboration and coordination between originators of the design and construction material supply chains.



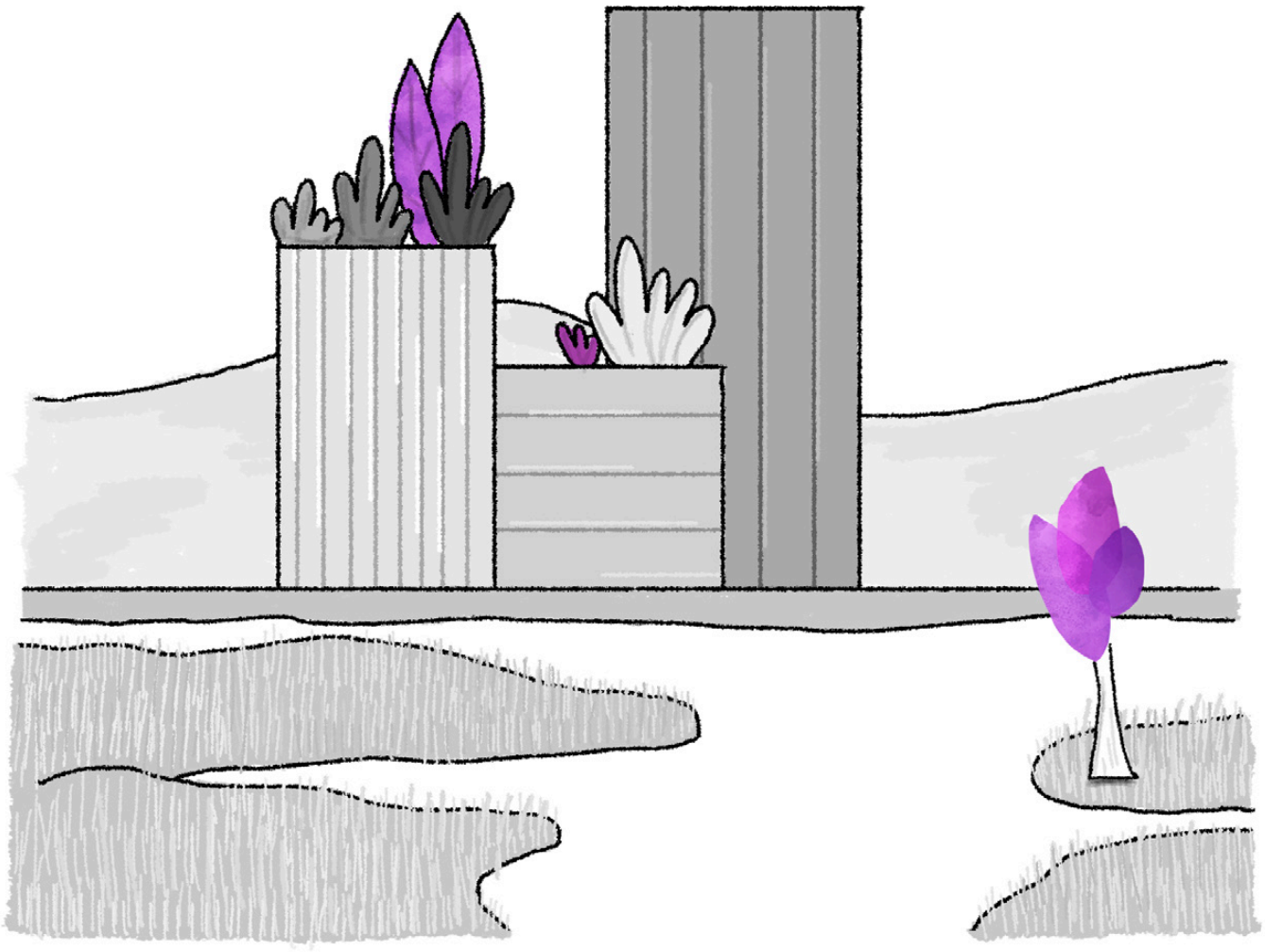
Similarly, innovative **modern methods of construction**, such as off-site and modular construction, additive manufacturing, and a platform approach to design for manufacture and assembly[29], may be opportunities to dramatically reduce the waste created and energy used during the construction phase[30]. **Digitally managed operations** using a BIM methodology and/or digital twins may also help reduce the carbon footprint of assets while they are in service by giving better data about energy use and other aspects of performance, enabling smarter maintenance and longer life. By extending the life of assets, we can reduce the overall footprint of the built environment, as 'the greenest building is the one that already exists'[31].

Finally, the decision process for planning needs better insights about when new buildings and assets are required, disincentivising new builds where appropriate[32] and **balancing the built and natural environment** through intelligent land use that considers long-term trade-offs, and by using nature-based solutions (green infrastructure) to solve problems where appropriate. Green infrastructure is the multifunctional use of nature integrated into human systems to solve human and environmental needs[33] and may include things like planting trees as flood defences or creating multi-purpose urban green spaces that manage storm water, support biodiversity and serve as recreation areas for local communities. While green infrastructure already forms part of the UK National Planning Policy Framework[34], it is important to treat it as more than a tick box on individual projects that can be met by adding a green roof, and embed it in the planning and procurement culture. Ideally, planning support systems will be able to model systems adequately to understand the impact of new build vs. refurbishing vs. green infrastructure on current and future communities, ensuring the right interventions in social and economic infrastructure are made for the right reasons.

GREEN INFRASTRUCTURE EXAMPLES

Green roofs in Basel:
The city of Basel has increased the coverage of green through the use of a combination of financial incentives and building regulations. This initiative will help mitigate the effect of increasingly warm summers, save energy on heating and cooling buildings, and support biodiversity by providing islands of habitat for wildlife all over the city[35] Digital modelling could help determine the top priority sites for installing green roofs, just as The Hague used data visualisations to understand links between green infrastructure and social outcomes[36].

Flood management in Beam Parklands:
Beam Parklands in Barking and Dagenham provide multiple benefits to the environment and the local community. The design of the parklands intentionally preserves wildlife habitats and creates floodwater storage to protect the surrounding built environment, while making the park more accessible and attractive to the surrounding communities[37].



GOVERNANCE TODAY FOR A BETTER TOMORROW

While individuals and organisations have power to shape the future, governance holds a central role in success. For example, it can set the **minimum standards** for natural, human and societal value, close loopholes that enable **ecocide** in the supply chain and set in place social support mechanisms such as national health services and **income support**[38]. Due to the complexity of existing systems, a wide range of governance tools will be needed to meet the SDGs by 2040. Governments should pursue policies 'to kick start the productivity growth while helping workers adjust' to rapid changes due to automation, robotisation, AI, autonomous vehicles, and similar technological changes. This also includes addressing the social cost of the effects of these technological changes. Major reforms on education, reducing barriers to changing jobs, helping people to easily move, getting rid of zoning restrictions, improving incomes and providing wage insurance to the people who lose their jobs due to the effects of these technological changes are all important steps to mitigate the negative outcomes of changing work environments and economic realities[39]. Training and reskilling could also be provided to people who lose their jobs as a matter of priority, to ensure they have the tools necessary to quickly re-enter the workforce.

Governance can also hold organisations accountable for social and environmental wellbeing, especially at times of economic difficulty. **Government bailouts** for struggling sectors – especially those sectors who have historically contributed the most to carbon emissions – 'should embed strategic conditions in order to align corporate behaviour with the needs of society'[40]. Long-term, these conditions should be used to ensure dignity at work, representation and environmental responsibility. These changes also need to be cross-sectoral, 'harnessing supply and demand, innovation and procurement, and public and private actors'[41].

While the SDGs set targets for reducing poverty and environmental destruction, **Green New Deal**-style policies attempt to address both crises simultaneously. While the specifics vary from country to country, proposals for Green New Deal policies seek to mobilise the workforce and create jobs by commissioning public works projects aimed at massively overhauling transport, energy and other infrastructure to be carbon neutral. If this legislative route were selected, the UK government could put people to work while simultaneously upgrading our infrastructure to disentangle us from future carbon emissions.

A vital component of reconfiguring and decarbonising infrastructure and services will be having better data and insights about them. Policymakers can enable a green information economy that would incentivise data sharing in the interest of better infrastructure performance as part of a wider effort to legislate for the benefit of future sustainability. A UK-wide **Future Generations Act**, like that passed in Wales in 2015[42], could help frame future legislation in the context of its impact on the ability of future generations to live a healthy, happy life on this planet.

As the Four Futures showed, any scenario with a shrinking workforce would potentially make widespread digital transformation more difficult to achieve[43], while at the same time making that transition more urgent. Labour migration, therefore, can reduce the decline of Europe's working age population. On one hand, COVID-19 and the xenophobic, fear-focused rhetoric around the crisis could provide the political space to implement structural policies to combat those fears and boost immigration rates. On the other hand, earlier resources from United Nations Population Division predicted constant net migration levels until 2050[44]. According to the UN, in high-income countries, net migration is projected to account for 82% of population growth. In most of these countries, the population size would decrease without future migration. At the same time, according to Migration data portal[45], migrants stand to add 71 million people to the working age population of the European Union by 2081. These two different outcomes and the current uncertainty around the COVID-19 pandemic crisis could put migrants and their families, as well as some of the foundations of the global economy, at risk of prejudice and social exclusion[46]. This would require **an end to any hostile policies toward immigrants** to the UK, who continually give more to the economy and society than they take[47].

Increasing **access to digital skills and infrastructure** is vital to ensuring universal access to a green information economy. 'Of the eight million in the UK who don't use the internet, 90% suffer from other kinds of economic or social disadvantages. They are also more likely to be in the lowest income bracket and/or be disabled with long-standing health conditions,' observes Dr Gemma Burgess[48]. The digital skills divide[49], therefore, is comorbid with poverty and other social stressors[50]. Burgess argues that tackling poverty, as well as expanding and subsidising broadband access, are essential for COVID recovery. While this is in part the role of national and local governments to ensure, organisations can help by lobbying and facilitating widespread access. The benefits to society of wider digital skills and literacy will in turn have benefits for businesses who want to recruit digitally literate employees and shift to digital ways of working. It also creates the opportunity for co-design and digital democracy, giving decision-makers, designers and planners better access to information about the wants, needs and insights of their public stakeholders.

The final governance strategy that is worth exploring is the greater involvement of citizens in governance processes through **participatory democracy and digital democracy**. With recent advancement in digitalisation and smart technologies, ordinary citizens who may not possess the technical skills of city planning are now shaping their cities in unorthodox but crucial ways. Starting in Brazil in the 1980s and spreading to some 1,500 cities worldwide, participatory budgeting, a 'socially inclusive' and transparent approach to city administration, now limits the monopoly that city authorities have enjoyed in unilaterally making spending decisions on city projects, by giving ordinary citizens a voice in those decisions[51]. Citizens' assemblies and online polls and petitions are another way people can interact with and influence the direction of policy. Similarly, crowdfunding is a technique where ordinary citizens raise capital from a large and diverse pool of donors via online platforms to complement public sector spending on local projects or to entirely finance a local community by themselves[52]. Recent studies on e-participation in planning have shown the prospect of how apps can prompt users to send comments on their surrounding environment to city authorities when they get to areas that have been proposed for physical changes[53]. Other apps are helping city authorities to receive up-to-date geo-tagged information on environmental problems such as potholes and damaged pavements from ordinary citizens and thereby prompting some response from city authorities[54].

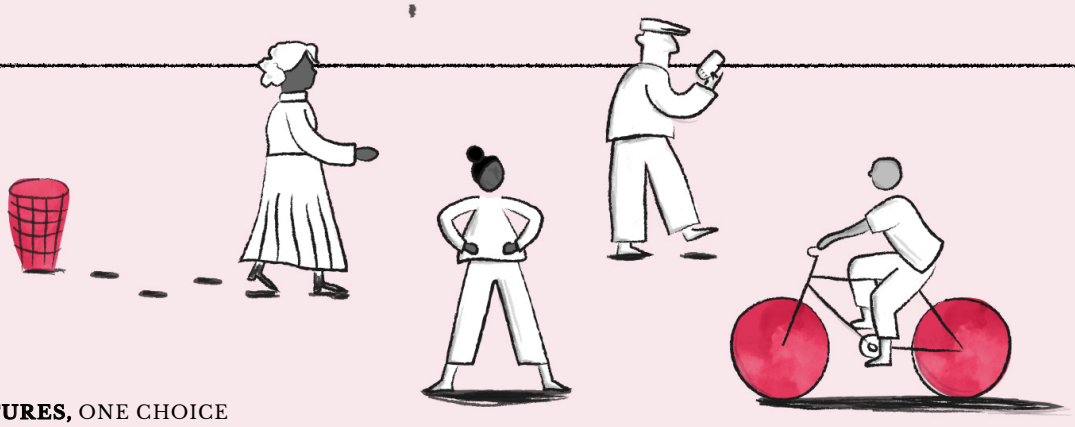
Governance is a vital mechanism for the type of widespread change we need to see in order to bring about the future we want. However, individuals and organisations have the power to vote for and influence policymakers, and campaign for policies that will make a difference. It is also always in the power of organisations to go above and beyond minimum standards for social and environmental wellbeing, recognising the long-term value and necessity of investing in these areas.

STRATEGIES FOR A BETTER 2040

These recommendations represent the ideas of the authors based on our expertise and exploration of the issues facing the UK over the next 20 years.

Thoughtful investment in digital technology	Prioritise decarbonisation and biodiversity	Governance today for a better tomorrow
Protect jobs: partner automated elements with human operators, monitors and decision makers.	**Circular economy:** design buildings, infrastructure and components for reuse and remanufacture; create a market for pre-used materials; digitally track materials through their lifecycle to ensure maximum value is acquired before disposal.	**Supply chains:** set higher minimum standards for transparency and sustainability.
Secure data economy: strengthen data protections for individuals while fostering an open data economy.	**Modern methods of construction:** invest in and research off-site, modular construction and platform approaches to find the best fit to deliver low- or zero-carbon projects.	**Accountability:** hold responsible parties accountable for ecocide and pollution.
Put people and planet first: use guiding principles and frameworks consider why technologies are being deployed or data is being collected.	**Balance built and natural environment:** by managing trade-offs between the needs of people and the planet, valuing ecosystem services and using nature based solutions where possible.	**Shrink the wage gap:** enable people to retrain for the digital future, and pursue careers that benefit society, by ensuring a living wage.
Target technologies that make lives better: for example, smart transport options that increase mobility for people with disabilities.	**Nature-based infrastructure:** prioritising local biodiversity, accessible green spaces, and nature corridors.	**Bailouts:** set conditions for relief packages that include environmental and human rights requirements.
Better inclusion and representation: work against replicating human and systemic biases in digital data and technologies.	**Decarbonise energy supply while reducing demand:** to achieve the most ambitious climate targets, both approaches are required.	**Green New Deal:** create jobs across the regions on big smart infrastructure projects that will help the transition to a green information economy.
Increase connectivity: shrink the digital divide and support remote working and education by investing in rural and local ICT infrastructure.	**Resilient infrastructure:** prepare for the unexpected by commissioning infrastructure that can be reconfigured for multiple demographic and climate scenarios	**Future Generations Act:** ensure legislation and planning decisions meet the benchmark of supporting the wellbeing of future generations.
Skills, training and education: up-to-date training and reskilling curricula with an emphasis on digital literacy, transdisciplinarity and sustainability.	**Understand dependencies of sectors on natural resources and materials:** consider not just the impact of the built environment on natural ecosystems,but the reliance of the built environment on healthy natural ecosystems.	**Welcoming environment:** end hostile environment to refugees and immigrants, who will continue to benefit the culture, economy and workforce of the UK.
Manage digital information better: using a BIM methodology to create a golden thread of asset information will help to realistically assess the environmental impact of the built environment, and ensure safety.		**Participatory democracy:** encouraging civic engagement through citizens' assemblies, digital democracy and co-design.

05 Conclusion



CONCLUSION

The year 2020 seems to have been defined in the popular culture by complex, interconnected crises, from the pandemic and economic downturn, to the climate emergency, online disinformation and racial injustice. These unprecedented problems all intersect with one another in the built environment and are connected to digital transformation. For example, in low-income communities in the UK, population density, lack of access to healthy food and activities and poor air quality combined to result in worse outcomes from COVID-19 than higher-income areas. The way the built environment is configured and operated currently tends to reinforce inequality, but it is not inevitable – we can make better decisions. And making better decisions about the built environment is key to ensuring people's lives are better in the future.

No model, no scenario, no prediction about the future can be completely accurate, but considering and analysing what could be is an important step to better understanding how to build in the type of broad resilience to the unknown – to unprecedented times – that will help us thrive in the face of whatever the next 20 years have in store for us.

We, the authors of this book, have provided advice for steps you can take, no matter what your role is in the built environment – designing, building, operating, or living in it. We presented priorities and potential steps to take ways of thoughtfully investing in and implementing digital technology, greening the built environment, and developing policies that protect the rights of future generations. Indeed, we are not alone in wanting to seize this opportunity, as every week seems to bring a new consultation, dialogue[1], report[2], article or event discussing what the next steps[3] are for manufacturers, construction, utilities, transportation, politicians and consumers. This is a vital moment in the global story, with many possible paths laid out ahead – but ultimately it is up to you to decide what you're going to do.

What kind of future do you want to live in and what are you going to do to make it happen? **It's your choice.**

APPENDIX 1
ORIGINALITY OF THIS WORK

This section discusses in more detail the originality of this book and its underlying work in the context of the scenario planning method and its application to the built environment and digital technology.

Scenario planning is an established future studies method with rich and varied application (Ringland & Schwartz, 1998; Schoemaker, 1995). It has been applied to support the decision-making process through studying the present in order to better understand the possibilities of tomorrow. In a rapidly changing world, the only certainty is change itself (Ringland & Schwartz, 1998). The scenario planning methodology is "that part of strategic planning, which relates to the tools and technologies for managing the uncertainties of the future" (ibid, p.2). It is an internally consistent view of what the future might turn out to be: not a forecast, but a set of possible future outcomes (Porter & Millar, 1985).

The scenario method has its critics who focus on the lack of a transparent academic basis for the future scenarios (Jefferson, 2020). However, by widening decision-makers' points of view, the scenario method can provide greater clarity (Wright et al., 2020) and lay the groundwork for influence campaigns (Gordon, 2020).The goal of the scenario building activity in this study was to analyse plausible medium-term futures rather than making short-term prognoses. For this reason, this study used the methodology to develop possible future scenarios about the world in 2040, to illustrate how the built environment for the UK could look when different certainties and uncertainties are considered. It then explored how these broad and complex future alternatives can be shaped by strategies that are available to implement today.

Scenario methods have been applied to the sustainability and digitalisation of the built environment in various ways, often focused on a narrow context or set of parameters. Epprecht et al. (2014) use scenario planning to explore decarbonisation of transportation using automated versus manual fleets, and Parkinson et al. (2012) use the method to predict energy use in the UK built environment. Magnusson et al., (2020) use a similar method to explore fossil fuel free transportation networks. These papers focus on specific aspects of the built environment, while others take a broader, system-wide approach.

For example, Erdogan et al., (2010) envision the construction sector in 2030, using a workshop to explore four broad scenarios characterised by different economic models and resource management strategies. Iwaniec et al. (2020) use a related methodology to explore only the future scenarios deemed to be positive and desirable, while considering the built environment as a complex system-of-systems. In most of these previous studies, the time period considered is far enough in the future to be uncertain, but near enough for present-day decision-makers to exert some control over the outcomes, often between ten to thirty years.

Other studies focus on understanding technological trends and their implications for implementation and architectures of smart cities. For instance, Silva et al., (2018) presented an extensive description of smart cities, identified key characteristics, presented real implementations and identified opportunities and challenges for the realisation of smart cities. Nitoslawski et al. (2019) explored how the management of urban forests and green infrastructure can be integrated into smart city planning by considering the increase in data-driven research and applications such as sensor networks, big data analytics, robotics, and augmented/virtual reality. Ahmad & Chen (2020) reviewed machine learning and artificial intelligence as a promising technological trend and identified the advantages, limitations and real-time applications of machine learning models for load planning and energy management in future cities.

Considering how effective a scenario method is in decision support, Ram (2020) explores the strategies of decision-makers with differing relationships to risk, noting that risk-aversion is best addressed by steering decisions away from scenarios in which they predict future regret. The scenario method has its critics who focus on the lack of a transparent academic basis for the future scenarios (Jefferson, 2020). However, by widening decision-makers' points of view, the scenario method can provide greater clarity (Wright et al., 2020) and lay the groundwork for influence campaigns (Gordon, 2020).

In the original study we, the co-authors, used scenarios to analyse plausible medium-term futures rather than making short-term prognoses. We used the scenario methodology to develop possible future scenarios about the world in 2040 to illustrate how the built environment for the UK could look when we consider different factors. We then explored how these broad and complex future alternatives might be shaped by strategies that are available to implement today, making this application of scenarios novel in the built environment literature.

APPENDIX 2
INFLUENCING FACTORS

The table below lists the factors that were identified during the workshop on Day 2. Later, they were re-evaluated and organised under the five dimensions by the authors and considered during the scenario building exercise. For each scenario, the authors have considered what the state of each factor might be, written here as brief summaries. This detailed work forms the foundations of the scenarios described in this book.

The dimensions are abbreviated as follows: Natural Environment (N), Digital Technology (T), Economy (E), Built Environment (B), Society (S).

Key Factors	Dimension	Scenario A:	Scenario B:	Scenario C:	Scenario D:
Sustainable Development Goals	All	SDGs reached	SDGs reached	SDGs not reached	SDGs not reached
Demographics/ dependency	All	High	Low	High	Low
Mobility solutions	S	Increasingly connected through digital platforms	Fully connected transport-as-a-Service platforms	Service-oriented with minimal digital connection	Transition toward connected platform
Transportation	B	Sustainable public transport	Green, integrated and predictive	Pressure for further green transport	Informal shared private transport
Digital connectivity	T, B	High	High	Fragmented	High
Working patterns and labour market	S, T	Longer working hours, greater automation; more remote working, growing service and caring sectors	Flexible, new skills, creative and digitally enabled; more remote working	Moderate remote working, greater automation	Longer hours, more remote working, less automation
Data regulation and privacy	S	Strong regulations with bias toward openness	Strong regulations incentivising openness with appropriate security	Regulation has lagged behind need	Not prioritised

Data economy	E	Improved for monitoring systems	Vital part of economy	Limited application to support public health	Becoming a priority
Digital twins	T, B	Modelling mostly limited to critical infrastructure (e.g. hospitals)	Fully adopted with high level of shared data	Monitoring of critical infrastructure	Fully adopted with low level of shared data, organisational siloes
Social behaviour	S	More social cohesion	More social cohesion	Less social cohesion	Less social cohesion
GDP/general economy	E	Recession	Peak	Recovery	Through
Internet of Things	T, B	Medical / environmental focus	Internet of Everything, full implementation	Gradual increase in uptake	Gradual increase in uptake
Automation/ robotisation	T	Increased in medical, environment and manufacturing	High rate of adoption in collaboration with human workforce	High uptake to make up for loss in workforce	Moderate uptake
Digital engagement	T, S	High	Very high	High	Increased
Smart cities	S, B, T	Low uptake	Key concept connector / hub	Advanced	Trying to increase but might be blocked
Post-Brexit legislation	S	Stagnation and no agreements for immigration but has for climate change	Agreements in place for both	Agreements in place for immigration but not for climate	Stagnation and no agreements for immigration or climate change
Average lifespan	S, N	Increase	Increase	Stable	Possible decrease
Natural resources	N	Renewable and recovering	Renewable and recovering	Under pressure, becoming unavailable	Under pressure, becoming unavailable
Health/healthcare	S, E	Public health supported by digital data and environmental protection	Public health supported by digital data and environmental protection	Better provision of Healthcare through digital technology, but lower quality health	Low healthcare provision and lower public health
Air/water/soil quality	N, S	Recovering rapidly	Recovering rapidly	Badly deteriorated	Badly deteriorated

Access to nature/ green space	N, S	Highly increased	Highly increased	Equal to 2020 levels	Less than 2020 levels
Effects of climate change	N, S	Manageable: similar to 2018 projections for –1.5° C warming	Manageable: similar to 2018 projections for –1.5° C warming	Run-away: similar to 2018 projections for +1.5° C warming	Catastrophic Run-away: similar to 2018 projections for +1.5° C warming
Waste disposal	N, E, S	Circular economy	Circular economy	Deepening waste disposal	Deepening waste disposal crisis
Coronavirus recovery	S, E	Slow green recovery with investment in society, jobs and digital technology	Rapid green recovery with investment in society, jobs and digital technology	Austerity and bail outs lead to a few chosen winners and a long recovery with no green components	Austerity and bail outs lead to a few chosen winners and a long recovery with no green components
Environmental protection legislation	S	Rapidly strengthened	Rapidly strengthened	Slowly strengthened, not equal to challenge	Slowly strengthened, not equal to challenge
Austerity	S, E	Abandoned in favour of investment in social and environmental programmes	Abandoned in favour of investment in social and environmental programmes	Continued as a means of economic recovery	Continued as a means of economic recovery
Planning process and policy	S	Focused on green infrastructure projects and healthcare	Focused on green jobs, digital economy and housing	Focused on combating effects of climate change and healthcare	Focused on housing, supply chains and combating effects of climate change
Artificial intelligence	T, B	Rapid – mature	Emerging – mature	Rapid – disruptive	Emerging – disruptive
Autonomous vehicles	T, B	Mature – wide usage	Mature – wide usage	Emerging – low adoption	Emerging – low adoption
Education, training and skills	S	Stable, not much improvement	Digital, data and green design focused	Digital and security focused	Pressure for increased digital skills education
Taxation	E	Increased taxes	Taxation model changes	Wider tax net	Increased taxation and tax evasion

ENDNOTES

01 UNPRECEDENTED TIMES

Preface and Keywords

1 See UK Green Building Council, 2019.

2 See Data & Analytics Facility for National Infrastructure, 2019.

3 See Bolton et al., 2018.

4 See Lee & Seshia, 2016.

5 See Gitelman, 2013.

6 See Bogman, 2007 cited in Kitchin, 2014.

7 See National Infrastructure Commission, 2017.

8 See Dorsemaine et al., 2016.

9 See Institute of Electrical and Electronics Engineers, 1990.

10 See Schooling et al., 2020

11 This is a common definition used across multiple standards but see for example BS ISO 15392:2019. It derives from Our Common Future, also known as the Brundtland Report (World Commission on Environment and Development (WCED), 1987).

12 See Dignum, 2017.

13 See Maeda, 2019.

Unprecedented Times

1 See Williams et al., 2020.

2 See Crump, 2020.

3 See Heglar, 2020.

4 See Jansen et al., 2020.

5 **Lessons for the future:** For a discussion of disaster preparedness cautionary tales and lessons for the future, see Harford, 2020.

6 See United Nations, 2015b.

7 See Department for Business Energy & Industrial Strategy, 2019.

8 See Dunstan et al., 2018.

9 **General resilience:** To be clear, strategic stockpiles at the local and national government level to enable general resilience to unforeseen events is not the same thing as hoarding toilet paper or any other reactive activity in response to a specific disaster. It's carefully planned and monitored distribution of supplies based on models of where the greatest need would be in the face of multiple possible crises. Scenario planning and data from past crises can help determine what is needed and where to provide the best trade-off between life-saving capacity and resource efficiency.

02 MEETING OF MINDS

1 See Lindgren & Bandhold, 2009.

2 **How scenario planning is applied:** Scenarios have been applied in a wide variety of contexts (see Ringland & Schwartz, 1998; Schoemaker, 1995). Generally, though, it has been applied to support the decision-making process through studying the present in order to better understand the possibilities of tomorrow when the only certainty is change itself (Ringland & Schwartz, 1998).
See Appendix 1 for a discussion of the originality of the approach as applied in this book.

3 See Ringland & Schwartz, 1998, p.2.

4 See Porter & Millar, 1985.

5 See Roxburgh, 2009.

6 **Scenarios methodology explained:** In this methodology, first a trend spotting activity is performed to identify the possible driving forces and influencing factors (certainties and uncertainties) on the context in question. These factors are analysed and ranked depending on their importance to the research objective. Then, scenario planning is used as a tool to imagine, organise and describe different future states based on the differences between the highest-ranking factors in the imagined futures (see Featherston & O'Sullivan, 2017; Konrad & Böhle, 2019we explore ways that FTA might be structured to investigate the complex innovation system journeys of novel technologies as they are developed, diffused, and deployed. In doing this, we draw on concepts from technology and operations management and related literatures to more carefully characterise the: (1). Workshops are considered the most useful technique for scenario planning (see Huss & Honton, 1987), because trial and error are necessary to produce the type of convergent thinking that makes for effective scenarios.

7 See Shell, 2017.

8 **Research context:** The context for this question is Britain, a subset of the UK comprising the countries of England, population 56,000,000, Scotland, population 5,000,000 and Wales, population 3,000,000 (Office for National Statistics, 2020). Britain's digital transformation is among the most mature globally (Breene, 2016), led by various figures in industry, government and academia. In the built environment, the three nations that make up Britain work closely together through the Home Nations Working Group (Centre for Digital Built Britain, 2020a) and the standards for digital data and information in the built environment are exported to become the international standards (Centre for Digital Built Britain, 2020b).

9 **2050 Net Zero Carbon Target:** This was the UK's target at time of writing but, as with all targets, may change in response to public or political pressure.

10 **Participants' backgrounds:** Wade (2018) argues that the ideal group size for scenario planning workshops is between 16-28 with group size of 4-5 participants. The facilitators of the workshop followed this guidance to maximise the outcome of the collaborative work. The participants' research interests span digital twins, digitalization of the BE, architecture, sustainability, stakeholder engagement, smart infrastructure, urban planning and related areas. These interdisciplinary backgrounds of the participants ensured that each dimension and factor was informed by different perspectives. In other words, the participants were selected relying on 'disciplined intuition', commonly adopted in studies following the intuitive logics approach (Bradfield et al., 2005).

11 **Centre for Digital Built Britain:** CDBB is a UK government-funded body, established in partnership with University of Cambridge in 2017, and aims to support the transformation of the UK construction sector using digital technologies to better plan, build, maintain and use the built environment.

12 See Lindgren & Bandhold, 2009.

13 This section contains multiple passages from an earlier journal article based on this research, Gürdür Broo et al., 2020.

14 **Discussing the Focal Question:** According to Huss and Honton (1987), the definition of the scope of analysis is the first step of the scenario planning work and it should focus on long range consequences, considering a time frame between three and 20 years (Bradfield et al., 2005).

15 **Trend spotting forms:** Each factor was recorded its own form. This form included the name of the factor, evidence of the importance of the factor and potential outcomes of the factor.

16 **Brain storming influencing factors:** As pointed out by Huss and Honton (1987), analysis tools such as brainstorming are appropriate for factors identification and discussions of certainties and uncertainties and their relationship are relevant in the analysis of influencing factors shaping the scenarios.

17 See McCarthy, 1978.

18 See Klooster & Asselt, 2006.

19 Sustainable Development Goals: See United Nations, 2015.

20 See The World Bank, 2019.

21 See Greve, 2012.

22 See Government Office for Science, 2016.

23 **Evidence from the workshop:** The workshop was documented by photographs taken at different stages throughout the two days with permission of the participants. Additionally, the notes, charts, post-it notes, discussion points and white board drawings were also collected and archived. The authors of this book used this archived information and worked collaboratively to re-iterate the process and finalised the details of the scenarios. This more detailed analysis outside the scenario process was a critical step to determine the implications of the scenarios, as recommended by Huss and Honton (1987).

24 **Trend spotting and influencing factors:** In this methodology, first a trend spotting activity is performed to identify the possible driving forces and factors of digital transformation in the built environment. Identified factors are analysed and ranked by the researchers depending on their importance to the research objectives and assigned to dimensions of the built environment. The factors we considered included: transportation, digital connectivity, working patterns and labour market, data regulation and privacy, GDP, Internet of Things, automation, digital engagement, post-Brexit legislation, resource availability, public health, air quality, access to nature, global temperature, coronavirus recovery, environmental protection legislation, austerity, planning process and policy, artificial intelligence, education and taxation (see Appendix 2 for full list). Higher-ranking factors are selected and categorised as certainties, or uncertainties, and assigned to the most relevant dimensions of the built environment. We did not conduct original research into each of these areas, but rather used existing research to understand how each factor might develop in our four scenarios. To give adequate focus to the scenarios and their implications, these activities are not covered in detail in this book.

25 **Scenario planning and innovation:** Carefully crafted scenarios are important elements in the governance of innovation processes (see Konrad & Böhle, 2019) and are a useful analytical tool for the production and distribution of knowledge on innovation.

26 See UK Green Building Council, 2019.

27 **Infrastructure:** The infrastructure as part of the built environment includes a range of services, such as transport, telecommunications, energy, water, waste and similar. Howes & Robinson, (2005) define infrastructure as central to the socio-economic development of countries and the wellbeing and prosperity of the society. The growth in urban populations shows how important it is to develop high-quality, well-planned infrastructure to provide the resources and everyday services needed by the inhabitants of the cities (The Visa Transportation Centre of Exellence, 2019). Moreover, the level and quality of infrastructure development plays a critical role for national economies to remain competitive and innovative. Centre for Digital Built Britain, (2020) details infrastructure as: 'the interconnected "system of systems" that provides the physical foundation for our society. It does more than just provide water, power or transport services; it helps to make cities liveable, boosts quality of life and supports productivity and prosperity, all in the context of its interface with the natural environment' (p.3). Nevertheless, the infrastructure is accepted as one of the most significant contributors to anthropogenic environmental change. The rapid urban growth and its anticipated escalation in the following years could pose significant challenges to infrastructure, increasing the demands in provision, quality and speed. These challenges are likely to be further exacerbated by the requirements for an energy efficient and carbon neutral future

of the built environment. More precisely, the UK has put in place legally binding commitments through the Climate Change Act to reduce the energy requirements and carbon emissions by 2050 (Department for Business Energy and Industrial Strategy, 2008). The construction and operation of buildings in the UK is responsible for approximately 40% of carbon emissions, therefore rendering a low impact design (LID) of infrastructure a critical factor in achieving these targets (UK Green Building Council, 2019). The continuous and increasing digitisation of the built environment is likely to occupy important niches in addressing these issues, through the incorporation of live feedback devices, AI and Internet of Things technologies in the built environment to optimise its design and operation. It becomes critical to design an integrated, resilient and resource-efficient infrastructure to achieve a lower-carbon and connected future. The level and quality of infrastructure development will play a critical role for national economies to remain competitive and innovative (Howes & Robinson, 2005).

28 **Wellbeing:** Access to urban green spaces, even small parks and gardens, have marked health benefits, but also help form a sense of community, foster an interest in nature and contribute to wellbeing in various ways. Fish et al., (2016) outline this in their framework for cultural values of ecosystem services. It is clear that intangible ecosystem services make urban, rural and wild nature a valuable resource in its own right apart from the other resources and benefits it provides. The preservation of wild spaces for the future is seen as having great inherent, albeit non-material, value (Bilmes & Loomis, 2016), showing that the preservation of even distant 'natural' spaces has value to people, fostering a sense of national pride, awe or aspiration. In totality, these ecosystem services to survival, livelihoods and wellbeing contribute more than twice as much to human wellbeing than the country's GDP (Costanza et al., 2014). Shortages of any of these resources will put pressure on the built environment as local, regional and national authorities try to manage the impacts, and residents and businesses face uncertainty. The uncertainty will occur at different times and different magnitudes for those with different intersecting vulnerabilities, such as age, physical and mental ability, socio-economic status, geographic location, ethnicity and gender. Even if the worst impacts of resource scarcity have yet to appear in the UK, global insecurities are likely to lead to more migration violent conflicts and global security threats if unchecked. Planning of the built environment has the potential to improve or exacerbate these problems, as discussed in later sections.

29 **Innovation:** Technological advancements are seen as a potential driver to transform how the built environment is delivered, managed and automated. Traditional roles, business models and measures of value are expected to migrate, and the built environment sectors need to recalibrate to meet that change (Bowers et al., 2018). Digital technologies bring opportunities to secure better performance and lower cost by enabling more intelligent operation of mature networks, more efficient operation for new infrastructure, and better whole-life value (ibid.). They also contribute to a more sustainable built environment (Centre for Smart Infrastructure and Construction, 2019). One vital foundation for technologically advanced, data-driven and smart built environment is data-centric decision making – through digital twins supported by technologies such as artificial intelligence (AI) and machine learning (ML), and visualisation. Data and digital twins can offer an opportunity to extract patterns; to evaluate the interoperability, complexity, and sustainability; to create an overview of the current systems; and to make smarter interventions in the built environment. The effective use of data and approaches can capture different viewpoints for the numerous stakeholders, focusing on what most interests each individual stakeholder (Gürdür et al., 2019). This can lead to optimising performance, automation, and the cooperation of distributed systems, development environment, and teams to deliver better decision-making (Gürdür, 2017). As the built environment is increasingly digitised and technologies allow governments, municipalities and decision makers to collect large quantities of data regarding a plethora of issues, technologies such as AI will also play a critical role on data processing. Through AI, the built environment will be able to digitally support intelligent and responsive services in real time. Another important aspect of this dimension is the effects of digital technology on the usage of and interaction with the built environment. For instance, today, the majority of smart built environments, including cities and infrastructure lack the ability to talk to each other and have very limited control and monitor operational functionalities (O'Reilly et al., 2001). Yet, through digitalisation, sensing technologies, data creation and sharing, artificial intelligence and other technological advancements, built environment is expected to transform into more of a self-

monitoring, self-governing systems of systems (Alavi et al., 2019).

30 **Mobility:** The key to success of any built environment lies in the ability to move people and goods quickly and easily and the mobility dimension is simply related to this ability. One result of the growth of urban populations and the rural-to-urban shift, is increase in the numbers of megacities. The UN (2015b) defines a megacity as having a population greater than 10 million people. According to The Visa Transportation Centre of Excellence report (2019), one in eight people currently lives in 33 megacities around the world. It's projected that there will be 43 megacities by 2030, and 50 megacities by 2050. With the increase in urban population, and the trend of megacities combined with the significant pressure on roads and mass transit systems, many cities face congestion and overcrowding. Even though in different parts of the UK urban planners and authorities are making huge infrastructure investments – for instance the Crossrail project in London – which may provide temporary relief for transport networks, the future for mass transit systems and the effect of emerging technologies to mobility requires further study. In the age of the Fourth Industrial Revolution, today, the convergence of industry and technology is leading to the emergence of, for example, clean energy vehicles or connected, intelligent, autonomous mobility solutions (Audenhove et al., 2014). Audenhove et al. (2018) presents findings on 100 cities worldwide. The report underlines that most cities still need to work intensively on improvements to their mobility systems if they are to cope with the challenges ahead. The global average score of the 100 cities were 42.3 out of a possible 100 points, which means that, worldwide, an average city has only unleashed less than half of the potential of its urban mobility system. The same study also found that only 10 cities were able to unleash more than half of their potential and London was in seventh place, while no city scored more than 60.

31 **Smart green cities:** Smart, resilient cities are also at the centre of the positive vision of the future outlined by Figueres & Rivett-Carnac (2020)– the future that they argue we must choose if we are to avoid catastrophic climate change. Aligning policy to positive visions such as these would help achieve the SDGs faster and with more cross-party buy-in.

32 **Economy:** Built environment investments form the large part of the tangible investments made-up in the national GDP. The construction sector contributed £117 billion to the UK economy, 6% of the total of UK GDP in 2019 (Rhodes, 2015). While built environment investments can be defined as tangible asset investments, the UK economy still has seen an increased dependency upon intangible investments needed to produce the tangible built asset. Bröchner (2008) defines the built environment as the accumulated residual history of mostly man-made environmental change and adds that: 'Buildings and the physical infrastructure in general are durable and immobile, more so than other resources in the economy. The relative permanence of most built structures explains their role as vehicles for long-term transfer of resources, through changes in ownership or mortgaging.' The built environment extends through new constructions, it is reinvested in, adapted, refurbished and maintained, or the structures are disused, dilapidated and disappear in time, despite their generally extreme durability compared to other goods in the economy (ibid). Fast changes in economic cycles are associated with transformations of the built environments. Furthermore, in periods of economic crises, such as COVID-19, changes in the consumption, production and the built infrastructure is inevitable. When considered together with the challenges of this century, such as climate change, the prevalent linear economy model becomes noticeably unsustainable. Therefore, the circular economy model has emerged as an alternative approach that proposes the disassembly and reuse of products and components from buildings and infrastructure in contrast with their current demolition and landfill disposal (Cruz Rios & Grau, 2020). Subsequently, the built environment industry (building sector and construction) is most often associated with cycles of 'boom and bust' widely accepted due to its importance to the national economy and the capacity of employment these industries collectively create (Ruddock et al., 2014). Indeed, many sectors look to the economic projections of construction as the first indicators of financial turmoil or as signs of a looming recession. On the other hand, the built environment industries (designers, contractors, supply chain, manufacturers, sub-contractors, operators) are considered for the most part as cyclical industries (Barras, 2009; Sun et al., 2013). A cyclical industry is ascribed to be sensitive to the business cycle, such that revenues generally are higher in

periods of economic prosperity and expansion and are lower in periods of economic downturn and contraction.

33 **Air quality:** Few natural resources are as vital as the air we breathe, but access to clean air is deeply interwoven with socio-economic status, geography and therefore to disparity of health outcomes. There is wide acknowledgement of the injustice this represents; the areas with lowest incomes and greater vulnerability experience the most traffic congestion and air pollution – and resulting ill health – despite residents in those areas emitting on average lower levels of greenhouse gases than their higher income counterparts (Barnes et al., 2019). Projections for air quality depend very much upon how and when governments and the private sector act in aid of the Paris Agreement, the SDGs and other international climate accords. In the UK, the Environment Agency's 25 Year Plan (Her Majesty's Government, 2019) includes measures specifically targeting air quality, including by ending the sale of new conventional petrol and diesel cars and vans by 2040. However, this plan has been criticised from various quarters for lacking specific and ambitious targets (Carrington, 2017; Client Earth, 2018).

34 **Water quality:** Stereotypes about soggy British weather and an unusually wet winter in 2019-20 (Tandon & Schultz, 2020) may give us the false sense that water scarcity is something that happens to other people, but a mindset of exceptionalism will do nothing to prepare us for the impact of droughts at home and abroad. Scientific evidence and government reports both warn of the growing danger of water shortages in the UK in future. Leaving for the moment the very real impact of global water shortages on commodities imported by the UK, projections of hotter, drier summers paired with increasing demand would spell potential disaster for our supply of water in the UK by 2050, particularly in the populous South East of England (Bevan, 2019). Marine ecosystems are on the front lines of the climate crisis. As the planet warms, so do the oceans, and as their delicate balance is thrown off, they lose their ability to absorb the carbon we emit. The ocean contains 200,000 identified species, but the real number is likely much higher as relatively little has been explored. Three billion humans depend directly on marine and coastal biodiversity for their livelihoods (United Nations Development Programme, 2015a). Marine resources, therefore, are critical to protect. Land-based ecosystems too depend on reliable water levels. Rapid depletion of this resource could spell disaster for wetlands, peat bogs and other ecosystems that act as important carbon sinks and form part of British natural heritage. SDG 3 deals with clean water and water scarcity (United Nations Development Programme, 2015b), while SDG 14 deals with marine ecosystem health.

35 **Food and soil:** One of the biggest impacts of water shortages is on global food supply chains. In 2017, the UK produced only 50% of the food it consumed (National Statistics, 2018). This means that water scarcity elsewhere in the world can lead to shortages of some foods here. Other contributing factors – heat waves, soil quality and flooding – are increasingly relevant to food produced in the UK as the climate crisis takes hold. As with clean air and water, access to food is not evenly distributed. Already many people in lower income brackets are priced out of fresh, local and sustainable food options, and this food insecurity is likely to increase alongside demand. 'A growing global population is expected to demand 35% more food by 2030. And the type of food increasingly demanded as populations' incomes rise – vegetable oils, dairy, meat, fish and sugar – will have a particularly high impact on energy and water' (pwc, 2018). At the same time as climate change and resource scarcity are reducing agricultural productivity, demand for water, energy and food is likely to rise.

36 **Energy:** While fossil fuels are a non-renewable resource and we could eventually extract and burn all of it for energy, the scientific consensus is that doing so would overfill our atmospheric 'carbon bathtub' (J. D. Sterman & Booth, 2007) and send the planet into climate chaos. Indeed, only a third of the known reserves of fossil fuel could be burned for energy without exceeding two degrees of warming by 2100, a level of global heating that has been deemed catastrophic by scientific consensus (pwc, 2018).The type and availability of energy resources, therefore, is one of the key factors that will shape the next 80 years of human existence. The spring of 2020 saw the fossil fuel industry in crisis, as the price of oil reached negative figures (Chapman, 2020) amid a wave of organisations announcing divestment plans and proposals to stop funding new fossil fuel extraction projects, including the University of Oxford (Lovett, 2020), Citibank (Citi, 2020), the European Investment Bank (Ambrose & Henley, 2019) and Goldman Sachs (Kirchgaessner, 2019). Debates are ongoing about whether 'peak oil', the apex of human consumption of oil and gas, has been reached or when it will be reached. Other forms of energy such as wind, tidal, thermal and solar power are

becoming more reliable, cheaper and are providing a growing percentage of energy consumed in the UK (Digest of UK Energy Statistics, 2020). However, the transition to clean energy needs to happen more quickly to ensure we do not over-reach our carbon budget. SDG 7 (United Nations Development Programme, 2015) deals with equal access to affordable and clean energy, phasing out fossil fuels, cleaning up the energy consumption of construction and heavy industry and providing jobs in the growing renewable energy sector.

37 **Minerals and materials:** The built environment and its services consume materials made from non-renewable resources, whether that is in building materials like concrete and glass that require quarrying and extraction; ICT equipment that uses rare metals like gold and tungsten, which are often mined in ways that are harmful both to the environment and to workers; medical equipment that relies on plastic from fossil fuels; or in MRI machines, welding, lasers and leak detection, all of which rely on the relatively small stores of Helium left on Earth. The rarity and utility of some of these elements have led to, and will likely continue to lead to, conflict, corruption, and their continued extraction from ever more invasive sites. The mining industry touches on each of the SDGs, and therefore has the opportunity to make improvements across the board (World Economic Forum, 2016). However, it is also up to consumers, product designers, advertisers, investors and policy makers to change the consumption habits of global markets and reduce the dependence on raw materials in favour of a more circular economy, with non-renewable resources designed out of the system.

38 **Intangible ecosystem services:** Apart from material benefits, such as food and air quality, flourishing ecosystems provide intangible benefits, 'non-material ecosystem services', whose value can be observed through changes to those ecosystems, but which do not possess traditional market value. (Small, Munday and Durance, 2017) The most well-known of these is the public health and wellbeing benefits of access to nature. As with the other natural resources discussed in this paper, this access in unequal, with lower income and minority groups disproportionately absent from natural landscapes (Natural England, 2020).

39 **Planning:** One can draw vivid example from how professional city or town planners and ordinary citizens have negotiated town planning and city administration. Indeed, for a considerable part of the 17th and 18th Century, planning was generally conceived as a very technocratic, rational and scientifically-driven enterprise reserved for a select few professionals, who seemed committed to promoting social justice and environmental sustainability (Wildavsky, 1973). The professionals were also perceived to possess unrivalled skills and insights into the art and science of envisioning, planning, facilitating and coordinating physical development in the built environment (Cullingworth, 2006) and hence enjoyed unfettered privilege. The footprints of such technocratic orientation of planning are still visible in some renowned cities of the world, including the public works by Haussmann in central Paris during the 1850s and Robert Moses' urban transformation of infrastructure in metropolitan New York in the early 1940s (D. Harvey, 2003; Townsend, 2014). However, over time, this received wisdom has been questioned as most countries that have adopted multiple party democracy have begun exploring a more participatory approach to city planning and administration (Allmendinger, 2009; Healey, 1999). Afterall, there is no such thing as the 'all-knowing and value-neutral' planning professional who handle city planning unilaterally, given that their rationality is bounded (Cascetta et al., 2015; Klosterman, 1985) and deeply implicated in parochial partisan (Grooms & Frimpong Boamah, 2018; Kiron et al., 2011; Klosterman, 1985). Hence, city planning is articulated to reflect the aspirations of different cross-sections of people in the built environment and in a collaborative manner (Healey, 1999). Following this recognition, it is now commonplace for non-planning professionals or ordinary citizens to also shape their built environment through different processes. For example, the rise of neighbourhood groups have made it possible for local residents to mobilise grassroot support and resources to resist proposals by city planners funded by corporate real estate magnates to regenerate what is variously known as blighted, derelict and deprived neighbourhoods (Davis, 1990; Obeng-Odoom, 2013; Rolnik, 2013).

40 **Governance:** Scenarios for Brexit have been debated in academia (e.g. Isoda, 2018), in the media and in halls of government across the world since the summer of 2016. For now, the public remains in the dark as to what human rights, trade agreements, agricultural standards and environmental protections will be in place after the UK exits the EU. The polarisation surrounding Brexit is likely to influence political discourse for a long time to come. That polarisation is echoed in perceptions of partisanship of the news media. While journalism is considered important for the functioning of political life by the majority of adults in the UK, trust in that media is relatively low (Pew Research

Center, 2018). The growth in the potency and reach of 'fake news' has further eroded that trust and populist rhetoric has fuelled a lack of trust in government, in expertise and in international partnerships. It is not clear yet what impact, if any, the COVID-19 crisis will have on this political landscape. The UK has pulled together in some ways, backing lockdown measures more cohesively than in the US, where protests against lockdown have only deepened divisions. The public at large has also shown remarkable trust in experts, given the doom-laden articles about the erosion of that trust that have shaped opinion columns over the last several years (Enfield, 2017; Mathieson, 2016), fuelled by public polling (M. Smith, 2017). There are signs that in this time of crisis, people are more likely to report trusting experts, including the news media (Jennings, 2020). The reporting of trust in these polls is questionable, as being sceptical may be seen as a positive trait, and most polls do not ask respondents to unpack what they mean by trust (Beckett, 2020). However, they feel about it, more people in the UK are turning to experts during this crisis, and whether that trust extends beyond 2020 and the COVID-19 crisis remains to be seen. It could have a profound effect on willingness to believe climate change science and make drastic changes to our societies and economies at a pace that would previously have been unthinkable (Uren, 2020).

03 FOUR FUTURES

Scneario A

1 **Visible effects of the climate crisis:** For example, the mass extinction event is still underway despite our best efforts to keep ecosystems from collapsing. Wildfires, floods and extreme hurricanes are an increasingly common occurrence, and the UK is getting warmer, with more frequent heavy rainstorms, year-round. Windstorms and droughts have also been problems in certain regions of the UK, putting pressure on the agriculture sector to be smarter and more efficient at producing food.

2 **Timber construction:** See Omer & Noguchi, 2020. Scotland's housing programme in timber (Offsite Solutions Scotland, 2020) was adopted UK-wide for schools and larger infrastructure projects. Other programmes from around the world that inspired policies were France's definitive shift to using at least 50% wood in its public buildings from 2022 and British Columbia, Canada's Wood First Act (British Colombia Laws, 2009).

3 See Churkina et al., 2020.

4 **Material efficiency:** Development of a thriving circular economy has reduced reliance on virgin materials such as plastics and metals and has cut down on harmful environmental and public health impacts of dumping around the world. The buildings and infrastructure under construction now are designed for long life, reuse and remanufacture, meaning that we are freeing future generations of the demand for new steel, concrete and other materials. Electronics are repaired and remanufactured, with their component materials used over and over again.

5 **Water management:** Reducing water waste in sectors like clothing manufacturing, construction, and landscaping has protected our increasingly strained water supply. To the current generation of architects and designers, grass lawns are seen as out-of-touch and most houses, office buildings and even large estates have designed out stretches of manicured grass or installed wildflower meadows in their place to simultaneously support wildlife and save water. This has dramatically changed the look and feel of the built environment, as more drought-hardy and shade-giving plants have replaced water-intensive grass.

6 **Government funding for public infrastructure projects:** Over the last 15 years, the government has been directing finances to strengthen the backbone of the economy related to the built environment: offsite manufacturing systems; clean transportation; better social housing that comprehensively restocks housing in major UK cities; cleaner infrastructure and innovation projects; and low-carbon construction systems. Radical rethinking of materials and manufacturing

has led to a dramatic drop in the carbon intensity of new buildings, while radical rethinking of current planning structures has led to better lives for citizens and residents of the UK.

7 **Most common modes of travel:** While we slowly moved from individual car ownership to public, connected, intelligent transport systems, we also moved the responsibility of carbon from individuals to the state. Now, our transport infrastructure is not only new but also integrated. Long-distance travel by high speed trains is at an all-time high, where short distance mobility is shared out between autonomous vehicles such as buses and pods, electric 'ride share' cars, e-scooters and e-bikes. Some of these mobility services are designed and developed to serve the older population and includes embedded health monitoring services, emergency support systems and have the ability to contact or acquire health professionals according to the user's overall health and potential needs. Like the rest of the built environment, there has been an emphasis on smart solutions. This helps maintain a safe and resilient transport infrastructure in case of incidents and changes.

8 See Remøy & Van Der Voordt, 2014.

9 See EOLI FPS, 2019; Thompson, 2020.

10 **Urban plants:** Urban wildlife corridors are now a regular consideration in planning schemes, especially for pollinators. The theory is that stringing together pockets of pollinator-friendly plants throughout cities will help these important species thrive. See Claire Thompson, 2012.

11 **The changing face of the housing market:** Greater access to the housing market at the affordable end has its mirror at the upper end of house prices. With a shrinking spread of the middle class, our growing elderly population finds it difficult maintaining Victorian homes. About a third of them have sold their homes in cities and moved to smaller dwellings in towns and villages where the cost of living is more reasonable. Those who stayed on cities have downsized by either renting part of their units to younger working professionals or have agreed to home-sharing arrangements (Burgess & Quinio, 2020). High-priced mega-mansions are now historical relics and have either had to be repurposed or dismantled in many cases.

12 See Sanguinetti & Eastman, 2015.

13 **Health, demographics and environment:** Air pollution, low income, lack of outdoor exercise and belonging to a marginalised demographic were all linked to worse health outcomes generally, and worse outcomes of COVID-19 specifically. See Myers, 2020 and Gray & Kellas, 2020.

14 See Moss, 2015.

15 **IoT is not just about digital twins:** More IoT solutions popular at the local level include automated customisation of hot desks anywhere from co-working spaces to coffee shops, local fleets of autonomous ride-share vehicles, which are subsidised for disabled users, home healthcare solutions and digitally connected mutual aid and community action networks benefit previously marginalised people and regions.

16 See National Infrastructure Commission, 2017.

17 See AI for Good, 2020.

18 **Standards for responsible AI in decision making:** In 2020, New Zealand became the first country in the world to introduce standards for the use of AI in government decision-making. Since then, government departments have been required to provide plain language information about how decision-making is driven by algorithms, how data is stored and to identify and manage biases informing algorithms. Other countries quickly followed suit, and the UK now requires such transparency for algorithms used in public services such as transportation, health care and social housing as part of its open public services programme. See Graham-McLay, 2020.

19 **IoT-enabled healthcare:** The UK is working on implementing strategies and policies to promote and improve the capacity, usability and more human-centred design for home-centred care smart technologies that have been regarded as a viable solution to empower older adults to maintain independence, functionality, well-being, and higher quality of life (Lê et al., 2012). Furthermore, assistive technologies such as robots are employed to help with patient care and caregiver tasks.

IoT applications are also very common during the rehabilitation activities and they are in use to provide constant monitoring of patients' progress and emergency healthcare (Baker et al., 2017).

20 **Protecting the vulnerable:** This agenda for social good is also seen in a housing-first policy, introduced in after the COVID-19 crisis and managed by an algorithm that can identify those at risk of homelessness, which ensures that individuals never lose the safety net of a stable roof over their heads. This has driven a movement to build tiny eco-homes as accommodation for the most vulnerable. For discussions of the benefits of housing-first policies, see Turnnidge, 2020 and Clarke et al., 2020.

21 **Government initiatives to support underrepresented and marginalised communities:** The disproportionate death rates among people from minority backgrounds, people in care homes and residents of council flats during the COVID-19 pandemic inspired protests and nationwide introspection about the impact of inequality. In response, the Government in 2025 started increasing its budget allocation to local authorities and charities to support efforts at providing decent, affordable and energy-efficient homes and reforming policing practices that target Black, Asian, and minority ethnic (BAME)-majority areas.

22 **Physical accessibility and digital accessibility:** As more of the built environment is accessed through graphical user interfaces, new dimensions of disability are becoming clear. For example, some adults find navigating transportation challenging to begin with because of physical disabilities impacting their daily instrumental activities (Hall et al., 2019)they will require assistance with activities of daily living (ADL, and fully digitalising transportation as a service has in some implementations made this worse. We have therefore had to design technology into the built environment carefully to avoid social exclusion.

23 **Digital skills gap:** There is also a supply gap of digital skills entering the workforce in many sectors, despite how reliant the green transition has been on digital technology and data. Today, one of the most important challenges we are facing is the significant increase in demand for care providers. Advanced technological applications such as AI, automation, robotisation, IoT, and digital twins are thus directed to improve the quality of healthcare through improved data capabilities, integration, monitoring and analysis as part of the healthcare system. We have numerous personal robots, including drones, which help the elderly and young workforce with cleaning, cooking, shopping, entertainment and so on. However, finding people with the skills to both care for older adults and manage this technology has been challenging, as the educational curriculum has been slow to catch up with demand.

24 See National Infrastructure Commission, 2017.

25 **Economic decline:** Changes in cultural attitudes toward consumerism, the growing population dependency ratio and a lengthy economic downturn caused a long-term lack of demand, known as secular stagnation. This has been characterised by a reduction in investment into the built environment, demand for goods and services from related sectors and the ability of construction supply chain businesses at home and abroad to supply them. This in turn has temporarily reduced private sector spending while putting upward pressure on government to spend more to address the needs caused by an increasing number of dependents.

26 **Skills and automation:** The overall restructure of built environment businesses - through automation, data, digitalisation, robotisation, and similar technological advancements – have displaced repetitive human work and tasks. Thus, the less-skilled workers are replaced with a fewer number of more-skilled workers or with machinery and automation techniques (i.e. modularisation, off-site construction and pre-fabrication).

27 See Moss, 2015.

28 See Bennett, 2019.

29 For discussion of the importance of green jobs to meeting both the economic and environmental crises post COVID-19, see UCL Institute for Innovation and Public Purpose, 2020.

30 **Energy sources:** The UK has abandoned coal and other fossil fuels for energy and now relies entirely on 'clean' sources, such as solar, wind, tidal and the controversial nuclear and biofuels options. Campaigns against nuclear power are still going on, but this year has seen the greatest share of UK energy coming from renewable sources yet. Recently developed microgrids allow

cities to create some of their own energy in their own way, making the entire UK grid more flexible and resilient. Of course, this has also been made possible through gains in energy efficiency of consumer products, buildings and infrastructure and processes.

31 **Digital divide:** See Lê et al., 2012. Importantly, the digital divide still exists and others, especially those with disabilities, have lower rates of engagement with healthcare Internet of Things (IoT) (see Hall et al., 2019). There is still much work to be done on this front to ensure that digitally-enhanced healthcare is accessible to all.

32 See Baker et al., 2017.

33 See Fingleton et al., 2019.

34 See Qureshi et al., 2020.

35 **Other future-friendly legislation:** As part of the recovery from the Covid-19 financial and public health crisis, we negotiated a Green New Deal that has ensured more green jobs in parts of the country that were struggling before the pandemic, has ensured a just transition to green energy and has tackled some of the unequal health outcomes seen in low income areas through tackling air pollution, clean water, waste and food availability where it is most needed first. This has had a transformative effect on the built environment, which most voters agree has been very positive.

36 **High taxes for polluters:** Many of the government initiatives to help the economy and environment recover have been paid for by progressive corporate and individual taxation, and savings from less expensive health care and infrastructure. Carbon taxation is now widespread and tightly enforced, so no longer is the environmental cost of burning fossil fuels and other forms of pollution artificially suppressed. Nor are fossil fuels a sound investment, so the UK government and all public institutions have fully divested. Low carbon activities and products are therefore cheaper and more accessible than high carbon alternatives.

37 **How we eat has changed:** Our food no longer comes primarily from industrial scale farming and import. Larger farms in the UK make use of permaculture techniques like crop rotation and sustainable grazing to provide for the majority of the UK's food needs (see Figueres & Rivett-Carnac, 2020), while cities also grow more food within their boundaries. Rooftops, former car parks, community allotments and public gardens have all been converted to provide food for the city's residents. Many retired adults volunteer to help grow, harvest and sell this produce to supplement the smaller workforce. In order to abolish food deserts in the lowest income areas, local growers have begun to sell produce on a sliding scale based on what residents in their area can afford. Most people are eating much less meat than they did 20 years ago and are enjoying the health benefits that come from local, plant-based food that is available to everyone. While seafood is still consumed, environmental protection legislation has ensured that fisheries meet a stringent code, which means that coastal and marine environments are gradually recovering from their previous depleted states. For the ageing population better food, along with better access to green spaces and cleaner air, have led to better health outcomes than at any time previously.

38 **How we work has changed:** While the UK has undergone a massive decarbonisation effort and some sectors have contracted in size as a result of this and automation, roles that have always been low-carbon and are less easily automated – the service professions of hospitality, elder care, medicine, mental health care, teaching, environmental conservation, gardening, forestry and so on – have seen increased interest from younger generations entering the workforce. Older adults in retirement have plenty of volunteer opportunities in these sectors as well. The increase of environmental pressure, education and opportunities for women has resulted in a declining birth rate (Goldin, 2006). As a result, fewer households have the need to live near schools, this has increased the demand for small, affordable living spaces in city centres (Kahn & Walsh, 2015).

39 **How we build communities has changed:** At the level of local authorities, planning policy has been focused on green infrastructure projects and healthcare for the ageing population. Green infrastructure has come in the form of both buildings, transport, water, energy and other forms of infrastructure that have lower net whole-life emissions, and finding nature-based means of serving public good, such as creating marshes and reforesting upland sites to serve as flood defences, urban nature as storm water management and green bridges over train lines and roads to aid with wildlife

corridors and biodiversity. The idea of a 'natural health service' has caught on after COVID-19, and the need for equal access green spaces to benefit public health has become embedded in approaches to urban planning.

40 **How we travel has changed:** For instance, the 'Frequent Flyer' tax has helped the recovery of both the UK economy as a whole and the airline industry specifically. The cost of one flight per year remains comparable to 2019 levels, but with each successive flight, the tax rate rises rapidly, discouraging frequent mini-breaks and work travel by air. This effectively acts as a wealth tax, as a minority of people in the UK were responsible for the majority of carbon emissions from air travel in the first place (F. Harvey, 2019a). As telework technology has rapidly improved, however, frequent flying for work meetings and conferences is less necessary. While this has meant a change of business model for the airline industry, bail outs contingent on the adoption of sustainable strategies helped ensure organisations survived this transition.

Scenario B:

1 **Timber construction:** The use of offsite construction has grown rapidly at all project scales, particularly in the use of engineered timber in construction in the UK. Timber has played a vital role in the history of the UK, from domestic scale of barns to ships, and in the 21st century it has been reinvented for use at unprecedented scale. Timber's lightweight yet robust properties have made it possible to upgrade or retrofit ageing infrastructure stock which conventionally have been done with cement concrete, thus capturing and sequestering excess carbon dioxide (see Churkina et al., 2020). As natural materials like cross-laminated timber have demonstrated their structural, environmental and physiological benefits, they have found widespread appeal and are now appreciated for their offsite construction capabilities and are used widely in new builds and retrofitting. Steel still has its place, thanks to innovations enabling more materially- and energy-efficient recycling of steel.

2 See Harvey, 2019b.

3 **Low car ownership:** In addition to public transport infrastructure driving car ownership down, cycling is increasingly common, with most commutes and short trips in the UK (70%) being made by bike last year. Among younger people this number leaps to nearly 95%. This is thanks to cycle and pedestrian infrastructure set up during the period of social distancing in 2020. Most people in these cities liked the change so much that it was made permanent, and from 2022 several major UK cities and many towns were dominated by bikes and pedestrians rather than infrastructure for cars. This has boosted businesses in these city centres, helped with loneliness, health problems and air quality.

4 **Buildings as Material Banks and modular construction:** See Magdani, 2016. The UK has shown proclivity for such working methods through past successes in major school building programme named Consortium of Local Authorities Special Programme (CLASP) (Designing Buildings Wiki, 2019) that operated in the 1960s and used prefabricated lightweight steel. While arising limitations in architectural monotony persist to a small degree, ideas once pioneered by CLASP continue to be adapted and extended to other infrastructure, blending with BAMB and carbon replenishment using natural materials and local labour. Today's designers and civil engineers treat limitations of offsite and modular construction as creative challenges. Novel methods and forms are being developed to ensure new buildings are green, smart, resilient and beautiful to look at, resulting in a rapid decrease of the carbon footprint of the UK construction sector.

5 See The European Network for Rural Development (ENRD), 2018.

6 **The demographics of cities:** Environmental improvements in city centres have increased investment in these areas, which in turn led to more young professionals eager to live in cities (see Kahn & Walsh, 2015). The increase in population of young adults has increased demand in amenities and open spaces (see Waldfogel, 2008) in city centres and has reduced the need for large homes. The focus of investment by local authorities is now in offering better amenities, the beautification of cities and the creation of leisure spaces (see Carlino et al., 2008). Families with young children are more likely to choose where to live based on the location of schools and more flexible ways of working mean that they are less likely to commute on a daily basis (Kelly, 2020), leading to major changes in urban mobility needs.

7 See Carlino et al., 2008 and Waldfogel, 2008.

8 See Kahn & Walsh, 2015.

9 See Parvin, 2014.

10 See AI for Good, 2020.

11 **The role of digital technology in halting global heating:** According to Figueres & Rivett-Carnac (2020), digital technology has the potential to be instrumental in meeting the climate emergency. Between capturing better data about the true carbon footprint of our assets and activities, organising a circular economy, identifying improvements in the design, construction and operation of the built environment and enabling us to travel less, well-managed digital innovation has been a key factor in our success over the last 20 years.

12 **Digital health management:** Personal digital avatars for health monitoring are securely managed through wearable devices, and AI has transformed the ability of the NHS to diagnose of a range of diseases earlier and track the progress of patients.

13 **The Hackitt Report:** After the tragic fire in the 24-storey Grenfell Tower block of flats in North Kensington, West London that claimed 72 lives, the inquiry pointed to many different factors, from flammable cladding and faulty fridge-freezer wiring, to social inequality and neglect. Amid this aftermath, Dame Judith Hackitt reported on the building regulations as inadequate. She put forward the need for a 'Golden Thread of Building Information' available to all relevant stakeholders across the building's life cycle. Failure to do so means that changes to the design or to the finished building that impact its safety may not be flagged appropriately. Keeping this information digitally, in interoperable and discoverable formats, with accountability for accurate information, is put forward as an essential component for ensuring building safety. See Hackitt, 2018.

14 **Human flourishing:** This language was introduced by CDBB (Schooling et al., 2020) as a way of centering people in the way we design our buildings, infrastructure and digital systems. This paper marked a change in approach to the built environment, claiming that, 'Human flourishing is the fundamental purpose of infrastructure… There is an enduring interdependency between infrastructure and society – it is a socio-technical system. Desirable outcomes for society should set the objectives for infrastructure.' This led massive changes in the procurement, design, construction, operation and decommissioning of infrastructure, and, combined with the Net Zero target for 2050, led to a dramatic drop in the carbon footprint of the built environment sectors in the UK.

15 **Digital Buildings and Services:** Not everyone was immediately comfortable with the level of digitalisation in the built environment and essential services. These services have, therefore, had to build trust and demonstrate resilient data security and privacy practices. Advocacy groups such as Liberty and doteveryone have been instrumental in making these services anonymous and accessible, with the ability to opt into a higher level of customisation in return for permissions to share data. Private businesses have had to start compensating individuals for sharing their data with third parties, enabling individuals to benefit financially from their personal data.

16 **Economic prosperity:** This economic peak and new mindset of sustainable construction lead to millions of new jobs in the built environment sectors. The sensitive nature of these once cyclical sectors mean that economic prosperity is equally reflected in the business cycles, thus anticipated revenues are higher in periods of economic prosperity. This factor means that the top of the curve represents a midpoint in GDP recovery, followed by a descent as fast as its recent ascent.

17 **Leaving behind GDP:** Major reforms to the economy of the past were made to ensure that the metrics of growth and GDP did not remain the sole aim of the nation's workforce. All of this necessitated a major change to the job market, at the same time as the world faced one of its largest global economic depressions. A green recovery package after the 2020 pandemic ensured that,

despite the depression, the growing workforce had plenty of green jobs in the built environment, including design, digital technology development, data analytics, caring professions and the food supply chain.

18 **Carbon taxes:** For example, a 'Frequent Flyer' tax has helped the recovery of both the UK economy as a whole and the airline industry specifically. The cost of two flights per year remains comparable to 2019 levels, but with each successive flight, the tax rate rises rapidly, discouraging mini-breaks and work travel by air. This effectively acts as a wealth tax, as a minority of people in the UK were responsible for the majority of carbon emissions from air travel in the first place (see Harvey, 2019b). As telework technology has rapidly improved, however, frequent flying for work is much less common.

19 See Pickett & Wilkinson, 2010.

20 **The state of the climate:** While there are many positive stories in environmental news these days, the fact remains that industrialisation during the Anthropocene destroyed much that cannot be recovered. The extinction event set in motion by the climate emergency is still being felt despite our best efforts to keep ecosystems from collapsing. Though for now we have prevented it from running out of control, the heating of the planet is still underway. However, the energy and enthusiasm of the younger generations in taking ownership of their future will ensure that the changes toward sustainable use of resources last into the future.

21 **Legislation that enabled the SDGs:** Other legislation and regulations that have made a difference to achieving the SDGs are: the biodiversity and rewilding strands woven through the Agriculture Bill; post-Brexit trade agreements that are strong on sustainability; using digital technology to ensure transparency and ethical standards throughout global supply chains; a housing-first approach to addressing homelessness; and experiments with a Universal Basic Income (UBI) to ensure that even those without secure work have enough stability to support their health and wellbeing. While a few choose to live off this subsistence level income, most still want to work, and a UBI has freed them up to pursue work they find fulfilling in areas such as the creative arts, design, community volunteering and the caring professions, as well as supporting people through the lingering contraction of the job market in the early 2020s.

22 **Insecure and unhealthy housing:** Housing was just one facet of the structural and environmental prejudice that was embedded in the built environment and that led to worse health outcomes and social mobility among BAME and low-income communities. Successive governments have worked hard to address these inequalities through investment in education, policing reform and social support, as well as participatory democracy initiatives. All of these programmes have been enhanced to some degree by digital technology.

23 See Pickett & Wilkinson, 2010.

Scenario C:

1 See Rich, 2018.

2 **Climate crisis inequalities:** Since better air quality translates into increased housing prices (see Kahn & Walsh, 2015), cities that have invested in good air-quality and amenities have attracted high-tech industries and high-income educated households. Areas that rely on large carbon footprint industries, on the other hand, or that are prone to flooding or erosion, have become the only affordable place to live for a growing number of citizens. This has deepened already existing inequalities throughout the built environment, and those with smaller footprints often experience the most severe effects of the climate crisis.

3 **Global heating:** The 2018 IPCC Report pointed to the dangers of reaching 1.5°C warming, but new science over the intervening years has revealed that environmental tipping points were reached earlier than most of the models suggested, meaning we are in a period of runaway heating globally. All weather on Earth is impacted by human activity.

4 **Digitalisation of the built environment sectors:** The digitalisation of infrastructure is still ongoing, with real-time data capture, sharing and integration platforms, in addition to data processing devices at the periphery of the built environment. Demands for hospitals, care homes and smart in-home care devices are high owing to the vulnerability of older adults. Digital technology is

also used to monitor degradation of critical assets such as bridges and water mains, but not yet to optimise other services. In parallel, the construction industry is moving toward full adoption of prefabrication and automation in medical buildings, enabling the time- and cost-effective construction.

5 **The problem with concrete:** 'If concrete was a country, it would be the third largest carbon emitter in the world after U.S. and China.' This eye-catching statistic from The Guardian in 2019 summarised the enormity of producing one of the most useful yet destructive materials on earth. The second most used substance on earth after water, concrete was widely considered to be the ultimate man-made material deployed to tame nature and had enabled some of humankind's most ambitious and daring undertakings since early 20th century. Despite recent restrictions, cement concrete production and use continued in the majority of new projects, but seems to have finally levelled off (see Rodgers, 2018), and is now gradually being replaced by natural substitutes like cross-laminated timber and other composites (see Harvey, 2019a).

6 See Metz & Griffith, 2020.

7 See AI for Good, 2020.

8 **Digital divide:** We have not achieved our target of eliminating the digital divide between disabled and older adults, and those in other demographic categories. This is especially true when age or disability intersects with another form of systemic disadvantage, such as class or ethnicity. Attempts to embed digital literacy in the curriculum have mostly been misguided, with the educational sector extolling the virtues of open data, while most will enter a workforce where proprietary data is the norm.

9 **Austerity measures from 2020:** In retrospect, austerity measures after the 2008 financial collapse hindered the ability of social programmes and health services to react to the pandemic in 2020. Various experts, including the Institute for Innovation and Public Purpose (UCL Institute for Innovation and Public Purpose, 2020a) predicted that similar measures implemented in response to Covid-19 and the attending economic crisis would be damaging to long-term prosperity, stating that recovery should be based on 'states assuming the responsibility to direct markets and co-shape investment towards green economic renewal'. This advice was ignored in favour of making the UK more attractive to businesses by eroding environmental protections and social investment, with disastrous results for the climate and much of society.

10 **Data economy:** This is the case despite the pervasiveness of the data economy. Management of built infrastructure is more reliant upon data-centric services. The total share of the data economy in global GDP is significantly higher and data market share reached up to 40% (a doubling of the 2017 market share of 20%).

11 See Scheffer et al., 2001.

12 **Food availability:** With the collapse of pollinator populations, little by little we can no longer get foods that we used to depend on. The diversity of food that is eaten in the UK has dwindled to what can be artificially pollinated and reliably farmed or grown in our depleted soil. After an initial reduction in meat-eating in the 2010s and 20s, meat consumption never dipped below the level that would force an end to factory farming practices. Cruelly, there are some years when the workforce is too small to harvest the crops that we do have, and so while many people go hungry as crops rot in the fields. More land than ever is developed and covered in concrete, meaning that farmland is at a premium, putting smaller farms out of business in favour of industrial-scale farming (Kass et al., 2011).

13 See Oikonomou et al., 2012.

14 **Climate refugees:** Sea level rise, droughts and armed conflicts over resources have led to a surge in refugees who, in a world that is wary of and even hostile to, people from other countries, are often left to fend for themselves in desperate conditions.

15 See Hao, 2019. In response to unequal policing and other structural prejudices, the 'Black Lives Matter' movement is a fixture in most cities in Britain and major protests have taken place in London, Birmingham and Manchester on a regular basis. Although post-Brexit migration policies and Government messaging attempted to promote multi-culturalism in Britain, trust in those efforts has been low. The exceptionalism revealed by the vote to leave the EU, coupled with the

slow economic recovery post COVID-19 and growing scarcity of resources, is fuelling sentiments of nationalism. Resentment of immigrants and people of colour by white working class is high, and anti-hate non-profits are tracking several active and violent hate groups who are recruiting online and planning demonstrations against BAME-owned businesses.

16 See Vaccari & Chadwick, 2020.

Scenario D:

1 **Finding solutions to our big problems:** For example, smart solutions using AI, big data, augmented reality and digital twins are helping to monitor the impacts of a violently changing climate on buildings and infrastructure, modelling storms and fires with better accuracy. Young designers are working to meet the challenges the world is facing using digital and engineering solutions. We are rushing to adapt to a changing planet, and trying to preserve and document as much of the world as we knew it.

2 **The promise of smart public transport:** The public transportation solutions that were introduced earlier in the century did not meet the expectations of the citizens, with long lead times, expensive price tags and controversial route plans that left some citizens feeling marginalised. In the age of big data and artificial intelligence, unfortunately, integration of the transportation systems did not live up to its promise and most local planning authorities abandoned the initiatives for market-led solutions. Privately owned lines that are controlled by private companies are not sharing data and this is leading to competition instead of collaborations, and the best public transport accessible primarily to the wealthiest cities and neighbourhoods.

3 **Remote working:** Nearly half of all professionals, and a growing number in manufacturing and construction, trades, work remotely and connect to work through devices on home or public networks.

4 **Cybersecurity:** Last month, for example, the servers of all Russell Group Universities suffered a major hack by unidentified cyber terrorists. It took joint efforts from scientists and engineers from Finland to restore the servers without having to pay the US$ 10 billion ransom demanded by the hackers.

5 **Monopolies in the data economy:** Romer (1990) assumed that private, maximising behaviour plays a pivotal role in generating technological change. This premise has been best exemplified in the major advances in the development and use of artificial intelligence through private sector companies and investors.

6 **Lack of corporate accountability:** In the UK, companies that two decades ago were shortlisted as being part of the global companies responsible for 71% of global emissions have not been held accountable for their actions, and neither have they amended their ways (Griffin, 2017).

7 See Romer, 1990.

04 ONE CHOICE:

1 See Waller, 2020.

2 See Construction Leadership Council, 2020.

3 See UK Green Building Council, 2019.

4 See Sharpe & Lenton, 2020.

5 See Paddock & Suhartono, 2020.

6 **Individual actions for reducing carbon emissions:** There are many excellent guides that give recommendations for how individuals can reduce their carbon emissions. For a simple visual guide to the effectiveness of different strategies, see Institute of Physics, 2017.

7 See Breland, 2017.

8 See Cooksley, 2020 and Givens, 2020.

9 See BrownC, 2020.

10 **Future of mobility:** Additionally, to unlock the potential of micro-mobility solutions and services such as bicycles, e-bikes, e-scooters and so on, government should implement necessary policies. These services and solutions can improve the access to public transport, support mobility behaviour transformation and enable responsible and sustainable new behaviour that is not car-centric.

11 See National Infrastructure Commission, 2017.

12 See AI for Good, 2020.

13 **Exploring who benefits from technology in the built environment:** For example, the future of public and private transportation is one of the most important dimensions related to the built environment. To be able to deal with the complexity of future transport and mobility challenges, a range of players, from think tanks and public authorities to strategic partnerships with private corporations needs to work together (The Visa Transportation Centre of Exellence, 2019). Another important challenge facing these players is to develop a clear vision of their future mobility systems and services, in addition to coherent strategies for getting there (Audenhove et al., 2018). While trends such as autonomous cars, new shipping routes, changes in global aviation demand, pandemics, rapid urbanisation, and so on, may propose disruptive changes in mobility and transportation, it is only possible to use them as opportunity for positive change if we build these vision and strategies.

14 See Allen, 2009.

15 See Frey, 2019.

16 **Transdisciplinary and future education:** For discussion of the importance of transdisciplinarity Gürdür Broo (2020) and Organisation for Economic Co-operation and Development (OECD) (2018) provide a vision of the sorts of outcomes that would be enabled by a new approach to education.

17 See Gürdür Broo et al., 2020.

18 **Outcome data on SDGs:** By 'outcome data on SDGs', the author is referring to data relating to the metrics by which the SDGs are benchmarked. Inadequate data means an incomplete picture of how close to achieving the SDGs the world actually is. See Sachs et al., 2019.

19 See Pouwhare, 2020.

20 The 'converging crises' language is from Heglar, 2020.

21 See Construction Innovation Hub, 2020. It is important to note that this is an evolving framework and longitudinal research would be needed to explore the impact of using this framework.

22 **Produced value:** This refers to artificially-derived forms of value such as financial and manufactured, as opposed to value arising from what innately enables human societies and the environment to flourish.

23 See Construction Leadership Council, 2020.

24 Carbon bathtub model: See Sterman, 2017.

25 **Carbon emissions from the built environment sector:** Whether it's from construction and operation processes (UK Green Building Council, 2019), materials such as steel and concrete (Vaughan, 2019) transportation of materials (T. W. P. Smith et al., 2014), or lifetime emissions caused by transportation as a service (Office for National Statistics, 2019), a huge percentage of carbon emissions are the direct result of, or linked to the built environment.

26 See Onat & Kucukvar, 2020.

27 See Dunant et al., 2018.

28 **Circular economy:** From an economic system standpoint, our traditional economic modus operandi of 'take-make-dispose' will manifest a resource-scarce future for manufacturers and built environment as a whole. In this context, a circular economy presents an alternative

economic model of consumption that is regenerative by design (MacArthur, 2012). If successfully implemented, a circular economy proposes to augment the traditional modus operandi of the one-way consumption mindset and convert it into a service-focused model instead, in a way that product ownership belongs to manufacturers that operate as a service provider rather than just consumer sellers.

29 **Platform design:** A platform approach for designing infrastructure buildings is being explored and advocated for by the Construction Innovation Hub. See Construction Innovation Hub, 2020b.

30 See Ministry of Housing, 2019.

31 See Adam, 2019.

32 **Incentives for new buildings:** According to The Use Less Group (2018), 'Commercial buildings in the UK are typically designed to last for 100-200 years, but on average are replaced after 40-60 years. The reasons for this early replacement are not fully clear, but primarily it seems that the very high price of land in the UK (generally much greater than the cost of the building on the land) drives decisions to replace buildings whenever rents could be increased for a different building design. Such replacement decisions are also influenced by choices made by local planners – and when restrictions on usage or building height change, this may immediately lead to further building replacement.' (The Use Less Group, 2019).

33 **Green infrastructure:** See Town and Country Planning Association, 2020. The UK Green Building Council (2019) outlines four categories of service that green infrastructure can provide: Supporting services for all other ecosystem services; provisioning services, providing resources such as food, raw materials and fuel; regulating services, maintaining air quality and climate; and cultural services, including recreation, aesthetic value and a sense of place. They point to examples as diverse as: urban woodland and wetlands, urban food, sustainable drainage, adaptable public spaces, shared mode transport infrastructure, permeable surfaces, wildlife corridors, cycle networks, city parks for recreation and temporarily floodable areas.

34 See UK Green Building Council, 2019.

35 See Oppla, 2019a.

36 See Oppla, 2019b.

37 See Natural England, 2020.

38 **Income support:** Nationally funded income support options include benefits and welfare schemes, Universal Basic Income and Living Wage schemes that provide every citizen with sufficient funding to survive. These latter two payments can be supplemented through paid work if desired, but will be sufficient to support people who are not paid for their work or may have inconsistent incomes, e.g. carers, volunteers, people in creative fields and small business owners. As a policy, it is an acknowledgement that while the exact pressures that working people will face in the future may be unknown, there is no scenario in which citizens of the UK would fall into poverty. It provides the kind of general resilience to crises to the most vulnerable in society. According to Shaheen et al. (2020), 'Any "levelling up" agenda must start with supporting well-paid unionised manufacturing jobs and utilising them as an anchoring point for raising the quality of work and prosperity for communities across all regions of our country.' They also highlight the rapid growth of the caring sectors, which are some of the lowest paid jobs in the country, noting that in order to build a stronger society, there needs to be a fundamental shift in how we value these workers. An income support scheme addresses both issues, enabling people the flexibility to retrain for manufacturing jobs, as well as supporting those who work as carers either professionally or on a voluntary basis.

39 See Frey, 2019.

40 See UCL Institute for Innovation and Public Purpose, 2020b.

41 See Mazzucato & Mcpherson, 2018.

42 See The Future Generations Commissioner for Wales, 2015.

43 **Shrinking workforce and digital transformation:** The logic behind this is that retooling, reconfiguring and reskilling all require a depth of works to draw upon across sectors. A Green New Deal imagines the creation of huge numbers of new jobs to redevelop infrastructure to be more

sustainable, and this is equally true when imagining the transition to a green information economy.

44 See United Nations Department of Economic and Social Affairs, 2015.

45 See Migration data portal, 2017.

46 See Gagnon, 2020.

47 See The Economist, 2018.

48 See Burgess, 2020.

49 **Digital skills divide by numbers:** Recent studies (Lloyds Bank, 2018) and official statistics in the UK suggest that there is also a clear digital divide among the population, with 8% of the population having zero basic digital skills and adults aged over 65 years consistently making up the largest proportion of adult internet non-users (Serafino, 2019). This divide is also reflected across the gender (ibid). Thus, in an increasingly digitised world, this divide has profound implications on what people can do in their built environment, including opportunities in earnings, employability, retail transactions, communication and time savings (Centre for Economic and Business Research, 2015). Lacking access to these benefits deepens socio-economic inequalities further, leaving some of the UK's citizens behind in the digital revolution.

50 **The digital divide in the SDGs:** According to Sachs et al. (2019), 'The sixth SDG Transformation calls for a comprehensive set of regulatory standards, physical infrastructure and digital systems to capture the benefits of the digital revolution for the SDGs while avoiding the many potential pitfalls. It comprises four sets of interventions. First, universal access to high-quality, low-cost mobile broadband. Second, measures to promote digital inclusion, skills, privacy protection and universal identity. Third, countries need to harness the digital revolution to attain SDGs, including through the digitisation of healthcare and education, online finance and payments, and supporting public goods. Fourth, public institutions need to be strengthened to govern and shape digital innovations towards sustainable development.' Fair and equal access to digital technology is therefore vital to success of the SDGs.

51 See Baiocchi & Ganuza, 2014.

52 See Davies, 2015.

53 See Wilson et al., 2019.

54 See Saunders & Baeck, 2015.

05 CONCLUSION:

1 For example, https://racetozero.unfccc.int/kicking-off-race-to-zero-dialogues/

2 For example, Imperial Tech Foresight and Grantham Institute, 2020.

3 For further expert discussion of next steps for the green recovery of a variety of sectors, see the newly released report by Cambridge Zero Policy Forum (2020).

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