# GOODFELLOW-SMITH2019PhD

# How can finance and insurance institutions help deliver sustainable city infrastructure?

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# ABSTRACT

Human society may be faced with the momentous conclusion that city living is forcing collapse of the planet's life support systems, and yet the scale of projected city infrastructure delivery is staggering. This thesis therefore examines two fundamental components that enable city infrastructure delivery – finance and insurance. The development of an evaluation and costing appraisal tool for the selection of finance and insurance is presented, demonstrating the potential for substantial cost savings. Its use can help shape a sustainable city transformation.

Moreover, there are several barriers to implementation of sustainable city infrastructure, which collectively form a 'valley of death'. This thesis examines the role of finance and insurance in speeding innovation across the valley in the form of a tool used by an 'entrepreneurial state', combined with participatory budgeting. Alignment to the Task Force on Climate Related Financial Disclosures requirements, the United Nations Sustainable Development Goals and system boundaries is shown to be practicable, efficient and urgently required. A restorative economic paradigm is argued to be the most effective way to secure a sustainable city transformation.

Proposed integration of these appraisal methods into a revised and practicable route map, is presented.

# DEDICATION

Many thanks to my wife Julia, always and forever smiling – well nearly.

To my father – who worked hard to give me opportunities.

My supervisors – they kept me on track, remained supportive throughout and made time for me when I needed it.

To my research partners – particularly staff at the University of Birmingham, whom gave of their time and knowledge to help me bring this research to a meaningful point.

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# LIST OF PUBLICATIONS

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# 1. INTRODUCTION

## 1.1 Overview

For cities to become more liveable (using only a fair share of one world resources and improving individual and societal wellbeing (Liveable Cities Project, 2018)), sustainable (capable of continuance into the long-term future (Porritt, 2005)) and resilient ("a measure of a system's ability to survive and persist within a variable environment" (Meadows, 2009)), significant infrastructure development is required, innovative technologies and techniques need to be deployed and city dwellers need to become deeply engaged in the future of the city.

Many technologies have been available to society for some time, yet deployment remains at an insufficient scale to make the city transformation that is required. Such technologies include renewable energy, district heating and electricity generation systems, hydrogen fuel cells, electric vehicles, pollution absorbent green infrastructure, hydroponic growing systems and many more.

And then there are the techniques that are available to us to transform cities. These include vulnerability risk reduction, valuing ecosystem services, community-based adaptation initiatives, development planning, participatory processes and many more.

This thesis explores the application of city assessment models and how they might best be combined with investment taxonomy and a sustainability specification process for infrastructure. In addition, a method of finance and insurance appraisal is developed. It is demonstrated that such an approach will enable rapid deployment of liveable, sustainable and resilient technologies and techniques to create cities of the future.

It is argued that an effective implementation methodology, supported by stakeholder participatory budgets and restorative economics, will provide the right environment through which an entrepreneurial government (Mazzucato, 2015) can transform the city – leading in risk taking and sharing in the rewards of a liveable, sustainable and resilient city.

## 1.2 Background and Justification

The current geological age is viewed as the period during which human activity has become the dominant influence on climate and the environment – it has been termed the Anthropocene (De Cristofaro and Cordle, 2018). It is a new period either after or within the Holocene, the current epoch, which began approximately 10, 000 years ago with the end of the last glacial period. This designation is based on overwhelming global evidence that biospheric, atmospheric, hydrological, geological, and in fact most earth system processes are now altered by humans. It is perhaps the technical system of the city and associated infrastructure that is the largest and most complex structure engineered by humans and the most expressive of anthropogenic dominance.

Although to provide the resources for these city systems, the sheer scale of deforestation, subsequent spread of mono-agricultures and biodiversity decline provide other examples of anthropogenic dominance.

Because of the scale of human urbanisation and the associated environmental, social and economic impacts, there is growing pressure to transform the way the city relates to its regional resource base. The United Nations publication, The World's Cities in 2016, states that we now live in a world where more than 50% of the population lives in cities. The growth expected over the next 10 – 20 years is quite staggering – a doubling of city population (United Nations, 2016). The problems of unsustainable growth and destruction of biodiversity stem from population concentration and increasing consumption exhibited by city living. Girardet (2015) states that we will need to switch from urban regeneration projects to building a 'regenerative' city, a city that rebuilds natural capital and enhances social potential. A city transformation is clearly required, and this thesis describes approaches that might support this transformation.

The scale of projected city infrastructure delivery is staggering – the estimated annual worldwide infrastructure expenditure is forecast to grow from $4 trillion per year in 2012 to more than $9 trillion per year by 2025. Overall, close to $78 trillion is expected to be spent globally between 2014 and 2025 (PwC, 2014). In the UK, construction output reached £14 billion in the month of September 2018 (ONS, 2018). Engineering construction turnover in the UK for 2016 was £325 billion (ECITB, 2017).

Given the scale of this investment, if it is not carefully steered away from business as usual, fossil fuel dependency and natural system destructive design, the cost of transitioning to a liveable, sustainable and resilient city may become prohibitive.

Public financing has had a critical enabling role in the development of city infrastructure. As constraints have been put in place, private financing has been more attractive, or the only option. However, evidence highlights that private finance can be twice as expensive as public finance (UK Parliament, 2011a); that substantial losses in tax revenue occur as private finance debt shareholders sell ownership offshore (UK Parliament, 2011b); and that inefficient management, delays and cost increases added €1.5 billion to the cost of just 9 EU-funded infrastructure projects (European Court of Auditors, 2018). Infrastructure project finance packages need to be carefully compiled from an increasingly varied and complex number of sources, with a full understanding of direct costs and other ‘intangible’ (the author uses the term ‘non-monetary’) factors that relate to outcomes. This thesis develops a set of criteria that more thoroughly evaluate the costs and effectiveness of finance sources related to the outcomes required from infrastructure investment.

A financial package to deliver infrastructure is generally reliant on insurance. Insurance provides the route for transfer of risks from investors, project owners, contractors and sub-contractors to the market, at a price that provides comfort in case of difficulty. Without insurance provision, investors would feel less

certain about supporting a project throughout its several stages. The UK insurance market is the fourth largest in the world, and the largest in Europe, with a total premium cost in 2016 of £225 billion (Swiss Re, 2017). UK insurance and pension companies held £1.7 trillion of investments in 2016 (ABI, 2017). Given its importance this thesis develops an insurance appraisal and selection tool that enables infrastructure owners and investors to adopt innovative products and best practices in insurance protection that can deliver significant cost savings and more sustainable outcomes.

The next step in securing a city transformation relates to increasing the speed of deployment of liveable, sustainable and resilient technologies and techniques, although many of these have been available for some time. The cause of the delay is commonly termed the ‘valley of death’ (VoD). The process of bringing ideas through to deployment has been characterised as a linear model (Godin, 2015). To give this model a greater sense of reality, a key feature that delays deployment, the VoD, has been added to demonstrate the interdependency of resources, time and risk associated with various stages of the linear innovation model. The VoD describes the process of bridging the gap between early stage funding and later stage capital-funded product development (Wessner, 2005). This thesis adopts the VoD descriptor for a range of obstacles, spread over a sequential time period, that delay the city transformation from fossil fuel dependency and natural system destructiveness to a state that is more liveable, sustainable and resilient. Defining what this VoD

is, and how to get through it more effectively, forms an essential component of this thesis.

Yet engineers and project managers are not those that necessarily define what features are most important for a liveable, sustainable and resilient city. This definition is developed through societal engagement and is one in which democratic institutions and organisations need to set a lead in prioritising investment needs of the city, aligning with principles being set at the highest levels across the world. Such defining principles that can direct a city transformation are for example, those of the United Nations Sustainable Development Goals (SDGs; United Nations, 2015), which define the outcomes that should be achieved through city transformation; city performance rating and investment prioritisation tools and the Task Force on Climate-Related Disclosure (TCFD, 2017) requirements to assist in selecting the source of finance for city transformation. This thesis describes how to align evaluation tools with city-wide priority-setting using city assessment models and combined with TCFD reporting requirements and UN SDG's. In effect these should become the moral conditions through which the city achieves restorative economic efficiency.

The context in which infrastructure is evaluated for investment is one in which Gross Domestic Product (GDP) contribution and economic efficiency are viewed as crucial measurements. Yet a liveable, sustainable and resilient city has a wide range of indicators of success, not just GDP, financial return or

efficiency. It requires a new way of managing our city economy that combines GDP with an equally important measure of restorative domestic product, such as Net National Product (Figueroa, Orihuela and Calfucura, 2010; Wu and Heberling, 2016). Chapter 6 of this thesis describes some of the key features of a restorative economic paradigm that will maximise the transformative infrastructure investment that is needed for more liveable, sustainable and resilient cities.

The steps discussed so far are not routinely followed in all infrastructure development. The Institution of Civil Engineers' 'Risk Analysis and Management for Projects' (RAMP) framework (ICE, 2014) and the Infrastructure Projects Authority's 'Project Initiation Routemap Handbook' (IPA, 2016) provide frameworks through which the approaches developed as part of this research might be integrated into accepted project management. This thesis argues that integration into accepted management approaches to infrastructure development is required to accelerate progress of technologies and techniques from idea to full implementation.

## 1.3 Aim and Objectives

In considering the scale of city impacts and the transformation required, my overwhelming concern was why change has been so slow when we have so many solutions available? I wanted to establish powerful mechanisms that could accelerate city transformation.

### 1.3.1 Aim:

The aim of this research is to determine ways in which finance and insurance can be used most effectively to accelerate the deployment of sustainable techniques and technologies to create liveable, sustainable and resilient cities.

### 1.3.2 Objective :

1. Link city assessment tools with identification and prioritisation of infrastructure investment.

2. Establish the principles for and design new normative finance and insurance models for infrastructure build.

3. Develop an appraisal and selection tool of finance and insurance products and providers that would support more liveable, sustainable and resilient city infrastructure through the ‘valley of death’.

4. Research and develop a set of criteria that would align an appraisal tool with sustainable outcomes.

5. Propose an effective and practicable delivery approach for more liveable, sustainable and resilient city infrastructure.

6. Define the economic paradigm and describe an element of city dweller engagement through which securing liveable cities could be enabled.

## 1.4 Summary

The overarching objective of this thesis is to contribute to delivering more liveable, sustainable and resilient cities. Describing what is meant by the city and sustainable infrastructure is presented in Chapter 2. This chapter begins to develop the model of **Li**veable, **S**ustainable, **R**esilient and **I**nvestment **R**eady **C**ity portfolios – LiSRIRC. The model encapsulates the key steps required to transform cities as identified through research interviews and literature review.

The focus of this thesis, within the **LiSRIRC** process, is on developing a set of criteria for identifying and evaluating sources of finance and insurance. The research approach is covered in Chapter 3, followed by Chapters 4 and 5 describing the finance and then insurance sectors and products. Analysis of data from previous research and findings from sectoral case studies, research interviews and current practice is presented within these chapters. Findings indicate that significant savings and more sustainable outcomes can be identified and delivered by adopting a multi-criteria assessment method for finance and insurance.

Chapter 6 begins to describe key obstacles to implementing more liveable, sustainable and resilient infrastructure. These obstacles are collectively entitled ‘the valley of death’ and include institutional leadership, and macro and microeconomics.

Chapter 7 presents the collation of all the steps of the LiSRIRC process, analysis of all research data and a discussion on the way in which **LiSRIRC** can be implemented to maximise the probability of transforming city infrastructure. Appropriate existing management frameworks are identified through which **LiSRIRC** can be efficiently implemented.

Chapter 8 presents conclusions and proposed future research.

# 2. CITY INFRASTRUCTURE

## 2.1 Introduction

Welcome to the age where a small creature, the human being, has achieved in just a few millennia such a legacy that some are describing a new epoch. The current geological age might be viewed as the period during which human activity has become a dominant influence on climate and the environment – it's been called the Anthropocene (De Cristofaro and Cordle, 2018). Defining features of the Anthropocene are the large-scale impacts associated with the rise and spread of humanity and humanity's consumption of resources. The scale of these impacts can be calculated (although not with full accuracy) and benchmarked against key processes that can be defined as 'planetary boundaries' (Rockström *et al.,* 2009a; Rockström *et al.,* 2009b). These boundaries, where clear and significant anthropogenic impacts can be measured, are:

> Climate breakdown, ocean acidification, ozone depletion, atmospheric aerosol loading, phosphorous cycle depletion and nitrogen cycle overload, freshwater depletion, land system change, loss of biodiversity and chemical pollution.

We now live in a world where more than 50% of the population live in cities. The growth expected over the next 10 – 20 years is quite staggering – a doubling of city population. The United Nations publication "The Worlds Cities in 2016"

points to 512 cities with at least 1 million inhabitants globally (United Nations, 2016). By 2030, a projected 662 cities will have at least 1 million residents. Cities with more than 10 million inhabitants are often termed megacities. In 2016, there were 31 megacities globally and their number is projected to rise to 41 by 2030 (United Nations, 2014a). The impact of such concentrated living is exerting extraordinary tolls on the very life support systems that sustain these centres of human population.

The city cannot be seen in isolation from the many supporting features that are required for its functioning. Eco-systems support the city, providing a multitude of life-sustaining and quality-enhancing services. As Girardet describes this process of change (2015) he charts a move from the ‘Agropolis’, a self-reliant traditional town, through to the dominant city form of today, the ‘Petropolis’, a city dependent on global, fossil-fuelled supplies and connectivity. If city living is to be successful, then an argument presented by Girardet and others is that society must transform city living towards the ‘Ecopolis’, a city that uses renewable energy, regenerates natural resources and reconnects to local supplies (Figure 2.1). Understanding, mapping, and working out what needs to change, must be done through democratic and multi-stakeholder led processes. These processes will need to be capable of handling a degree of data and social complexity not experienced in world history to date. Yet this is simply a technical response to an issue that arises from a human tendency to treasure power and wealth above most other attributes. Redefining our goals as a

society and transforming the ways in which we measure prosperity are critical to enable technical solutions to function adequately.

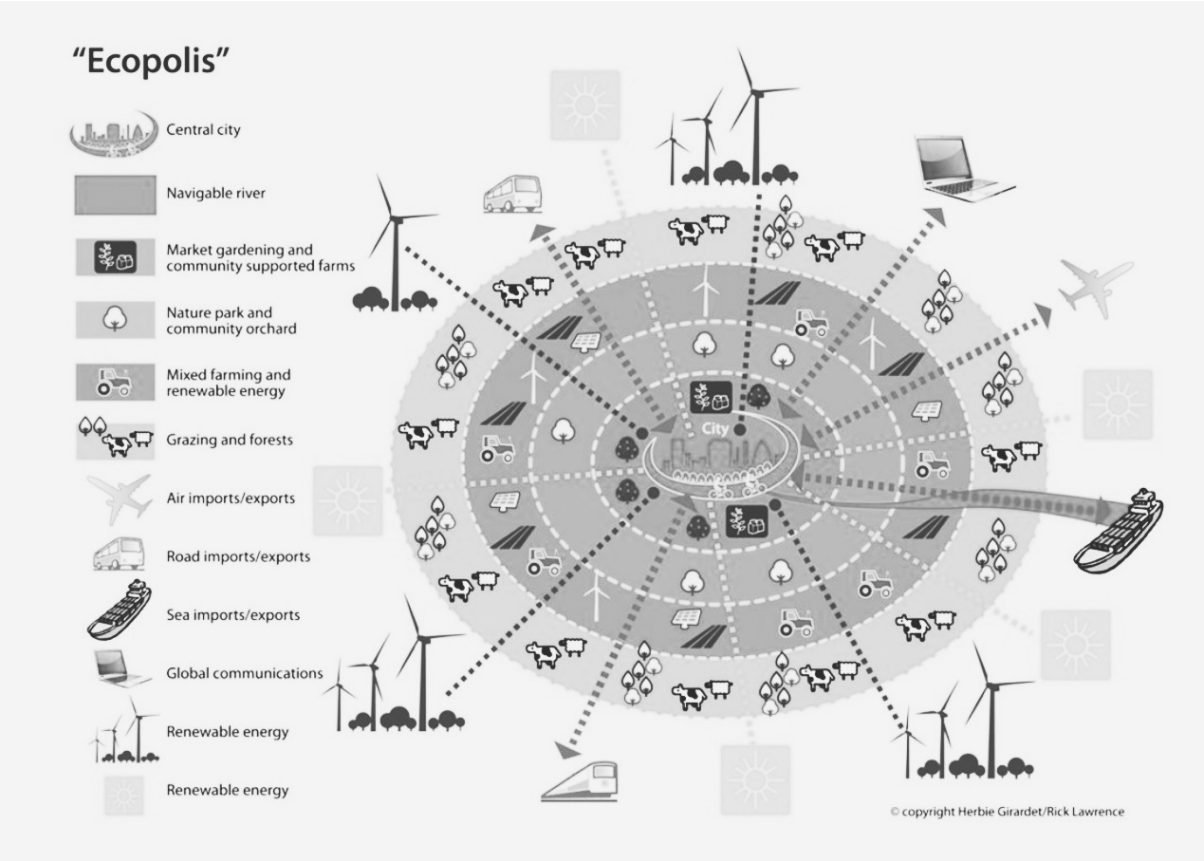



**Figure 2.1:** Ecopolis. 2015. Reproduced with the permission of H. Girardet.

Whilst the negative impacts of city growth are very considerable, we have developed knowledge of the context and consequences of these impacts. Concepts such as 'planetary boundaries' (Rockström *et al.,* 2009a) and system conditions (TNS, 2018) – and an appreciation that our eco-system's ability to provide services is being exceeded – can provide human society with methods

and approaches to frame a transition away from these harmful impacts. Some of these approaches will be explored below.

However, as the evaluation of the success or otherwise of city living accumulates evidence, human society may be faced with the momentous conclusion that city living is forcing collapse of the planets life support systems. How long can human society continue to invest in a system with such huge burdens? Well, society has experimented for millennia; the next radical experiment might require making our cities small, green and self-sustaining. Now there's a novel idea. An idea that evokes the need for a city system transformation - a renewal process with a 'One Planet' (BioRegional, 2018) impact.

This chapter describes the mounting and catastrophic levels of environmental impact exacted by current forms of city living, leading to the conclusion that radical city transformation to liveable, sustainable and resilient levels is required urgently. Some of the types of sustainable city infrastructure that we know can work well are presented, although the acceleration of deployment and scaling of implementation is daunting. These transition technologies need the support of a new set of techniques. Again, we have experiments that demonstrate ways in which we can transform cities for the better but again it is evident that the acceleration and deployment of these transition techniques is happening at nowhere near the level the evidence suggests is required for the transformation.

As technologies and techniques are deployed, a system of evaluating city infrastructure for liveability; selecting liveable city infrastructure; taxonomy; and specification are required.

## 2.2 City Impacts

The resources of this planet are limited. That means that continual economic growth is impossible, unless we exploit the resources of another planet. And although we can exploit solar radiation from the sun (arguably we need to exploit this resource far more and far quicker) our ability to exploit the resources of other planets for material inputs, food, water or other resources remains extremely limited. So how quickly do we need to reduce resource consumption? How much resource do we have left? How much resource does a city consume?

Global overshoot occurs when humanity's demand on nature exceeds the biosphere's supply, and its ability to absorb and render harmless pollution. Such overshoot leads to a depletion of Earth's life supporting natural capital and a build-up of waste. According to the Global Footprint Network (2019), August 19 was Earth Overshoot Day in 2014; it was August 13 in 2015 and August 1 in 2018 (www.overshootday.org). This marks the date when humanity has exhausted nature’s budget for the year. For the rest of the year, we will maintain our ecological deficit by drawing down local resource stocks and accumulating carbon dioxide, wastes and poisons in the atmosphere, land, water and our bodies.

So, the point at which we must reduce resource consumption is now, immediately, with massive and continual reduction, subsequently supported by restorative programmes, programmes that restore our stocks of natural resources. Can we tell if pollution is building up in the eco-system? The government reported in 2008 that 29, 000 deaths in the UK were attributable to air pollution. (COMEAP, 2008). According to a report from the Royal College of Physicians, air pollution has increased its contribution to the early death of 40 000 people in the UK (RCP, 2016; Lancet, 2017).

How much resource do we have left? Metals such as iron are forecast to reach peak production in 2030, zinc in 2025 and copper in 2038. These metals are forecast to become scarce approximately ten years after peak production years. The forecast includes variable rates for recycling, material use and population (Sverdrup, 2014). Many of these materials are integral to renewable energy technologies and advanced communications equipment. Of course, this relates to exploitation at current rates and with current technologies, yet, at a cost, resources can be exploited that currently are economically unviable, and in some cases a complete substitution of current resource consumption may take place in the future. So, although resource availability can look bleak, human ingenuity and discovery may prolong or even completely substitute the need for depleting resources.

However, cities are increasing rates of consumption at such a pace that research and innovation may not be able to provide technology for further

resource extraction or substitution quickly enough. The Intergovernmental Panel on Climate Change in its Fifth Assessment Report (IPCC, 2014) estimates that by 2030 city consumption of global energy output will be 70 – 76%, with a similar percentile of $CO_2$ emissions. Only 160 million residents will have clean air, whilst 3 billion residents will be using polluting and unhealthy fuels for basic cooking.

A rare visual representation of carbon emissions for the city of New York illustrates the scale of pollution that we are accepting from city growth (Figure 2.2). Each sphere represents one tonne of carbon; the overwhelming pile of spheres represents a single day's emissions, along with associated fine particulates, sulphur dioxide and nickel; enough to contribute to the deaths of 2000 New Yorkers each year (NYC Health, 2013).

A city impact study conducted for the city of London (population 7.4 million) noted the following staggering data (City Limits London, 2002).

**Energy consumption**: 154,400 Gigawatt hours (GWh) of energy (or 13,276,000 tonnes of oil equivalent), which produced 41 million tonnes of $CO_2$.
**Material consumption**: 49 million tonnes of materials. On a per capita basis, this represents 6.7 tonnes; leading to the generation of 26 million tonnes of waste.
**Food consumption**: 6.9 million tonnes

**Water consumption**: 876,000,000,000 litres, of which 28% was lost due to leakage.

**Figure 2.2:** One tonne spheres representing New York City carbon emissions in one day. Carbon Visuals 2010 www.carbonvisuals.com. Reproduced with the permission of Carbon Visuals.

**Natural capital consumption**: 49 million global hectares (gha), which was 42 times its biocapacity and 293 times its geographical area, or twice the size of the UK.

The ecological footprint per London resident in 2007 was 5.48 gha (Calcott and Bull, 2007), exceeding the global 'earthshare' of 2.18 gha / person. For Londoners to be ecologically sustainable by 2050, will require a 35% reduction in consumption by 2020 and an 80% reduction by 2050 (GLA, 2003). So, what does a 35% reduction in consumption feel like? The average UK household

energy bill is £1163 (UK Power, 2018); reduce this by £407 in just 1 year; and then reduce by another £523 over the next 30 years. The average car mileage travelled in a year has reduced over the last few years, (although the total number of cars has increased) to 6580 miles (DfT, 2018); reduce this by 2303 miles in just 1 year and then another 2961 miles over the next 30 years. Now apply to cups of tea, bottles of wine, and tubes of toothpaste.

Indeed, it is clear to see that cities are having a huge negative impact upon resource consumption, pollution levels and the well-being of the human population. There are some glimmers of positive returns from our investments in change. Certain urban forms reduce the carbon footprint; these include more compact urban growth, more mass transit and greater use of cleaner, more sustainable energy supplies for buildings and transportation. But the scaling of these improved responses has yet to be seen.

The impact of this resource consumption is being felt over an ever-increasing area, often described as the city region (Robson *et al*., 2006). City Regions are essentially functional definitions of the economic and social ‘reach’ of cities. In Figure 2.3, Ravetz (2014) provides a generic map of the interconnected and independent series of flows for a city covering the key areas of ecology and resources; finance and economy; production and supply chains; livelihoods and consumption.

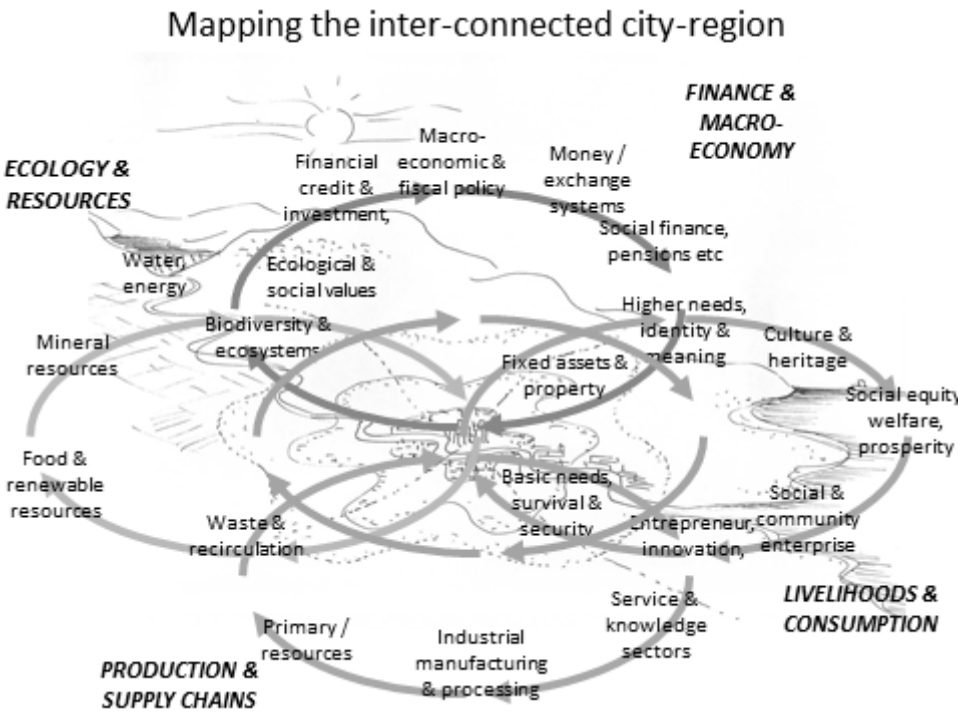



**Figure 2.3.** Mapping the Interconnected Region. Reproduced with permission: Ravetz (2014).

Another perspective is that cities are the exciting, interactive centres that generate new ways of living and societal values; the massive concentration of interconnections increases the likelihood of finding a solution to any issue. For instance Bettencourt *et al.,* (2007) and Bettencourt (2013) argues that when a city's population doubles, there is an approximate 15% increase in the city's output per capita, a 15% increase in wages, a 15% increase in GDP, a 15% increase in patents, a 15% jump in violent crime; this is urban scaling. This is of course a view back in time and does not necessarily dictate the growth of cities in the future. However, as cities grow the compromise between space and travel time to maximise connectivity leads to denser city development. But

without sustained protection of green infrastructure within the built environment, the city then draws more resources from further afield.

Recent research indicates that in the megacities, consumption appears to be higher than average, and megacities exhibit faster than average population growth. The 7% of the world's population living in these megacities consumes 9% of the world's electricity and 10% of its petrol and produces nearly 13% of the world's waste. (Kennedy *et al*., 2015). To keep them running, these cities also require services from surrounding areas such as industrial lands, ports, suburbs, infrastructure routes, water catchments, and agricultural land. The environmental benefits of a dense urban core can be outweighed by the resource-inefficient hinterland. The ecological footprint[1] of London's hinterland for example, is the equivalent to twice the entire UK land area (City Limits London, 2002).

City region thinking is rapidly advancing as an innovative way of planning future development. Ideas advanced by the Regional Development Agency (RDA) in 2005 advocated a London City Region governance structure that would enable integrated action across the south-east (SEEDA, 2005). Areas of economic activity should be aligned to city requirements, transport routes should enable rapid transit of the people that will make the city function, housing should be provided along these routes and energy systems should be engineered to maximise city growth. Heavily orientated to the city's needs and predominantly

[1] Ecological footprinting relates consumption of natural resources to the ecological sustainability of an area, by aggregating impacts to global hectares.

geared to economic growth, initial city region thinking exploited resources, rather than enabled sustainable development.

Advances on this thinking saw opportunities to develop economic growth in regional nodes, each town developing its own specialisms, agreed across the region. This approach had the potential to recognise the needs of all components of the city region, giving opportunity throughout the region. The regional approach was based on the *Renaissance* programme, established to support regional spatial and economic strategies developed by the RDA – Yorkshire Forward (McDonnell *et al*., 2011). *Renaissance* sought to engage communities in developing their aspirations for their city, town and area. This enabled distinctiveness, set within an agreed regional planning framework, the implementation of which became a joint effort between the local authorities and the RDA. Subsequent development of Local Enterprise Partnerships (LEPs) has reverted activity across the UK to 39 localised areas, with the LEP heavily dependent on inadequately resourced local authorities, rather than pan regional, collaborative, sustainable development (NAO, 2016). The result may well be exploitation of resources rather than the sustainable development of benefits across the city region. This is now being addressed in part by the establishment of combined authorities, which are bidding for funds from central government and for the right to raise and spend taxes within their respective spatial areas.

Cities impact on a wide area and how this is managed is clearly difficult and complex. The task is made more intractable by several features: a system that overwhelmingly focusses attention on economic growth; that benefits a relatively small number of city workers, entrepreneurs and officials; and the fact that policy encourages this complexity to be reduced to the interaction of market mechanisms. The responsible answer is to develop a system that incorporates the price of dealing with the consequences of economic growth, and a system by which benefits are more equitably distributed, combined with the rapid deployment of sustainable technologies and techniques, some of which are considered below.

## 2.3 Sustainable City Infrastructure

Given the scale of city development across the globe it is appropriate to adopt the following approach: to tackle climate change, tackle the cities (Tyndall Centre, 2009). There are many approaches that can be used to transform the city, to make it liveable, sustainable and resilient. By identifying the type of transition technologies and techniques available and benchmarking the current city inclusion of technologies and techniques, plans can be put in place to evaluate the suitability of specific approaches to city need. Once this has been done there is an opportunity to determine the level of technology penetration required, project readiness across the city, the financing and insurance requirements and the business models required to deliver deployment.

### 2.3.1 Transition Technologies

A range of typical technologies suitable for a sustainable city strategy are reviewed below, drawn from the Intergovernmental Panel on Climate Change (IPCC) reports of 2012 and 2018.

#### 2.3.1.1 Renewable energy and carbon

The Stern Review (Stern, 2007) and the IPCC both contend that the most significant impacts of climate change can be reduced if 1% of global GDP is spent on renewable energy. The IRENA report Global Energy Transformation (2019) now states that the requirement is 2% of GDP. The further investment is delayed, the greater the eventual cost will be and indeed the greater the sum of the opportunities not realised. In an update on his report in 2016, Lord Stern reflected that action has only just begun. However, committing to such an investment target can help each country and indeed each city identify whether they are achieving the sort of technology investment level that will help them reduce city risk and vulnerability.

The Paris Agreement of 2016 enables an acceleration of activity, but the costs of not acting are increasing even though the costs of renewable technologies are rapidly decreasing. Infrastructure investment must increase at a scale far beyond the current value of all existing infrastructure – in fact Lord Stern calls for $5 trillion to be invested each year over the next 20 years into low and zero carbon infrastructure and, along with the IPCC (2018), calls for a complete rethinking of the way in which finance systems work to achieve a city and world

transformation (Stern, 2016). Therefore, on a world scale investment based on the Stern estimate of 1% of world GDP, needed to have been running at $600 billion / year in 2007 and needed to have reached $800 billion in 2017, based on the World Bank's estimate of global GDP (World Bank, 2018). The IPCC (2018) estimates total annual average energy supply investments required in 1.5°C pathways of US$1460 to 3510 billion and total annual average energy demand investments of US$640 to 910 billion for the period 2016 to 2050. The Climate Policy Initiative report estimates total global climate finance flows for 2015 amounted to US$472 billion and US$455 billion for 2016. Potential for 2017 is estimated at US$510 billion (CPI, 2018). The gap between estimated required investment levels and actual remains vast.

The economic gross value added of London is £408 billion – investment in renewable energy should be at £4 billion / year based on Stern's original review. Similarly, the economic output of Birmingham is £28 billion – investment should be at £280 million / year based on Stern's review. These are the minimum levels of estimated investment required. A mini-Stern review for Birmingham and the Wider Urban Area (Gouldson, 2012) highlighted a potential 31.8% reduction of carbon emissions based on a 1990 base level after a £17.8 billion investment in appropriate technology, generating a £3.3 billion annual saving. Evidence for this level of investment having been made is negligible, the carbon and financial savings unrealised.

A focus for innovation has been to harness renewable sources of energy. What change has occurred, if we look back over say 50 years? In that time period we have increased renewable energy generation from 6% of the world total to 13%. This is not a radical transformation, and certainly does not equate to the level of investment suggested in the Stern Review.

What progress have we made in transforming the world's energy system over the last 30 years? It's still not good news - certainly not good enough. In 1980, 82% of the global energy system used fossil fuel. In 2012, 86% of the vastly expanded global energy system used fossil fuel. Until the Paris COP21 agreement in 2015, fossil fuel-based companies had every confidence in predicting massive reliance on their fuels for another 50 years. What kind of investment is required to achieve the renewable energy targets established in Paris? A Ceres report finds that it is a daunting, yet manageable, figure of US$12.1 trillion over 25 years, or US$485billion / year on average. The Renewables Global Status Report totals new investment (annual) in renewable power and fuels at US$312.2 billion in 2015 and US$241 billion in 2016 (REN21, 2017). Developing the renewable energy systems of the future is compromised whilst subsidies into the fossil fuel system exceed US$6 trillion / year (Coady *et al.,* 2015). In contrast renewable energy subsidies stand at US$120 billion / year according to the Coady report on behalf of the International Monetary Fund.

The IPCC stated (IPPC, 2012) that if governments were supportive, and the full complement of renewable energy technologies were deployed, renewable energy supply could account for almost 80% of the world's energy use within forty years. This means that by 2050 world renewable energy sources would occupy the larger of the pie segments in Figure 2.4, a complete reversal of the current situation.

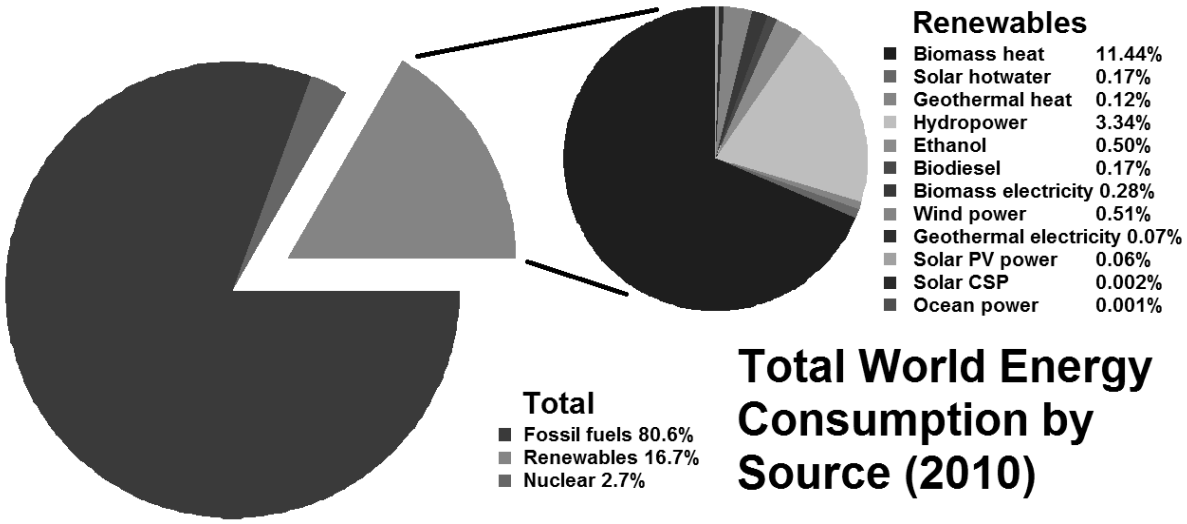



**Figure 2.4:** Total World Energy Consumption by Source 2010. Reproduced with the permission of Vital Signs. 2014.

The IPCC reports that there are few fundamental technological limits to integrating a portfolio of renewable energy technologies to meet most of the total global energy demand. The IPCC expects renewable sources to supply more than 17% of total energy by 2030, and 27% by 2050 (IPCC, 2014). Yet the International Energy Report (IEA) on Global Energy highlights that energy demand increased by “2.1% in 2017, compared with 0.9% the previous year and 0.9% on average over the previous five years” (IEA, 2018, pp.1). Over 70%

of the rise was met by fossil fuels, a quarter by renewables and the remainder by nuclear (Figure 2.5). What is needed is an exponential growth of low-carbon energy sources which must increase by > 1% / year. This is more than five-times the growth registered in 2017 to meet carbon reduction targets.

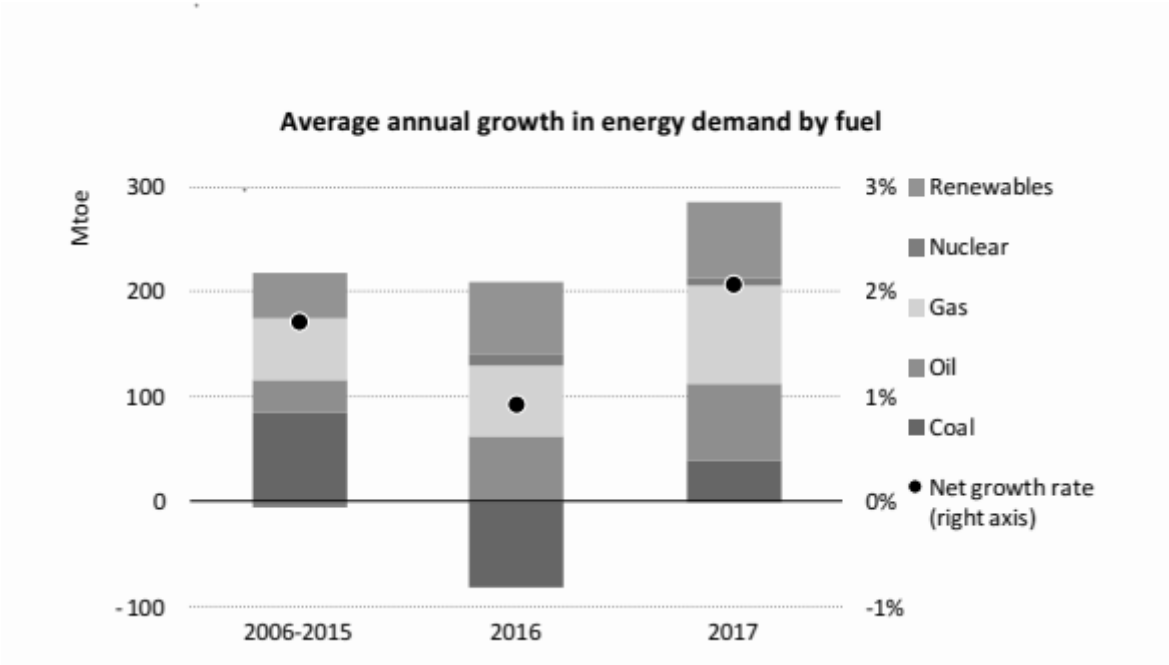



**Figure 2.5:** Average annual growth in energy demand by fuel. © OECD/IEA, 2018, Global Energy & CO2 Status Report 2017, IEA Publishing. Licence: www.iea.org/t&c

### 2.3.1.2 Adapting Electric Power and Energy Systems

A few cities have adaptation initiatives underway for energy systems, while others have begun to consider the steps needed. The City of Sheffield, UK, in partnership with E-ON has built the Templeborough biomass plant. Initial start-ups at the renewable energy plant began during the summer of 2018 after which it will generate around 41MW of green electricity, which is enough to supply 78,000 homes and save over 150,000 tonnes of $CO_2$ every year. This is along with a new £20 million low carbon district water heating network

(Templeborough Biomass Power Plant Limited, 2019). City networks in Denmark, Sweden and Germany are setting world leads, but take-up of integrated renewable energy electrical and heating systems remains relatively low.

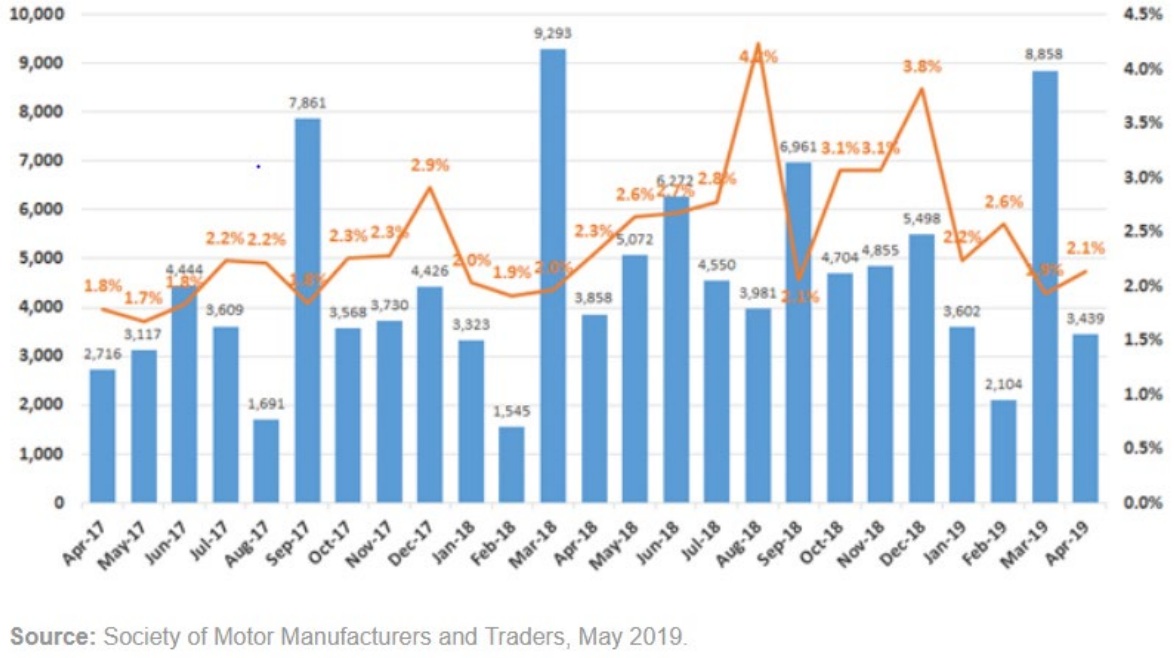
Because of the slow deployment of district heating networks, research is suggesting that private independent measures will dominate the adaptation response as people adjust their buildings, generate their own energy and change space-cooling and heating preferences (Hammer, 2011).

#### 2.3.1.3 Transport

Improved transport technologies have been noted as one of the most positive indicators of city improvements and indeed as the density of population increases, public transport modes increase in use. If public transport is supplied with renewable energy, this can lead to significant decreases in overall city material and energy consumption as well as reduced emissions and associated health improvements. A recent transport technology that has begun to hit the streets of our cities is the ultra-low emission vehicle, which includes electric powered means.

In the UK at the end of 2014 there were approximately 20,000 electric powered and ultra-low emission vehicles registered, representing less than 0.07% of the 29 million cars currently on our roads. With dramatic increases, the total in April 2019 reached over 210, 000 vehicles. This remains a small fraction of the total

37.5 million licensed vehicles in the UK, being less than 6% of total UK vehicles. There is an increase in the percentage of new cars registered (SMMT 2019 Figure 2.6), but we can see that once again the scale of the transformation required is considerable.




**Source:** Society of Motor Manufacturers and Traders, May 2019.

**Figure 2.6:** New Ultra Low Emission Vehicle registrations 2011 - 2017. Source: DfT Statistical Release 2017

### 2.3.1.4 Resilient buildings

Resilient building, both in design and implementation, is a viable technique for cities. Rapidly growing cities, or those rebuilding after a disaster, have opportunities to increase resilience, but this is rarely realised. Without adaptation, risks of economic losses from extreme events are substantial in cities with high-value infrastructure and housing assets.

“Central Christchurch (New Zealand) will become the thriving heart of an international city. It will draw on its rich natural and cultural heritage, and the skills and passion of its people, to embrace opportunities for innovation and growth. Redevelopment will acknowledge the past and the events that have shaped the city, while reflecting the best of the new” (CERA – pp27, 2014). The Christchurch Central Recovery Plan outlines how the vision can be achieved in three ways: define the form of the central city; set out the locations of key anchor projects to encourage investment and growth; outline block plans to show what the city could look like in the future. This does not read as if resilience and sustainability is at the heart of the Christchurch city rebuild after a natural disaster.

The resilience of poor-quality housing, often at risk from extreme weather, can be enhanced via structural retrofitting and interventions that reduce risks, such as flood attenuation as developed at Alkborough, Yorkshire (HM Government, 2011), and non-structural interventions such as insurance (FloodRe, 2019).

Cities need innovative cooling ideas for property. Air conditioning and other forms of mechanical cooling are too expensive, unavailable for the many urban households with no electricity, and simply do not make sense when electricity generation contributes to GHG emissions. Electrical supply needs to be both secure and from renewable sources to allow communities to seek adequate cooling in extremes, supported by increased green infrastructure. Simulations for London (under UKCIP02 Medium-High emissions scenarios), for example,

suggest that passive designs are a viable option for the UK (Hacker and Holmes, 2007).

Leading the way in building design is the Bullitt in Seattle, USA. “All big advances begin as an idea. The Bullitt Centre is designed to show what’s possible, increasing the pace of change in the movement toward high performance green buildings and resilient cities’’ (Bullitt Center, 2018).

#### 2.3.1.5 Water supply management

Across the world, concerns over water scarcity are rising (Figure 2.7). For cities with climate change adaptation plans, water and waste-water management are usually important components. But developing such measures is not yet commonplace.

Supply-side approaches to seasonal water shortages are frequently advocated. An analysis of twenty-one draft Water Resources Management Plans in the UK found that agencies usually favoured reservoirs and other supply-side measures to adapt to climate change (Charlton and Arnell, 2011). However, since 2004, in New South Wales, Australia, homeowners have been required to ensure that newly built houses use 40% less potable water than an established benchmark level of consumption. This is to be achieved by water-saving measures such as water-efficient shower heads, dual-flush toilets, rainwater tanks and greywater treatment systems (Warner, 2009).

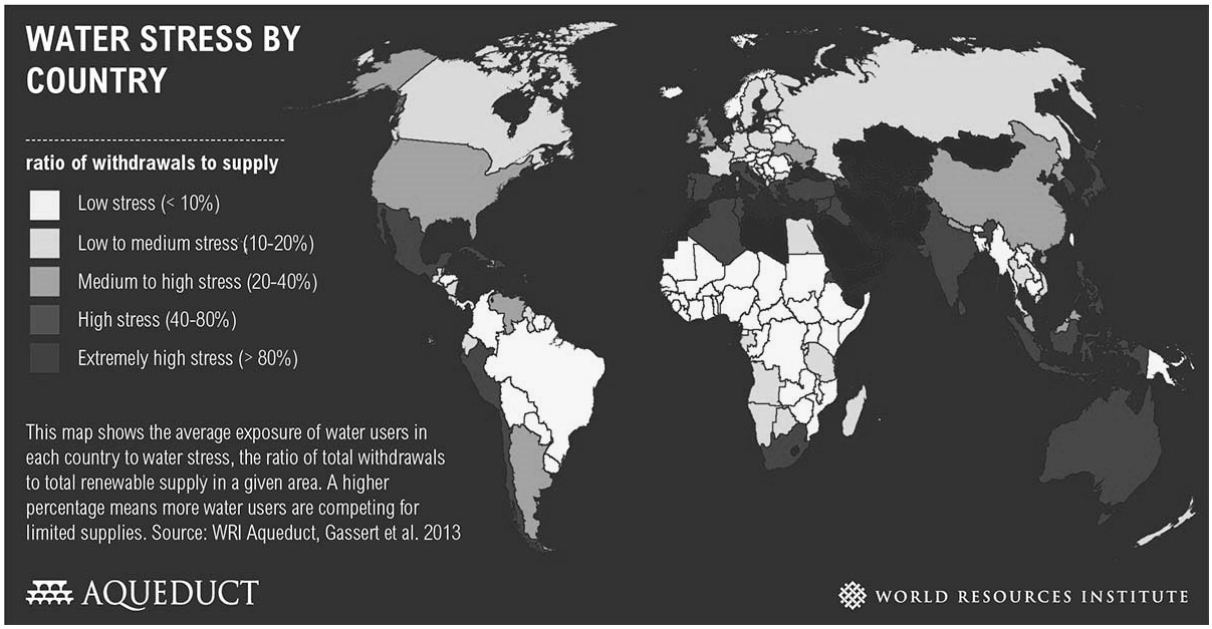



**Figure 2.7:** Water Stress by Country. Source: World Resources Institute, 2013.

In most parts of the world adaptation measures are still too general and lacking institutional commitment. These measures require dramatic changes to supply systems, effective land management, and extensive demand side management measures. These are not easy fixes and until the crisis hits city authorities, making some incremental improvements is more politically acceptable and, in the short-term, less expensive, than tackling the issues now. The current issues in India seem to highlight this mentality (Gogoi and Tripathi, 2014).

Evidence from Cape Town, South Africa, shows a level of activity to tackle decreasing water input and rising demand over a sustained period (Cape Town, 2016). However, what surprised the planners was a dramatic shift in rainfall patterns, extending the drought from an anticipated 2 year maximum to 3 years. Reacting to severe crisis the city has put together a holistic, integrated water

management plan, incorporating new technologies, management systems and collaborative techniques (City of Cape Town, 2017).

Altogether, low-carbon urban actions available today could generate substantial savings in the period to 2050 with a current value of US$16.6 trillion (Gouldson *et al.*, 2015). This could be enough to finance the energy transformation costs of $12.1 trillion identified by CERES (REN, 2017).

### 2.3.2. Transition Techniques

The 2014 IPCC report (IPPC, 2014) is quite sobering as it reviews the techniques that are being adopted across the world in the face of rising risk, primarily climate breakdown. Urban climate risks, vulnerabilities, and impacts are increasing across the world in cities of all sizes, economic conditions, and characteristics. These risks include rising sea levels and storm surges, flooding, drought and extreme precipitation, heat stress, landslides and air pollution. These impacts are all closely linked with widespread negative impacts on people. Yet there are many techniques available to us now, which if rapidly deployed at scale could make a significant difference in efforts to mitigate and adapt to actual change and predicted dire circumstances.

#### 2.3.2.1 Eco-system services

These are the benefits provided by ecosystems that contribute to making human life both possible and worthwhile. The term ‘services’ is usually used to encompass the tangible and intangible benefits that humans obtain from

ecosystems (Boulter, 2011). Some ‘services’ such as floodwater attenuation or soil retention have been completely buried by urban development or partially damaged. Only in recent years have studies tried to place a financial value on the multiple services provided by the very environment that has been removed or built over. Only now are city managers beginning to realise the multiple benefits of green infrastructure for climate change mitigation and impact management, as well as for the provision of clean air, clean water, food and so many other essentials that improve the life of the people in the city (TEEB, 2010).

#### 2.3.2.2 Vulnerability risk reduction

This approach has been developed from risk assessment in global supply chains – and applied to critical factors across key resources, regions and cities (City of Belgrade, 2015). For example, urban food sources are dependent on local, regional, and often global supplies. Climatic drivers can exacerbate food insecurity, especially of the vulnerable urban poor. Urban and peri-urban agriculture, local markets, and vegetable gardens on roofs hold good prospects as adaptive measures but are under-utilised in rapidly growing cities. In more developed cities, the investment in the existing infrastructure makes it unattractive to retrofit, or to clear development to make way for localised food production. Evidence of urban sources of food being re-introduced remain scarce and are certainly not at scale, therefore food security risk is not decreasing; it is in fact an increasing vulnerability across the world.

#### 2.3.2.3 Community based adaption initiatives

Community-based solutions can build the social fabric of a city, generating urban resilience. Examples are becoming more plentiful, an exemplar being the Urban Farming Guys (UFG) of Kansas City (Urban Farming Guys, 2018). UFG uses alternative forms of capital and works to get things done by whatever means available and with assets the community already has in place. It is organic process, responding to community support and resources, using appropriate technology to grow food and techniques to help realise the potential of the people in the community. However, even these solutions may exacerbate inequality at the city level, with only those local areas with already existing strong levels of social interaction being able to benefit most from community-led action or secure support from international and national partners.

#### 2.3.2.4 Climate impact models

There are now significant massive data streams available to feed national and city authorities' climate change models to help make investment decisions for adaptation and protection. The United Kingdom Climate Impacts Programme (UKCIP) was established in 1997. In 2003 the first decision-making frameworks were published followed by guidance for business in 2005. By 2007, UKCIP data was commonly used by policymakers across the country. In 2014 the UK Government stopped funding the programme, work now being completed for various partners and research agencies provides the organisational funding. However, across the world; existing climate models are not downscaled to the city level. Data on climate impact risks are infrequently collected and often

fragmented across city government departments (Hardoy and Pandiella, 2009). Better decision-making will be enabled when data sets are made locally relevant and when decision-makers have assurance in the data that is provided. The whole SMART City concept is being built around the feasibility of providing decision-makers with real time data from across a city area, with multi-level and multi-source inputs. SMART cities must be presented through a governance and assurance process that provides the basis for confidence.

#### 2.3.2.5 Development Planning

This has been the main tool used in guiding city development. Planning has led to garden cities; zoning; cities for cars; high rise; low rise; commuter belts; satellite towns and green belts, to name just a few of the ideas that have been put forward. But now the determining factor in development planning must be climate breakdown risk and vulnerability. The form and geography of urban development, as well as the scale and location of climate-related risks to urban buildings, enterprises, and populations should provide direction to new investments. Migration flows should be directed away from high-risk sites through climate-sensitive disaster risk management, urban planning, zoning and infrastructure investments. But the priority given to economic growth usually means this is rarely implemented (Reed, 2013). Even in the UK with UKCIP (UKCIP, 2019) data and Environment Agency clear planning warnings, 200, 000 houses were built in areas of significant flood risk during the period 2001 – 2011. Large numbers of these were subsequently flooded (Committee on Climate Change, 2012).

In the United Kingdom, significant flood events which endangered critical national infrastructure led to the commissioning of the first report on UK national infrastructure adaptation readiness for climate change (DEFRA, 2011); a first stage in UK sector adaptation. This study was directed by the Adaptation Sub-Committee (ASC) to provide insights into preparedness across the UK to deal with the following issues: assets or institutions that are sensitive to current climate risks; decisions that have long-lasting consequences; and decisions that may have systemic and far-reaching effects. This criterion led the ASC to identify five priority areas for immediate action in preparing for climate change: taking a strategic approach to land-use planning; providing national infrastructure; designing and renovating buildings; managing natural resources sustainably; and effective emergency planning. This report has laid the foundation for strategic documents developed by all major UK infrastructure organisations. Extreme weather can impede economic activities, damage infrastructure and disrupt ports, rail, road and supply chains.

Design for resilience in distribution networks such as electricity, water, food, and manufacturing supply chains have developed considerably over the last few years yet is still not a strong feature world-wide and is not a consistent feature at city level. There appears little evidence that cities' adaptive capacities currently influence private sector investments.

#### 2.3.2.6 Participatory Governance

Participatory processes figure prominently in cities that have been leaders in urban adaptation. Across the EU such processes are a legal requirement for major infrastructure projects and strategy documents. The UN describes a common vision of a future city that is resilient, safe and healthy as the first step towards achieving a leadership position and one in which the citizens are fully engaged (UN-HABITAT, 2011). Putting people first in city planning is seen as the pre-requisite for success. Yet a review of forty-five vulnerability mapping exercises found that only 40% included stakeholder participation (Preston, Yuen and Westaway, 2011). It also highlights the challenge local governments face to secure the resources, including technical expertise and institutional capacity (Mazzucato, 2015), to organise and use participatory processes to strengthen rather than delay adaptation decision making.

This technique has many financial and ownership implications that will be examined further in Chapter 4 (on finance).

## 2.4 Evaluating City Infrastructure for Liveability

This chapter thus far has presented the city as a dominant expression of anthropogenic activity. The city is where most humans live and work. The city generates enormous benefits, but benefits that currently exact an unsustainable toll on the earth's life support systems. The city continues to attract a massive influx of new residents eager or desperate to seek out better opportunities than are currently available in rural areas. Some might argue that a reversal of this

trend is urgently required; others, that making the city more liveable, sustainable and resilient is a practicable approach.

This thesis has opted to explore how to make a city more liveable and therefore presents a brief review of the ways in which cities are currently evaluated for success in this process and concludes with the identification of a pressing research need to present the most sustainable infrastructure solution for the actions selected to improve city liveability. For the purposes of this thesis, liveability is defined as “using only a fair share of one world resources and improving individual and societal wellbeing” (Liveable Cities, 2018).

### 2.4.1 City Ranking

A multitude of assessment methodologies to rank the liveability, sustainability or otherwise of the city have been developed (Bell and Morse, 2008). Many have strict set criteria; many keep the detail of these criteria confidential and many require payment for support to improve the city rating. They have been developed to measure the socio-economic and environmental impacts of current urban form, infrastructure, policies, systems of supply and demand, and equality, amongst many other possible components. They should allow for a ranking of issues that might require coordinated efforts to improve the current condition in a way that should reflect citizen aspirations and needs as well as aligning with current scientific consensus. Finally, they should enable a city to monitor whether interventions are improving the baseline indicators.

There is a proliferation of ranking tools (Zavadskas *et al*., 2007), performing three main functions – performance assessment, explanatory and test (Shen *et al*., 2011). The Science for Environment Policy (2018) unit selects fourteen scalable, easy-to-use indicator frameworks with supporting online resources and tools. There is no doubt that ranking city liveability, sustainability and resilience performance can be done, one way or another.

An example (not included in the Science for Environment Policy report) would be The Economist Intelligence Unit's liveability survey (EIU, 2018). Every city is assigned a rating of relative comfort for over 30 qualitative and quantitative factors across five broad categories: stability (25%), healthcare (20%), culture and environment (25%), education (10%), and infrastructure (20%). These criteria may not reflect the priority needs, or aspirations of the city concerned.

A further example is The Thriving Places Index (Happy City, 2017) which comprises three main elements – sustainability, local conditions and equality. These elements are supported by eleven domains - $CO_2$ emissions, energy consumption, waste and recycling rates, work & local economy, mental and physical health, education and learning, place and environment, people and community, wellbeing inequalities, health inequalities and income inequalities. These in turn are supported by nineteen sub-domains. Scoring is provided at each level, so that a headline indicator comprises only three elements that can be easily communicated. All data for each indicator selected is available to all

150 English local authorities. Data is brought forward from a range of well-established agencies and accuracy is being continually developed.

A very powerful component of this tool is the easily communicated visual representation of results for all areas. The information gathered enables areas to develop an improvement plan that reflects the ambitions and the needs of the area.

The UK CityLIFE$_1$ (Leach *et al.*, 2017) has a most comprehensive set of 345 city performance parameters for assessing the merit of city interventions developed around the four lenses of society, environment, economy and finance, and governance and policy. There is recognition that the complexity of the city and the frustrating lack of critical data prevent causal effects from being correctly described and interpreted. Nonetheless the proponents of this approach advocate the in-depth policy discussions that are enabled through this approach as well as its ability to define the areas where detailed study would uncover the reasons for specific performance levels and thus provide direction into appropriate interventions.

And it is precisely at this juncture that the application of city rating methodologies should be challenged. If the criteria are set by others, just how relevant to the specific city are they? Participation (Sarker, Ross and Shrestha, 2008) and inclusiveness (Gilbert *et al.,* 1996) are fundamental to succeeding in delivering a liveable city. The UK CityLIFE$_1$ approach specifically requires a

detailed, participative process; a process that is very difficult to achieve given staffing and financial constraints evident across many cities and regional areas, but nonetheless fundamental to preparing an investment ready city portfolio of infrastructure interventions. The setting of goals, targets and timescales for implementation are the pre-requisites to prepare an investment plan. Plans completed with full stakeholder participation, would include those that could finance and insure the process and the investment portfolio. Currently this is where there is a significant gap – matching investment ready infrastructure programmes with the source of finance (Kim, 2016).

### 2.4.2 Selecting Liveable City Infrastructure

The implications for city infrastructure are quite profound when city ratings are applied. Firstly, we can measure the success of existing infrastructure in delivering sustainability elements relevant to sections of the rankings systems. Next, a ranking system allows participative discussion on priorities for improvement, which, in many cases, will require some sort of infrastructure to support the process. Then we need a method to help cities identify the most sustainable and appropriate infrastructure to invest in.

There is plenty of money around, particularly for investment in infrastructure assets (Kim, 2016). Pension funds have a need for stable, long-term investments which align with bankable infrastructure investments. In addition, there is a growing trend for pension and insurance funds to interact more directly with local authorities and government. Cities need to be proactive in

involving stakeholders as early as possible, designing projects that are bankable, and marketing to global investors.

MIPIM (Le marché international des professionnels de l'immobilier) Cannes, (MIPIM, 2019), is a leading property exhibition hosting over 20,000 participants from office, residential, retail, healthcare, sport, logistics and industrial sectors enabling links to investors. Many UK cities participate in MIPIM, generally highlighting very specific investment opportunities. However what cities really need to engage in is the development of a **Li**veable, **S**ustainable, **R**esilient and **I**nvestment **R**eady **C**ity event (**LiSRIRC**); a process that this thesis sets out to describe. This event would feature a holistic city infrastructure portfolio, with early engagement of investors and all other stakeholders.

There are at least two significant approaches to assist in this process of matching investment-ready infrastructure and sources of investment.

#### 2.4.2.1. Infrastructure taxonomy

Analysis reveals that barriers to increased investment in liveable, sustainable and resilient cities are predominantly a lack of investment ready projects and a lack of trained personnel that can evaluate the sustainable benefits of the investment (Confidential research interviews). In trying to rectify the second of these two barriers the Climate Bonds Initiative has started to develop a Climate Bonds Taxonomy. This provides guidance on which assets and activities are consistent with a rapid transition to a low-carbon economy (Climate Bonds

Initiative, 2018). The broad asset areas are energy, transport, water, buildings, land use and marine resources, industry, waste, and information and communications technology. Local government, other city institutions and other infrastructure developers can pool their projects into a portfolio, aligning, wherever possible with this taxonomy. This allows a potential investor to have a degree of confidence in the suitability of the project.

#### 2.4.2.2 Infrastructure sustainability specification

Once the type of infrastructure has been identified, that infrastructure has to be built at the highest level of sustainable performance. For example, wind turbine blades would be classified as low carbon infrastructure and would qualify as a sound investment under the Climate Bonds Initiative Taxonomy. However, wind turbine blades are made from balsam at the centre, upon which highly toxic and explosive compounds are layered. Once the whole is finished the product is inert and totally unrecyclable. Therefore, it is ever more important to ensure that the specification for appropriate infrastructure avoids the creation of products that cannot be reused, remanufactured or recycled.

Zavadskas (2018) reports a total of 195 publications covering multi-criteria decision-making (MCDM) in civil engineering, construction and building technology over the period 1991 – 2017, 61 of which have been in the period 2015 – 2017. All of these publications were selected for their contribution towards the sustainability specification of the infrastructure type concerned. They have covered detailed approaches to building structures and systems,

location selection problems, construction technology, retrofitting, sustainable construction, construction management and building maintenance.

There is much more research required to complete the series of infrastructure sustainability specifications, yet when combined with a taxonomy that certifies investments and provides investors with confidence in the investment, one can conceive of a very powerful combination of tools to help achieve liveable, sustainable and resilient cities.

## 2.5 Citizen Dialogue and Investor Partnerships

This entire chapter has been based upon the perception that our cities do not currently evidence many of the features that practitioners, academia, policy makers and other representatives of business and institutions advocate. This perspective and what cities implement to rectify the situation is not complete, though, without the full engagement of city stakeholders - those that have benefited from city growth and those that are feeling the negative impacts of city growth; and those that will invest in liveable, sustainable and resilient cities.

### 2.5.1 Citizen Dialogue

Citizen dialogue (including those citizens of the city hinterland) must be conducted in a meaningful process that embraces awareness, education, training, resourcing and empowerment. “Cities are nothing without their citizens, and citizen–centric solutions are at the heart” (FCD, 2017, pp.13) of **LiSRIRC**. Surely citizen engagement is at the heart of an urban democracy and is

founded on the rationale that if citizens are more directly involved in the process of governance, they are better citizens and that city-wide decision-making with citizens should lead to better decisions and better government or at least more widely accepted decision-making (Mansbridge, 1999; Rogers and Hunt, 2019).

The Future Cities Dialogue report (FCD, 2017) includes many of the technologies and techniques that have been presented in this chapter, the difference is that these have been reviewed by several hundred people in a process designed to help ensure that city planning is led by citizens; not done to them. ‘Deliberative planning’ (Forester, 1999) approaches to stakeholder dialogue, or ‘collaborative planning’ (Healey, 2003), elevates the role of citizens to active participants contributing to decision-making. Given the challenges of the future and the costs that need to be borne, having a majority of citizens actively participating in the hard work and the benefits of change is surely one of the ‘moral conditions’ (Shultz, 1950) that underpins the economic efficiency of the city.

Stakeholder dialogue is now embedded into planning legislation – environmental impact assessments; strategic environmental assessments; new legislation; review of legislation; planning applications and many more (OECD, 2019). Often seen as an expensive hurdle to circumnavigate, stakeholder dialogue can be the means to rapidly accelerate deployment of liveable, sustainable and resilient infrastructure in the city. It’s a process that lends itself to securing financial support through community shares, crowdfunding and peer

to peer (P2P) equity or debt loans. It's also a process that the French (amongst others) have developed even further – public participative budget allocation.

### 2.5.2 Participatory Budgets

Latin America experimented with citizens' participation in budgets in the 1980's. There are now in excess of 1000 projects across the continent. In Europe, between 2005 and 2012, experiments with participatory budgeting (PB) increased from 55 to over 1300 projects involving more than 8 million EU citizens (European Parliament, 2016). Across the USA and Canada US$300 million has been allocated through PB and 402,000 people have been engaged in the process (Participatory Budgeting Project, 2019). In the UK, over 100 projects have taken place with the allocation of several £millions (PB Network, 2015).

Participatory budgeting is a process in which members of a community decide directly how to spend part of a public budget. "It represents a direct-democracy approach to budgeting. It offers citizens at large an opportunity to learn about government operations and to deliberate, debate, and influence the allocation of public resources" (World Bank, 2007). The European Union (EU), the World Bank and the UN all recognise participatory budgeting as a legitimate methodology to invest with, and in the case of the UN and World Bank, it is a now a mandatory requirement for some projects. Paris now has the largest PB process in the world, starting with €20 million in 2014 and now having committed to €500 million up to 2020. The Parisians see this as reconnecting

the people with the place and with Government. Each project selected and delivered is labelled ‘Made by Parisians’ (Cabannes, 2017). Significant infrastructure projects have been a part of the Paris PB process and the profile of Paris as a city that delivers, with a citizenry that is thoroughly engaged, has not escaped the notice of potential investors (Invest in the EU, 2016).

There are 3 main phases to PB (Wampler, 2007):

1. Organisation - public meetings aligned with the fiscal planning process; interfaces between the local authority, partners and the public; training and awareness.
2. Deliberation and negotiation – priorities; funding allocations.
3. Implementation**,** oversight and reporting.

It is important to maintain the original intent of PB, that of engaging the populace. It must not deteriorate into a shopping spree for pet projects by more powerful groups. But if managed well, PB can transform the relationship between the local authority and the citizens as well as acting as a very sound interface for further investments to flow to the city (World Bank, 2007; Masser, 2013). Further investment, however, will only follow if priority projects are delivered, serving to boost the confidence of the community and the potential external investors (DCLG, 2011).

For the city seeking to develop a portfolio of infrastructure projects, PB demonstrates a process that engages community in a programme that realises their needs for a more liveable, sustainable and resilient city. It provides investors with a potential portfolio of smaller projects, that, when combined with communities from across a city, and indeed from across a city region, can prove viable, or align with long-term, value driven investment criteria. It is similar to the process that Yorkshire Forward, a Regional Development Agency (RDA) embarked upon in a programme entitled *Renaissance* (McDonnell *et al*., 2011). *Renaissance* sought to engage communities in developing their aspirations for their city, town and area. This enabled distinctiveness, set within an agreed regional planning framework, the implementation of which became a joint effort. The RDA developed a portfolio of infrastructure projects for each town / city that was engaged in *Renaissance,* often at the higher value end of investment. This portfolio was used as the basis for Government investment allocation and for discussion with specific potential investors.

An improvement on this process would be to engage investors as early stage partners.

### 2.5.3 Investor Partnerships

A McKinsey report claims that spending capital is the main issue, not raising it (Duvall, 2015). Although infrastructure spending requirements are enormous, governments and investors are all increasing their focus on infrastructure. Across infrastructure funds, institutional investors, public treasuries,

development banks, commercial banks, corporations, and even retail investors, it is estimated that over US$5 trillion a year will become available. What are the ways in which cities currently promote infrastructure projects?

Every city attempts to advertise why businesses should locate in the area, why investors should invest in the latest high-profile opportunities and why foreign companies should set up operations in the city. From the City of London Inward Investment Services team (City of London, 2019) - to Business Birmingham, West Midlands Growth Company (Business Birmingham, 2018) - many organisations are established to face outwards and secure additional investment into the city. One method used to engage with investors is the West Midlands Forum for Growth event (West Midlands Forum for Growth, 2016) - a traditional speaker, networking and exhibitor event.

A far more prestigious and heavily pre-managed event (attendees can book into certain exhibits / specific meetings / or be invited to specific events by hosts) is provided by MIPIM (Le marché international des professionnels de l'immobilier) in Cannes (MIPIM, 2019). Many UK cities participate in MIPIM, generally highlighting very specific investment opportunities to a select group of investors at a high profile and expensive event.

By combining PB that includes *Renaissance* style project portfolios with investors in the early development process of infrastructure programmes at all spatial and investment levels – micro / local (£000's), right through to macro /

city, region or national (£billions / £millions), it is possible to prepare a **LiSRIRC** portfolio. Instead of competitive advantage being sought between investors and project developers, and instead of bringing a loosely aligned series of high-profile projects to the marketplace, a joint effort is made to enable project development that meets the criteria for investor platforms of different types. This is increasingly important as many investors align themselves with the UN SDG's, the TCFD and other environmental, social and governance (ESG) issue-related investments. The FTSE Russell 2018 survey reports that 40% of respondents anticipate applying ESG considerations to investment strategy in the next 18 months (FTSE Russell, 2019). The total sustainable investment market is worth US$23 trillion, with around 50% of all assets managed in Europe and 33% in USA (JP Morgan, 2019). Although growth has been huge, investors report several obstacles (Schroders, 2018; research interviews) to expanding investment to the scales thought necessary (PwC, 2014). Yet most significantly, investors report an inability to find enough projects meeting their increasingly specific ESG criteria to unleash the full investor potential that currently exists (Confidential research interviews).

Developing an early stage 'Investor Forum' to support the process of city stakeholder engagement will accelerate the process of identifying and developing a **LiSRIRC** portfolio that meets the ESG criteria and values alignment of the type of investor best suited to achieving a sustainable city transformation. Such a forum would be invaluable in assisting with project prioritisation and placing an investment portfolio of different spatial and finance

levels to the most appropriate investors within the forum. This research has not identified any forum that currently functions in this manner.

## 2.6 Summary

This chapter highlights the positive and negative impacts of the growth of the anthropogenic phenomenon – the city. In asserting that it might be possible to engineer more liveable, sustainable and resilient cities, a sample of the technologies and techniques that are available today have been reviewed. Essentially it is possible to describe many features of that desirable city and we have many of the approaches required to deliver them. To assist in gathering momentum to make the shift to a more liveable city, a plethora of city assessment methodologies, ratings, tools and resources are available to assist a city leadership team in producing an improvement strategy.

In terms of selecting a city assessment tool, this research has concluded that two key approaches stand out – the highly visual and communicative approach Thriving City Index (Happy City, 2017) and the highly detailed, data driven approach (UK CityLIFE$_1$, 2017). The common determinant in implementing both systems is full and comprehensive stakeholder participation. This should include active public participation in identifying the technologies and techniques that would meet their needs, developing the infrastructure projects that will transform people's lives and actively engaging in participative budget allocation. Without this process, some of the key features of a more liveable city are lost right from the outset.

Linking a city strategy for improvement to a rating system allows for interrogation of performance, both internally and externally. Enabling early engagement of the investor community with the development of a city investment portfolio will deliver a more robust investment portfolio which can be aligned to a taxonomy (Climate Bonds Initiative, 2018) that is acceptable and understood by the investor community. Indeed, it is important to conceive of engaging the finance and insurance industries directly in financing the initial process of developing a city investment portfolio. The outcomes would deliver a robust portfolio of investment ready projects at the standard required by these stakeholders, accelerating the process of linking supply and demand. To complete this first stage of delivering a more liveable city are a set of technical sustainability specifications for each element of the infrastructure portfolio brought to the marketplace.

This process is described herein as completing a **Li**veable, **S**ustainable, **R**esilient, and **Investment R**eady **C**ity portfolio – **LiSRIRC**. The first five stages have been described above and portrayed in Figure 2.8.

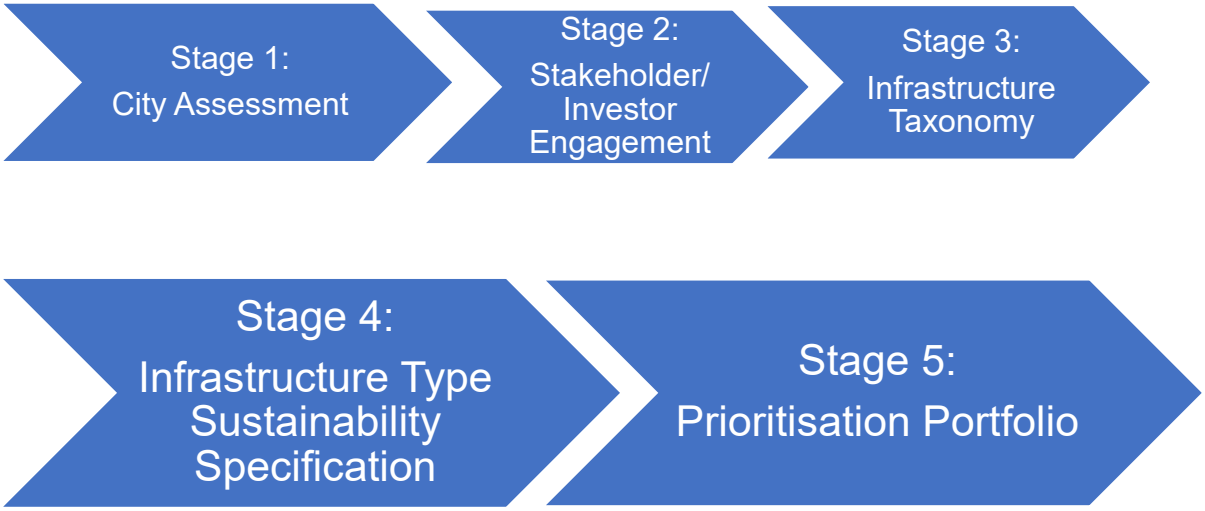



**Figure 2.8: Li**veable **S**ustainable **R**esilient and **I**nvestment **R**eady **C**ity portfolio (**LiSRIRC**), Stages 1 – 5.

Yet this review of the city, its impacts, methods of assessment and the first steps towards identifying appropriate infrastructure requirements and sustainability specifications is but the foundation of transforming our cities. There are many more fundamental components that are required to ensure, and to accelerate, the deployment of sustainable infrastructure for city transformation. On this basis, this research has undertaken a wide-ranging set of interviews with key individuals across the infrastructure sector – local authority, private sector, government, academia, finance, insurance, design, infrastructure owners, developers and construction firms. These interviews were critical in identifying the most significant issues that need resolving in developing a **LiSRIRC** portfolio. The issues identified through the research interviews are explained in Chapter 3 – Research Methods. They were finance, insurance, the valley of death (many factors are relevant, but a carefully curated

number of issues, identified through research interviews and research techniques are included within this research thesis), the economic paradigm and the role of the state.

The thesis structure has been developed to address the literature review, research data and analysis in topic specific chapters, which have been brought together as a related and interdependent set of key activities that complete the **LiSRIRC** process and project portfolio. As each topic chapter is completed a further section of the **LiSRIRC** model is illustrated and the final model, and its application, is presented in Chapter 7 – A Routemap to Implementing Sustainable Infrastructure.

# 3. RESEARCH METHODS

## 3.1 Introduction

In 2007 Yorkshire Forward Regional Development Agency (YF) brought forward an innovative compressed straw modular building concept (Modcell, 2019). The insurance costs increased to a point where the cost of perceived risk, as well as associated additional engineering safeguards, had to be underwritten by YF. The deployment of this particular innovation remained slow for many years, although currently approximately 50 buildings have now been completed using locally sourced material (often waste) and with standard performance of 80% less embodied energy and 80% less operational energy requirements (Modcell, 2019).

After initial research into city impacts (Goodfellow-Smith *et al.*, 2019), presented in Chapter 2, the evidence suggests that **accelerating** the implementation of sustainable city infrastructure is an urgent requirement, but that there are many obstacles to deploying sustainable technologies and techniques. So although the original premise for this thesis research was to identify the ways in which finance and insurance can accelerate deployment of innovative and sustainable technologies, it became apparent that a veritable 'valley of death' (VoD - a term commonly used to describe the difficulties of bringing a new idea through to commercialisation: Godin, 2015; Wessner, 2005; STC, 2013) exists and that understanding the components of the valley of death is critical in effecting rapid deployment - see Chapters 2 and 6.

Phase 1 research was based on several interviews held with leading experts across the finance, insurance, infrastructure, development, academia and city governance sectors. The objective was to identify the major obstacles to accelerating deployment of sustainable infrastructure in the city.

Finance related research interviews indicated that the organisations initially identified and interviewed had very limited exposure to complex finance packages and therefore had rarely considered the cost of different types of finance and certainly had not considered how the source of finance might influence the desired outcomes of the infrastructure investment. This meant that the original and detailed data collection research questionnaire was of less use than was hoped. Insurance was considered a basic and legal requirement, with little appraisal of the insurance product market taking place. Simple cost comparisons were found to be the norm. Initial assumptions that finance and insurance type / cost and alignment were investigated thoroughly were mistaken. “Any money is good money” and insurance is a “necessary evil” (Confidential research interviews). Research interviews were indicating that finance and insurance were not being used to their full potential to accelerate sustainable infrastructure through the VoD. In addition, interviewees were highlighting other very significant issues that affected sustainable outcomes in city infrastructure. The research method then became one of assimilation - identifying concerns and defining which could be usefully researched within the constraints of the research period. Some of the issues raised and considered

for inclusion were access to finance; insurance duplication; economic viability; economic growth; vision; targets; lack of leadership and capacity within the local authority; lack of public awareness / engagement and participation.

Meanwhile the influence that the source of finance might have on infrastructure was becoming ever clearer. Short-term, profit seeking money or long-term, outcome seeking money influences the infrastructure investment selected, the motivations for return on capital employed or on wider social, economic and environmental outcomes secured. This moved the research method further into assimilation and integration of observed data sets and practitioner experience, combined with academic research, to formulate a much wider picture of the process of progressing city infrastructure towards a more liveable, sustainable and resilient position. Evidence was indicating that the wrong type of finance would cost more and would deliver unsustainable outcomes. This led to the idea that better finance combined with a better process was required. The formulation of a conceptual framework in which the city could assess current liveability, plan a strategy that would include infrastructure and have an adequate appraisal of finance options to support that strategy and its desired outcomes, became the main orientation of this research, rather than a simple cost effectiveness assessment.

In the case of insurance the adopted research method of data acquisition, supported by practitioner interviews and case studies of insurance products and dilemmas, provided a robust process that has identified significant opportunities

for cost savings in insurance methodology and far better outcomes if supported by the implementation of improved risk management processes.

Whilst developing an understanding of how finance and insurance influence infrastructure from an operational perspective, it became clear that the economic paradigm in which sustainable development has struggled to take root is a key determinant in the way in which society uses money. This has a direct impact on the type of infrastructure that is more easily deployed and invested in. An assimilation of key academic research and practitioner reports demonstrated that fundamental components of economic thinking need to be modified to enable finance and insurance to accelerate the creation of liveable, sustainable and resilient cities. This led to investigative research on the macro-economic policies surrounding infrastructure deployment, in the realisation that society urgently needs to reorient governance and financial systems to enable liveable, sustainable and resilient cities.

## 3.2 Research Questions and Objectives

The following research questions were formulated in 2016 to investigate this original conceptualisation:

What are the current finance and insurance arrangements used by an infrastructure delivery body? Leading to - **Objective 1:** To ascertain the financial and insurance arrangements related to infrastructure projects from

2010 – 2016 within the Worcestershire Local Economic Partnership (WLEP) strategy.

What finance and insurance arrangements would deliver more cost-effective infrastructure in the future? Leading to - **Objective 2:** To review and test what financial and insurance arrangements could be made for infrastructure projects from 2016 – 2020 within the WLEP strategy.

Can improvements and / or practicality be added to the only multi-criteria finance appraisal methodology identified in the literature review? (See Chapter 4). Leading to - **Objective 3:** To test and develop a set of theoretical statements and cost evaluation improvements to the Henn *et al.* (2016) model.

Although the WLEP expressed interest and support for the research, that support was not translated into a cooperative research programme. The researcher then sought the support of Birmingham City Council (BCC); this was secured at the highest levels and significant insights were gained from the organisation but did not translate into satisfactory support at the project officer level within the time constraints of the research. A third partner was sought and secured at the University of Birmingham (UoB) with personnel from the Estates and Finance teams supporting the research. UoB personnel have enabled access to the infrastructure providers for new site development projects.

The research questions and objectives then resolved through several reflective processes into an overarching question. If the financial system can be destructive, what types of finance and insurance will accelerate the development of liveable, sustainable and resilient cities?

**Aim:** The main aim of this research is to determine ways in which finance and insurance can be used most effectively to accelerate the deployment of sustainable techniques and technologies to create liveable, sustainable and resilient cities.

## 3.3 Revised Research Questions and Objectives

How to identify what needs to improve in a city? Leading to - **Objective 1:** Link city assessment tools with identification and prioritisation of infrastructure investment.

How does finance and insurance work at present in delivering city infrastructure? Leading to - **Objective 2:** Define normative finance and insurance models for infrastructure build.

Is there a method available to evaluate finance and insurance options against infrastructure requirements and desired outcomes? Leading to - **Objective 3:** Develop an appraisal and selection tool of finance and insurance products and providers that would support more liveable, sustainable and resilient city infrastructure through the ‘valley of death’.

Can the providers of finance and insurance be assessed against sustainability / best practice criteria to enable appropriate selection? Does selecting high performance sustainability rated providers lead to more sustainable infrastructure? Leading to - **Objective 4:** Research and develop a set of criteria that would align an appraisal tool with sustainable outcomes.

Project managers are busy enough; is there an established management framework into which this entire process can be integrated? Leading to - **Objective 5:** Propose an effective and practicable delivery approach for more liveable, sustainable and resilient city infrastructure.

An effective tool is all well and good but what systemic factors would enable liveable cities to be engineered at a faster rate? Leading to - **Objective 6:** Define the economic paradigm and describe elements of city dweller engagement through which securing liveable cities could be enabled.

## 3.4 Research Method

This research combined a positivistic paradigm, therefore using a quantitative (Orlikowski & Baroudi, 1991) element to the programme, and a constructivist paradigm, using a qualitative methodology (Tashakkori & Teddlie, 2003; Henderson, 2011). As the research questions would help formulate a conceptual framework, would require assimilation of various tools and would need the collection of data to gain further insights into applicability, this is a

mixed method approach (Teddlie & Tashakkori, 2003). Even more importantly has been the regular reflection (OU, 2006) on whether the original research questions were still relevant as scoping, interviewee insights, data and pilot research indicated that a different approach was needed. It became apparent that a simple cost effectiveness tool was not the real answer to the questions. Conceptual frameworks connecting several connected activities were more likely to achieve the original aim of accelerating infrastructure deployment.

This thesis adopts the approach that mixed method research is most appropriate to the issues that relate to finance and insurance in infrastructure implementation: concluding that the work of Ang and Slaughter (2001) demonstrates its applicability to the requirements of this research with the use of qualitative questioning regarding the use of finance and insurance products, the attitudes and behaviours of infrastructure related personnel; followed sequentially by quantitative analysis of performance.

Creswell and Clark (2007) suggested four major types of mixed methods designs:

1) Triangulation: merge qualitative and quantitative data to understand a research problem.

2) Embedded: use either qualitative or quantitative data to answer a research question within a largely quantitative or qualitative study.

3) Explanatory: use qualitative data to help explain or elaborate quantitative results.

4) Exploratory: collect quantitative data to test and explain a relationship found in qualitative data.

This research adopts an embedded approach. Whatever selection of mixed method is adopted Table 3.1 demonstrates how to verify the validity of the approach. Table 3.1 provides examples of some widely used validity types that were identified and defined by Cook *et al.,* (1979) and Teddlie and Tashakkori (2003) and brought together by Venkatesh *et al.,* (2013).

**Table 3.1: Examples of Validity in Quantitative and Qualitative Research**

Adapted from Tashakkori and Teddlie (2008) and Teddlie and Tashakkori (2003, 2009) by Venkatesh et al (2013).

| | |
|---|---|
| Quantitative Methods | |
| Design Validity | • Internal validity: Inferences made are based on observed responses and are linked to any stated causal relationship.<br>• External validity: The validity of the inference holds in related but different activities. |
| Measurement Validity | • Reliability: Test-retest reliability, internal consistency reliability.<br>• Construct validity: Inferences lead to a conceptual framework. This when applied to a practical situation is found to be useful. |
| Inferential Validity | • Statistical conclusion validity |
| Qualitative Methods | |
| Design Validity | • Descriptive validity: The accuracy of what is reported<br>• Credibility: What is stated can bear interrogation and acceptance by those that have participated in or are affected by the research.<br>• Transferability: The degree to which the results can be generalised or transferred to other contexts or settings. |
| Analytical Validity | • Theoretical validity: The explanation developed fits the data, is credible and defensible.<br>• Dependability: changes to the original plan are described<br>• Consistency: verify each step<br>• Plausibility: The findings fit the data. |
| Inferential Validity | • Interpretive validity: The degree to which the participants' statements are accurately understood by the researcher.<br>• Confirmability: The degree to which the results could be confirmed or corroborated by others. |

In developing an embedded mixed method, sequential, research approach, of questionnaire, data collection and testing, an eight-stage process (Burgess, 2001) has been adopted. This is outlined as follows:

**a. Define research objectives**

**Objectives:** As listed at 1.3.2

**Method:**

1. Substantive academic and practitioner review of established approaches. This has generated both qualitative and quantitative material, leading to a change in research objectives.

2. Structured interview with questionnaire to ascertain past financial and insurance arrangements secured under various constraints. This has generated both qualitative and quantitative material, leading to a change in research objectives.

3. Development of a revised finance and insurance cost assessment model. The Henn Model (Henn *et al.,* 2016) for multi-criteria finance cost assessment is the only existing methodology of this nature located through academic research and practitioner report searches analysis, or through practitioner interviews. In anticipation of improvements being made, verification through additional secondary data analysis was executed as well as a desk-top test.

The research questionnaire includes questions to help describe the context within which the delivery teams are operating.

**b. Identify the population and sample**

The population is defined as (a) the different types of infrastructure delivery organisation and (b) the individuals involved in the delivery of infrastructure.

Infrastructure spend can vary significantly, from a few thousand pounds to a £multi-billion energy or transport system. The focus of this research is to ascertain the different types of finance and insurance related packages used or available for different scales. It was anticipated that the evaluation, assessment, finance and insurance risks would all increase with increased financial spend.

c**. Decide how to collect replies**

Replies have been collected in interviews, discussion and tool application. There have been several return interviews for further discussion and clarification.

**d. Research design and questionnaire design**

Two of the most widely used mixed methods research designs are: concurrent and sequential (Creswell *et al.,* 2003). In a concurrent design, quantitative and qualitative data are collected and analysed in parallel and then merged for a complete understanding of a phenomenon or to compare individual results. In a

sequential mixed methods design, quantitative and qualitative data collection and analyses are implemented in different phases, allowing for reflection, learning and research realignment, culminating with a phase of overall integration.

This research has directed attention at the qualitative context in which finance and insurance package selections are made and seeks to then understand whether the selection choices can be correlated to project scale, project risk, sustainable outcomes or any other verifiable factor. In the first phase of research this has been done sequentially, as the review is essentially one of past decision-making.

**e. Data and information requirements:**

The following is a list of data and information requirements, in part drawn up from the original research aim in 2016 and developed to its current state as the research process continued:

City performance assessment methods; aligning investment with sustainable infrastructure techniques; sustainability specifications for infrastructure; infrastructure type; infrastructure cost; key personnel; key stakeholders / organisations / contact details; details of finance and insurance products; source of capital finance; cost of capital finance; anticipated rates of return on investment; values captured to enable investment decisions; forward selling of capital finance ownership; source of capital finance insurance; cost of capital

finance insurance; cost of contractor insurance; what factors cause the valley of death; techniques to select finance and insurance providers that perform well to best practice and sustainability; management frameworks that support rapid deployment of sustainable infrastructure; data on private and public finance cost effectiveness; current economic paradigm inhibitors to sustainable infrastructure; indicators of what a sustainable economic paradigm will look like.

**f. Pilot survey**

The pilot survey set out to test research questions and the questionnaire structure (Appendix 1). The focus was to gather quantitative and qualitative data on financing and funding infrastructure delivery, by arranging for research interviews with personnel from organisations in Birmingham, London, the UK and internationally. These research scoping meetings also gave access to key documents on management of infrastructure delivery from various organisations. What transpired was the need to simplify the questionnaire and move away from the financial details of the project (most organisations had very simple financial profiles and acted as a funnel for mainly government funds, or single source investors). The revised questionnaire (Appendix 2) was used to identify criteria by which to establish the full costs of finance, insurance costs and best practice that could be deployed to eliminate these costs.

**g. Main research and organisation survey**

The main research activity focussed on two key aspects. The first aspect was to seek data and research / practitioner reports that gave insight into the type of

criteria that enable the selection of the most cost-effective source of finance. These criteria should also include social and environmental aspects in the evaluation. This work was a mixture of assimilation and integration of information from research interviews, case study generation, academic research and practitioner reports. The research confirmed the validity of the Henn *et al*., (2016) model and highlighted criteria to add and criteria to improve.

Secondly, the research focussed on the use of insurance, the cost of insurance and better practice in risk management in infrastructure and contracting. In depth research interviews with leading insurance practitioners on the world stage, several tier one and tier two contractors, insurance innovators and knowledgeable insurance brokers secured mixed qualitative and quantitative data.

This main piece of research began to suggest that it was really the way in which infrastructure is delivered that makes the transformational difference. This included the process through which infrastructure need is identified and prioritised; the way in which finance sources are evaluated; the way in which risk is analysed and mitigated; the way in which contractors work together - these factors became more significant than simply the cost of the finance or insurance. This in turn led to added features in the research programme, namely – city assessment; infrastructure investment ready taxonomy; infrastructure sustainability specifications; best practice frameworks; management frameworks; and the economic paradigm.

**h. Analyse the data**

Mixed method data capture requires rigorous analysis of all types of data. More importantly, the quality of inferences from qualitative and quantitative studies contributes greatly to the process of developing high quality statements. Statements that are developed from interview material, 'triangulated' and 'bridged' about a phenomenon, its interrelated components and boundary conditions will help shape the way in which finance and insurance package selection will be implemented to achieve multi-criteria benefits.

Locke (2007) outlines how researchers should first develop a substantial body of data to be able to formulate valid concepts that are fundamental building blocks of a theory. Researchers then need to look for evidence of causality and identify causal mechanisms, providing evidence of an analysis route so that the credibility of the inference and the theoretical statement can be validated. Lewis and Grimes (1999) suggest that in testing the validity of statements derived from research, two approaches should be applied – 'bracketing' and 'bridging'.

Bracketing is the process of incorporating a diverse and / or opposing view of the derived theoretical statement. In effect the researcher is testing the assumption derived from the evidence by testing it against an extreme and opposite interpretation. Bridging is the process of developing a consensus between qualitative and quantitative findings. Bridging helps a researcher understand transitions and other boundary conditions.

A method to assess the quality of the statements developed from a combination of qualitative and quantitative research methods is described in Table 3.2. In effect a process of triangulation has taken place, using data, qualitative statements and testing theoretical statements within a conceptual framework, developed through this thesis. Triangulation and bridging questions were added to questionnaire 2 (Appendix 2).

**Table 3.2: Integrative Framework for Mixed Methods Statement Quality**

Adapted from Tashakkori and Teddlie (2008) and Teddlie and Tashakkori (2003, 2009) by Venkatesh et al (2013)

| Quality Aspects | Quality Criteria | Description |
|---|---|---|
| Design quality<br><br>The degree to which a researcher has selected the most appropriate procedures for answering the research questions | Design suitability/ appropriateness | Select appropriate quantitative and qualitative methodologies and decide whether they will conduct parallel or sequential mixed methods research |
| | Design Adequacy | Quantitative: quality and rigor<br>Qualitative: quality and rigor. |
| | Analytic adequacy | Quantitative: analysis procedures are adequate to provide plausible answers to the research questions.<br>Qualitative: as above |
| Explanation quality<br><br>The degree to which credible interpretations have been made based on obtained results | Quantitative and qualitative inferences | Interpretations follow the relevant findings, consistent with theory and the state of knowledge in the field and are generic. |
| | Integrative inference/ theoretical statements | Integrative efficacy: The degree to which inferences made in each strand of a mixed methods research inquiry are effectively integrated into a theoretically consistent statement. |

## 3.5 Research Procedures

The research procedure was described in detail to research supervisors and to the University and a Participants Briefing and Consent form developed. This was approved by the University Ethical Review Committee - **ERN_17-0017**. The form was sent to participants in advance of interview discussions. This provided interviewees with comfort, but what emerged was that some information was treated as confidential by the interviewees some of which the researcher was able to report but some of this information would not be disclosed even with the confidentiality agreement in place. Future research of this nature will require a partnership with potential participants at the earliest stage possible to ensure confidential information can be disclosed in a timely manner.

Interviewees were identified by practitioner networking, research papers, and scoping interviews held with City and University officials; senior financial advisors, bankers and insurers. Interviews would include reference to product details, case studies, and sometimes academic work, but primarily practitioner experience.

Each interviewee was reminded of the confidentiality statement and that permission to ascribe any material to them or their organisation specifically would be requested before publication. Notes were made of the interview sessions. Write up followed as quickly as possible.

At several stages in the research process new strategies had to be devised as partners failed to stand by their original commitments. As this occurred, tests were made to realign the research plan with feasible and useful outcomes.

## 3.6 Research Interviews

### 3.6.1 Phase 1 pilot, scoping and research interviews

**Table 3.3 Phase 1 Interview List – 17 Interviewees**

| Name | Organisation | Expertise |
|---|---|---|
| **Wendy Yorke** | Government of Western Australia | Infrastructure investment |
| **Stuart Russell** | Government of Western Australia | Infrastructure investment |
| **Julian Benton** | SunCorp | Insurance |
| **Annabelle Butler** | SunCorp | Insurance |
| **Alethea Gollan** | SunCorp | Innovation |
| **Joshua Kelland** | SunCorp | Insurance |
| **Faith Kimani** | SunCorp | Innovation |
| **Tim Pezzack** | Santander | Infrastructure finance |
| **Graham McKean** | Santander | Health finance |
| **Patrick Crawford** | Charity Bank | Finance |
| **Killean Pinder** | Green Finance Company | Finance |
| **Richard Rees** | Birmingham City Council | Policy |
| **Derrick Taylor** | Birmingham City Council | Policy and carbon finance |
| **Jack Gloneck** | Finance Birmingham | Investment finance |
| **Nick Oakley** | Finance Birmingham | Infrastructure investment |

| | | |
|---|---|---|
| **Tom Fletcher** | Greater Birmingham and Solihull Local Enterprise Partnership | Infrastructure delivery |
| **Leo McCulkin** | Acivico | Infrastructure finance, operations |

### 3.6.2 Phase 2 research interviews, data collection

**Table 3.4. Phase 2 Interview List – 28 Interviewees**

| Name | Organisation | Expertise |
|---|---|---|
| **Mike Steele** | Birmingham City Council | Infrastructure insurance |
| **Nigel Greenwood** | Birmingham City Council | Infrastructure finance |
| **Clive Heaphy** | Birmingham City Council | Infrastructure finance and insurance |
| **Sylvia Broadly** | Birmingham City Council | Infrastructure delivery |
| **Matthew Davies** | Birmingham City Council | Insurance |
| **Alison Jarrett** | Birmingham City Council | Finance |
| **Chris Smith** | Kingscote Enterprises | Energy infrastructure finance |
| **Graham De Roy** | Griffiths & Armour | Insurance |
| **Louise Pryor** | Callund Consulting | Climate change actuarial insurance |
| **Steve Johnson** | Dudley College | Infrastructure delivery |
| **Martin Davies** | IPI Initiatives | Infrastructure delivery, insurance |
| **Andrew Else** | University of Birmingham | Insurance |
| **Matt Home** | University of Birmingham | Infrastructure procurement |
| **Stuart Wilson** | Wilmott Dixon | Infrastructure delivery |
| **James Wilcox** | Wilmott Dixon | Infrastructure sustainability |
| **Roy Horsfall** | Wilmott Dixon | Infrastructure delivery |
| **David Kelly** | Morgan Sindall | Infrastructure delivery |

| | | |
|---|---|---|
| **David Boyland** | Morgan Sindall | Infrastructure delivery |
| **Darren Eaton** | Morgan Sindall | Infrastructure delivery |
| **Thomas Anderson** | Morgan Sindall | Infrastructure insurance |
| **Liesel Henn** | Civil Contractors Federation, New South Wales, Australia | Infrastructure finance |
| **Peter Yates** | Constructing West Midlands | Infrastructure procurement |
| **Richard Roberts** | NG Bailey | Infrastructure insurance |
| **Jerry Leach** | Sage Building Envelope Contractors | Infrastructure delivery |
| **Mark Coss** | Munich Re, Australia | Infrastructure insurance |
| **Peter O'Brien** | Newcastle University | Infrastructure |
| **Andy Pike** | Newcastle University | Infrastructure |
| **Mike Clark** | Ario Advisory | Infrastructure finance, insurance and adaptation |

## 3.7 Summary

A mixed method sequential research programme has been adopted to build a conceptual framework that will be tested for its ability to accelerate the deployment of liveable, sustainable and resilient city infrastructure. A process of academic and practitioner literature review, scoping, pilot and main study research interviews with embedded data capture, supported by questionnaire led interviews and practical testing, form the main components of the research programme. A process of reflection and realignment has been necessitated by research outcomes and subsequently formed a consistent part of the research process.

Forty-five people were interviewed in this process; some more than once. Management procedures, cost data, case study material, practitioner insights and rigorous analysis of academic papers and practitioner reports has led to the development of criteria for finance cost assessment; a set of criteria for insurance cost assessment; estimates of potential savings on finance and insurance costs; identification of better contractual processes that will deliver efficiency savings and more sustainable outcomes; and the development of a dynamic process for assisting with the transformation of the city. The working title for this process is the **Li**veable, **S**ustainable, **R**esilient and **I**nvestment **R**eady **C**ity (**LiSRIRC**).

**LiSRIRC** can become functional and assist in the rapid transformation of cities if the economic paradigm and the moral conditions under which investment decisions are made is changed to those that facilitate a restorative economic approach, supported by an entrepreneurial government and an engaged populace.

**3.6.1** The following chapters of this thesis cover the main areas of topic literature review, supported by research information, data and analysis. As each topic is explored, the findings of the research help to develop another stage of the LiSRIRC process.

# 4. FINANCE SYSTEMS AND INFRASTRUCTURE

## 4.1 Introduction

The scale of both existing and planned infrastructure investment is staggering. Worldwide, infrastructure spending is expected to grow from $4 trillion per year in 2012 to more than $9 trillion per year by 2025. Overall, close to $78 trillion is expected to be spent globally between 2014 and 2025 (PwC, 2014). This is close to 5% of world GDP (Kim, 2016). The OECD (2013) suggests that an annual investment of 3.5 per cent of global GDP into infrastructure is necessary to prevent negative impacts on growth. This need for infrastructure is driven by several factors, not least is the accelerating growth of cities across the globe. However other factors include demographic trends – in some parts of the world, ageing populations have different infrastructure requirements to other parts of the world where a youthful and growing population require housing, education, health, water and energy. The development of emerging economies into leading economic powers will also demand massive infrastructure investment. Scarcity of key resources for a growing population creates infrastructure demands in exploiting resources in more demanding areas as well as driving innovation to create new infrastructure systems. The growing threat of climate breakdown has led to increased occurrences of natural disasters (Hoeppe, 2016) which in themselves demand the rebuilding of damaged infrastructure as well as the design and building of new climate resilient infrastructure, using materials that are sustainable. These same pressures are creating demands for new energy,

water, food and transport infrastructure as well as the demand for funds to invest in achieving the United Nations Sustainable Development Goals (SDGs; United Nations, 2015).

In the United Kingdom significant infrastructure investment is required to keep existing systems fit for purpose. According to HM Treasury (2014), the UK spent an average of £47 billion a year on infrastructure (public and private) between 2010-11 and 2013-14, equivalent to approximately 2.75 per cent of annual GDP. In 2014 total infrastructure spend reached £72 billion and is expected to increase to £110 billion / year by 2025 (PwC, 2015). In its Global Competitiveness Report 2015-16, the World Economic Forum ranked the UK 24$^{th}$ out of 144 countries for the overall quality of its infrastructure, behind most of its main competitors (WEF, 2015).

## 4.2 The UK Finance System

The scale of UK financial flows is summed into one figure, UK Gross Domestic Product (GDP). The UK GDP for 2017 was £2 trillion (ONS, 2018a). Approximately 50% of this sum is paid to households in wages or earned by the self-employed. Yet the total value of payments in the UK finance system totals approximately £247 trillion, a figure which includes the buying and selling of assets. Some assets are physical assets, such as homes, which are valued at £6 trillion. But many are financial assets, such as loans, deposits, shares and bonds, Figure 4.1. The sum of all the financial assets owned by banks and non-

bank financial companies in the United Kingdom is approximately £20 trillion (Burrows, Cummings and Low, 2015).

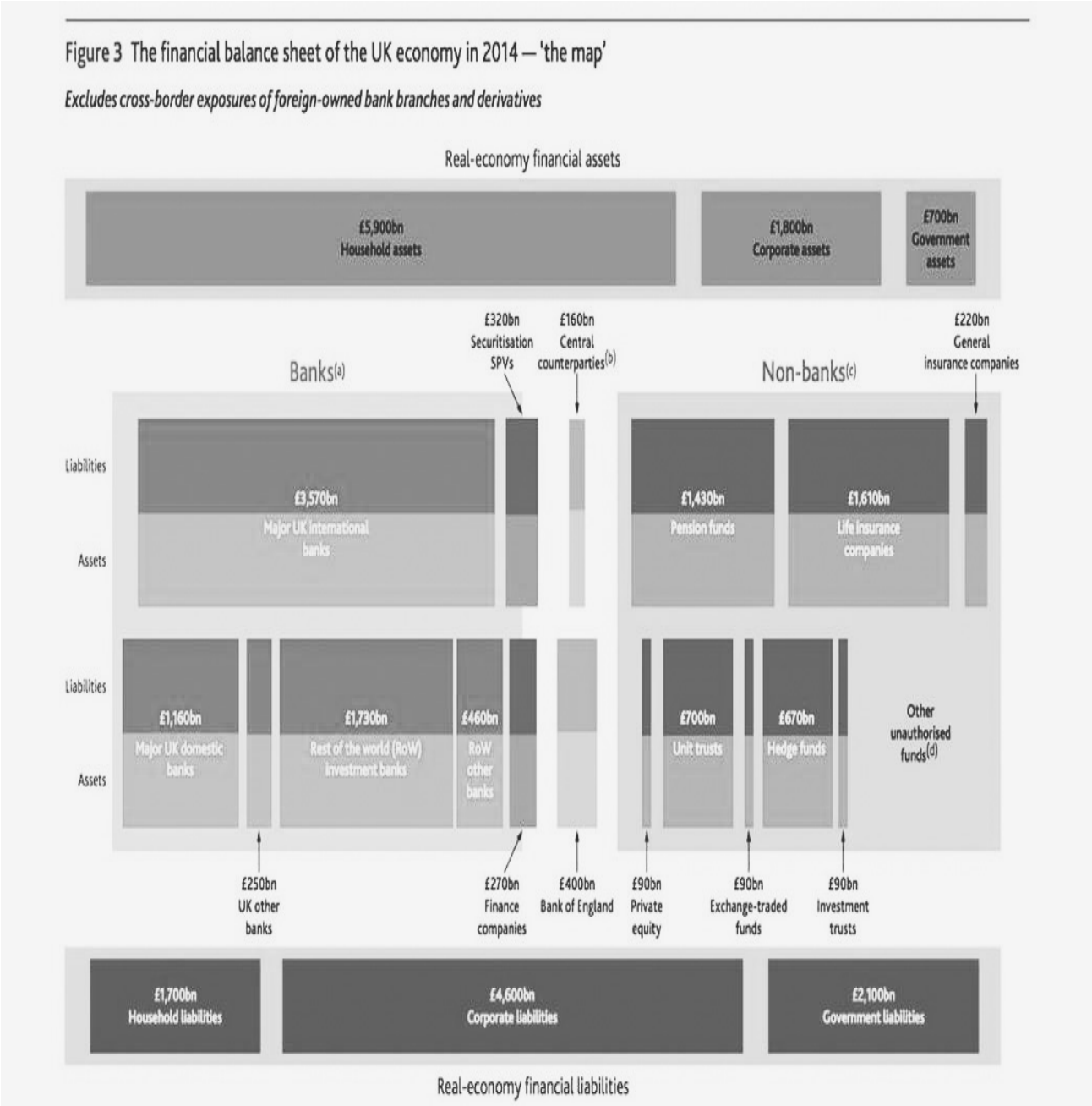



**Figure 4.1:** The financial balance sheet of the UK economy in 2014. Source: Bank of England Quarterly Bulletin 2015 Q2.

The Office of National Statistics has produced data on the UK financial system since 1987, organising the economy into seven sectors: non-financial corporations; monetary financial institutions; insurance companies; pension funds; other financial institutions; households; and government.

The Bank of England regulates other banks, issues bank notes, sets monetary policy and maintains stability (Bank of England, 2019). It has established the Monetary Policy and Financial Policy Committees, charged with maintaining UK financial stability. The Prudential Regulation Authority promotes the safety and soundness of firms it regulates, some 1,500 banks, building societies, credit unions, insurers and major investment firms, and protects policyholders of insurance contracts.

Banks provide some of the core services of the financial system, such as holding deposits, providing payment services and lending. Investment banks operate in capital markets, raising funds for government and companies, or managing risks. These are institutions that do not accept deposits but are still regulated by the PRA. Another two important components of the system are finance companies and securitisation special purpose vehicles (SPV). Both banks and finance companies use SPV's to transfer or sell a bundle of loans into and which then becomes an asset of the SPV. Additional investors can secure debt securities from the SPV, the costs of which are paid for through revenues generated from the original loans. The debt securities can themselves be traded on financial markets, often using arbitrage pricing theory (APT; Moss,

1976), to maximise profits through sales across different markets, enabling investors from all over the world to own a share of UK loans on assets (APT is reviewed in more detail in Chapter 6 – Valley of Death).

Asset managers provide a wide range of savings products, such as pensions and life insurance and a range of products that are appropriate for investors. Often the return period on these investments is long, aligned with long-term insurance and pension requirements. Significant levels of pension savings are held in the private sector and again, these funds are invested for long-term returns.

Insurance companies usually provide compensation to clients after risk has become reality. Relatively small, defined regular payments offset the discomfort of a risk becoming a reality. Insurance companies have significant funds available for investment. There are also re-insurance companies that sell insurance to insurance companies, spreading risk across financial markets.

The UK finance system also has several collective investment schemes that pool the money of investors to buy assets such as shares and bonds. Investors need to be cognisant of their specific requirements for liquid or illiquid assets. If their money needs to be liquid, then unit trusts are best suited to manage fast and more frequent trades. When longer-term, illiquid investments, such as in property and infrastructure, are more appropriate then investment trusts enable investors to purchase shares in the fund from another existing investor,

receiving only dividends on those shares. Then exchange traded funds allow bundled assets to be traded across the globe to take advantage of differences in exchange rates. All such investment models are regulated, and risk profiles determine the type of investments permissible.

Hedge funds, private equity funds and unauthorised funds are available for the professional investor and are therefore not so heavily regulated, investors in this case being deemed to have capacity to evaluate risks independently. A hedge fund is an offshore investment fund, typically formed as a private limited partnership that engages in speculation using credit or borrowed capital. Private equity funds take a controlling interest in a company. Unauthorised (not subject to high level regulation or scrutiny) funds are unregulated, difficult to estimate in size and invest in more risky ventures. (Burrows, Cumming and Low, 2015).

## 4.3 Infrastructure Finance

In the view of the Association for Financial Markets in Europe (AFME, 2015), there is increasing complexity in the financing of infrastructure as more interest has developed in infrastructure as an asset class. In many ways this is a positive development but there are important factors that need to be assessed in securing finance for infrastructure by evaluating the relative merits and priority weighting of different finance products and sources. An emphasis is placed on risk appetite of the investors, flexibility and cost in changing finance profiles dependent on circumstance and interest rate structures. Usage

guarantees can open the range of financial packages available but the risk exposure to both parties needs to be carefully examined.

Financing is the allocation of money to pay for the building of infrastructure. The money comes from government, institutions and private companies. Funding is how the money for building the infrastructure is paid back. It is often in the form of payment for usage, or the output and in some instance's outcomes, generating revenue which is used to pay back the debt or dividend on equity. Public finance for infrastructure is sourced from taxation and from borrowing with a significant change in moving from national to local authority finance. Private finance can be borrowed by government to invest in public infrastructure from banks, insurers, pension funds and private equity firms. Mixed public and private finance has been growing in popularity until fairly recent investigations have cast doubt on the efficiency of arrangements such as Private Finance Initiatives (PFI) and with the recent announcement by the government that there will be no new PFI contracts, new business models / new sources or types of finance will need to be sought (Davies, 2018). The choice of public or private finance mix in UK infrastructure is illustrated in Figure 4.2.

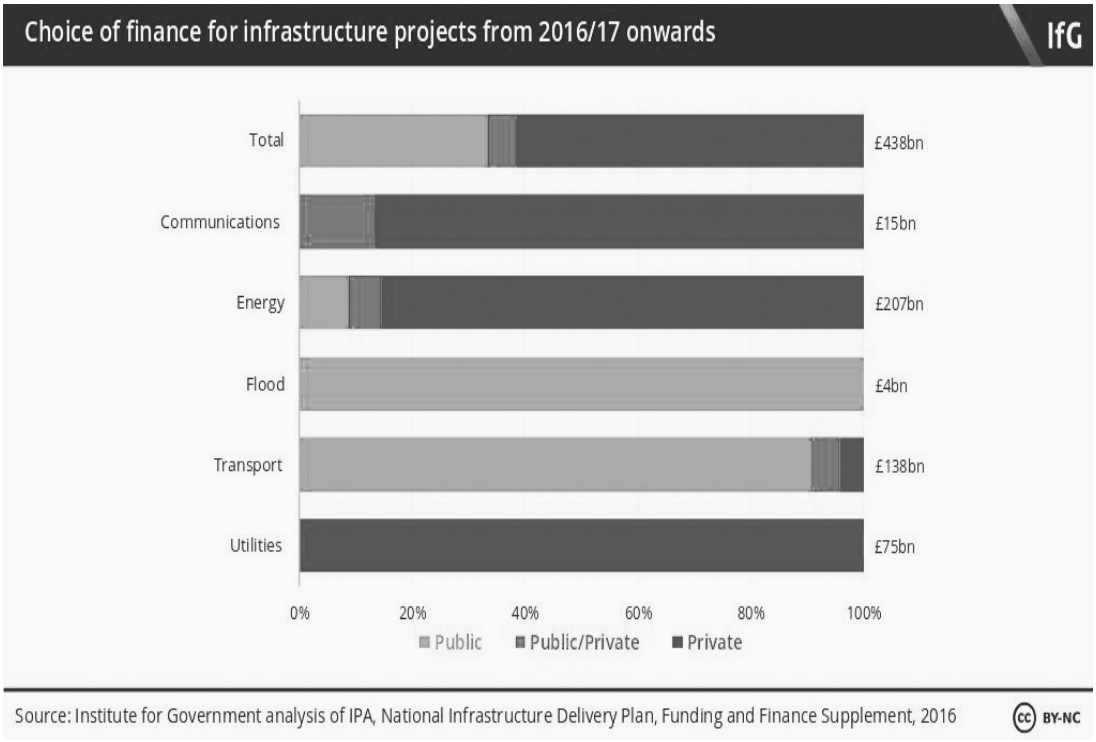



**Figure 4.2:** Choice of finance for infrastructure projects from 2016/17 onwards.

There are advantages and disadvantages to each finance choice (IfG, 2018):

**Public finance:** lower direct cost of borrowing; potentially lower procurement costs; retention of asset control. However, limited budgets may leave critical infrastructure with underinvestment and increased time is required for review, public scrutiny and political cycles.

**Private finance for publicly owned infrastructure:** expenditure remains off the public balance sheet; if construction and operation contracts are bundled, greater probability of whole-life costing used to provide reduced operational costs. Generally, however, borrowing costs are higher; procurement costs rise as contract specifications have to be very accurate; many risks are still retained

by the public sector, risking significant financial demands at later stages; once the contract is signed, it is very difficult to manage cost effective changes.

**Private finance for privately owned infrastructure:** if contracts have been written correctly and private companies cannot just walk away, then maintenance costs have been transferred to the private company; finance costs are cheaper than main-stream finance costs. However relatively high finance costs remain; contracts may be inflexible and serious consideration as to how better results can be obtained in the light of recent scrutiny of the water and rail operators' performance to date.

Figure: 4.3 indicates the broad range of financing options available split between equity and debt products. A very significant interest is now emerging from institutional investors in the infrastructure market, as perceived yields, stable over long periods of time, generated from mature infrastructure assets, have become attractive in the pervasive low-interest rate period currently dominating the marketplace.

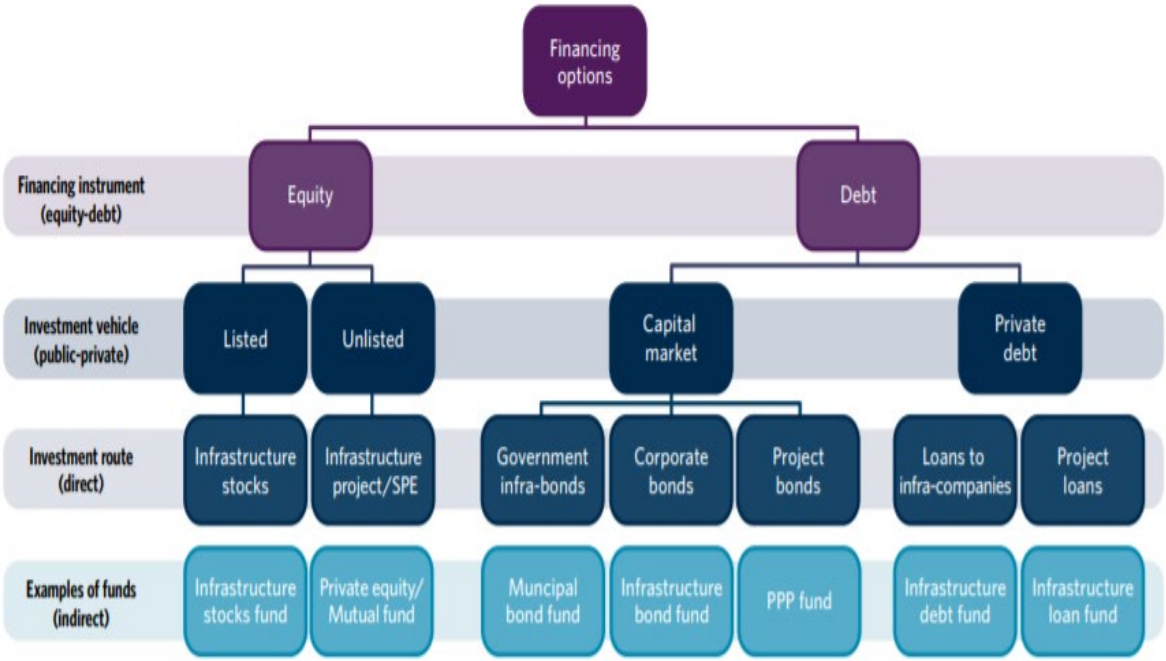



**Figure 4.3:** Infrastructure Financing Options. Source: Public-Private Infrastructure Advisory Facility – Inderst and Stewart 2014.

The top-ranking infrastructure investor is Macquarie Infrastructure and Real Assets, Sydney, Australia (Macquarie used to own Thames Water): "our purpose is to realise opportunity for the benefit of our clients, our shareholders and our people. We are in business to be profitable … (the) Macquarie Group achieved a net profit of $A2,063 million for the year ended 31 March 2016, up 29% on the prior year" (Macquarie, 2016, pp9). Of a 222-page annual report, 8 pages cover environmental, social and governance issues. There is little evidence that there is a wider aspiration to support the creation of sustainable and resilient cities, although the purchase of the UK Green Investment Bank in 2017, supported by improved environment, social and governance reporting, may signal a more holistic approach.

An important feature to potential investors is an established infrastructure asset's ability to generate stable long-term cash flows. This makes infrastructure investment increasingly attractive to insurance and institutional investors, pension and sovereign wealth funds. Because infrastructure assets are often very large, debt funding may be provided by a group of investors lending together (syndicated). Infrastructure has become an attractive financial asset class and therefore at risk of a management approach that maximises profit, rather than maximises sustainable outcomes. This in turn leads to global trading in infrastructure assets which can be subject to arbitrage pricing theory strategies, thereby exposing local assets to international fluctuations and the risk of being used for short-term financial gain.

Within the broad range of financing options available some relatively new, alternative sources are developing rapidly. These include debt and equity-based peer-to-peer funding and revolving loan funds (Roelich, 2015). The UK online alternative finance industry market volume grew by 35% year-on-year to reach £6.19 billion in 2017. 'Peer2Peer' (P2P) business lending increased by 66% to £2 billion in 2017, P2P consumer lending recorded just over £1.4 billion and P2P property lending achieved £1.2 billion. Equity-based crowdfunding grew by 22% to reach £333 million, real estate Crowdfunding increased by more than 200% to £211 million and donation-based Crowdfunding grew by 2.5% (Zhang *et al.*, 2018).

The fact that the alternative finance market (£6.19 billion by the end of 2017; Figure 4.4) is small in terms of the overall investment market and, as yet, is only on the periphery of infrastructure investment, the potential to enable far greater participation in the transformation of cities is evident from the participants profiles: they are interested in small and local companies; institutional investors with distinct responsible investment requirements; individuals who review investment portfolios carefully; and individuals who often make personal judgement calls (Confidential research interviews).

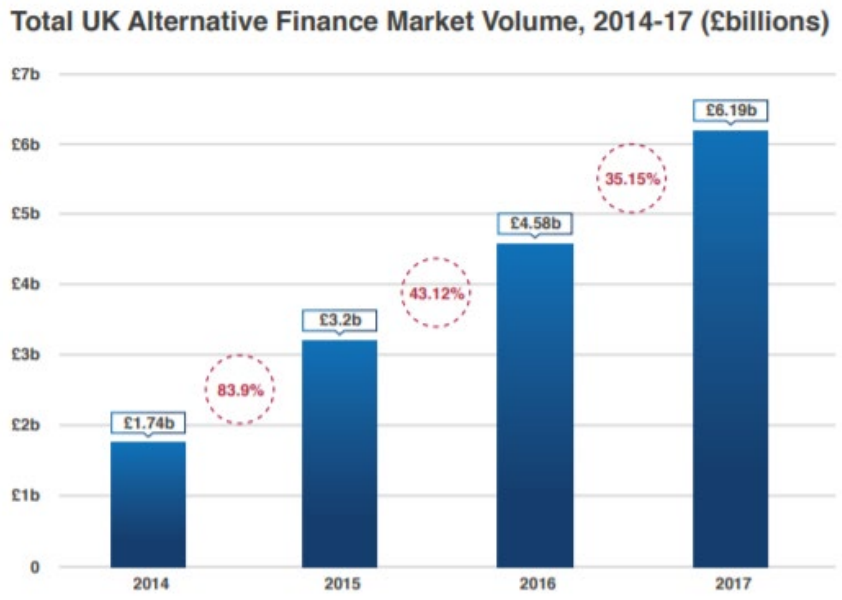



**Figure 4.4:** Total UK Alternative Finance Market Volume. Source: The 5th UK Alternative Finance Industry Report. 2018.

There are several promising areas of alternative finance in the UK that might be steered towards infrastructure investments and businesses involved in developing sustainable products and deployment partnerships for city transformation.

These include:

- Real estate – reached £221 million invested in 2017. A very significant increase. Across Europe, the growth in this sector is rapid.

- Community shares – experienced a very significant decrease in 2017, to just £20 million invested in community enterprise but could be very useful for participatory budgeting processes.

- P2P Equity – reaching £333 million in 2017, investments are made in value aligned enterprise and could make a significant contribution to infrastructure-related companies and products.

Creating the platform through which to engage city level investors is the challenge for a **Li**veable, **S**ustainable, **R**esilient and **I**nvestment **R**eady **C**ity portfolio (**LiSRIRC)**.

The key risks that concern infrastructure investors, according to Deloitte research (Deloitte, 2016), are macro-economic, political and regulatory. If macro-economics is directed by profit maximisation, then investors will insure their investment against any deviation from forecast growth. However, if macro-economic policy rewarded investment in sustainable and resilient infrastructure, perhaps investors could be encouraged to help steer progress towards the allied goals of sustainability and resilience, as well as liveability (Leach *et al.*,

2017), in infrastructure and urban systems. To support this process, both key economic tools and economic policy need to be improved by factoring in liveable city indicators, sustainable technology outcomes and climate-related risks (as a minimum), supported by independent regulatory bodies and a stable, consistent regulatory framework. This will in turn provide a balanced portfolio of benefits to people, society as a collective and the planet that accommodates and supports us all, as well as the economy.

To assist in meaningful investment there is a growing portfolio of advisory frameworks that have been developed to steer investors towards more sustainable and resilient choices. One such tool proposes a set of 14 indicators across physical, reputational, regulation and litigation risks (Demertzidis *et al.*, 2015). The benefits would be the ability to select the least climate risk exposure for the investor.

A risk analysis approach that exposes the much higher risks associated with fossil fuel intensive infrastructure is supported by the findings of the Task Force on Climate-Related Financial Disclosures (TCFD, 2017), set up by the Financial Stability Board in 2015. [The Financial Stability Board is an international body that monitors and makes recommendations about the global financial system in order to promote international financial stability.] The taskforce has concluded that one of the most significant financial world risks is climate change. The taskforce estimates that the financial value of assets at risk is between $4.2 trillion and $43 trillion. Such financial risk on such a scale has severe

implications for international stability and therefore the recommendations are for climate-related risks, opportunities and financial impacts to be disclosed and that the organisational response, (banks, insurance companies, asset managers and asset owners) should be reported under core thematic areas of governance, strategy, risk management and metrics and targets.

In effect the Taskforce on Climate-Related Financial Disclosures (TCFD) has reported that international financial stability is dependent on investment decisions factoring in exposure to climate change and that investment decisions should be cognisant of these risks. Investment advisors therefore have a fiduciary duty to include climate risk in assessments. Even given this strategic advice the report *Banking on Climate Change* (RAN, 2018) finds that 36 of the world's biggest banks funnelled $115 billion into extreme fossil fuels in 2017, an increase of 11% from 2016. This perhaps illustrates that typical investors, as described above, take time to move away from traditional areas of investment and they typically steer clear of technologically challenging projects, or early stage innovative investments. The insurance industry surely has a role here – perhaps incentivised by growing climate and natural disaster insurance pay-outs. The report 'Issues Paper on Climate Change Risks to the Insurance Sector' (IAIS & SIF 2018) notes that "total global economic losses from natural disasters between 2005 and 2015 were more than $1.3 trillion, with total direct losses in the range of $2.5 trillion since 2000; major hurricanes and other natural disasters in 2017 caused insured losses of $138 billion; overall

economic losses from natural disasters in 2017 amounted to $340 billion, the second highest annual figure ever".

The insurance industry has become a major investor in infrastructure projects as well as performing a key function in spreading infrastructure risks from clients, contractors, subcontractors and other parties involved in the project to insurers, providing contingent funding in time of difficulty. In tandem with the government's announcement of a National Infrastructure Plan outlining more than £483 billion of planned public and private sector infrastructure investment (IPA, 2016), six major insurers also announced in 2013 plans to collectively invest £25 billion in UK infrastructure. The UK insurers are Prudential, Aviva, Legal & General, Standard Life, Friends Life and Scottish Widows; only three, Aviva, Legal & General and Standard Life, currently subscribe to the TFCD approach. This move coincides with the insurance industry having begun to develop a more flexible approach to infrastructure insurance, moving from single risk insurance placement towards insurance for a package of risks that reflect the lifetime of an infrastructure project. This has developed through Owner/Contractor Controlled Insurance programmes and one of the newest insurance products on the market, in fact only used once to date, is the Integrated Project Insurance product (IPI - will be covered in more detail in Chapter 5; UK Government Cabinet Office, 2014).

Given the two factors described above – the contrasting intransigence of financial and insurance organisations and the accelerating engagement in

climate-related and sustainability practices of some financial and insurance organisations, it is proposed that a selection process is required to maximise the movement towards liveable, sustainable and resilient infrastructure and cities. These financial institutions – investors and insurers – should be selected as a supplier based on an evaluation of the product, the organisations' strategic approach and cost. Conversely, investors and insurers are looking for the right type of sustainable and resilient infrastructure project to support. Although this paper focusses on the role of finance and insurance appraisal in infrastructure; all parties would benefit from an evaluation approach that conferred attainment of best practice in terms of striving towards a level of performance that meets the criteria of the TCFD and the UN Sustainable Development Goals (SDGs; United Nations, 2015) and drives forward progress towards a restorative infrastructure. ['Restorative Infrastructure' includes impact minimisation, includes positive attributes and contributes to repairing damage done – environmentally, socially and economically]. Such an evaluation would provide a development partnership with several benefits:

1. Identification of cost-effective products.
2. Identification of products that match the development partnership's attributes and capabilities.
3. A combination of product features and implementation practices that accelerates innovative deployment of sustainable methods and technologies.

4. Appraisal of investor and insurer performance in relation to the TFCD requirements.
5. Appraisal of investor and insurer performance in relation to the UN SDGs.
6. Guidance and enforcement of TCFD and UN SDG standards by the investors and insurers.
7. Progress in developing an approach that delivers restorative infrastructure.

## 4.4 Finance Appraisal

There are many claims that there is currently plenty of capital available for the infrastructure demands around the world (Duvall, 2015). It is therefore an issue of finding the right types of capital, at the right price. Infrastructure typically requires a mix of 25% equity (shares of profit funded from revenue) to cover operational and debt payments and 75% debt (loans – payable over extended periods with defined capital interest payments rates).

There are many diverse sources of finance (Roelich, 2015) and several important innovations reaching the marketplace, such as the UK's first Innovative Finance ISA from Abundance launched after customer feedback suggested £28.5 billion would be invested in renewable projects and that transfers from existing ISAs could add a further £30bn into the market, creating a green investment pot of almost £60 billion (Jones, 2016).

Significant redirections of funds are taking place as well. The World Bank has committed to spending 28% of its budget (World Bank, 2018) on tackling climate change and to ensuring that all investments undergo a rigorous audit against SDG's and carbon issues (Edie, 2016). Bill Gates has gathered investors together to create a US$1 billion Breakthrough Energy Fund (Edie, 2016).

Capital availability also brings complexity and diversity in infrastructure investment partners, as evidenced by the Thames Tideway Tunnel special purpose vehicle (SPV) - Bazalgette Tunnel Limited, whose shareholders are a consortium of investors comprising funds managed by Allianz (insurance – managing €12 billion in alternative assets), Amber Infrastructure Group (infrastructure investor), Dalmore Capital Limited (fund manager - £1.5 billion UK pension fund and investor assets) Swiss Life (insurance - CHF183 billion assets) and DIF (fund manager - €2 billion assets). Their total investment is projected to be £2.8 billion, with an additional £1.4 billion from Thames Water (Temple Group, 2019).

With this capital complexity and diversity, it becomes ever more important to ensure that investors are of the right type for the specific infrastructure project. One tool that can be used in safeguarding and maximising infrastructure value is an appraisal framework for evaluating finance sources – identifying the cost of different finance packages to achieve the stated outcomes for an infrastructure investment (Henn *et al.*, 2016). Further selection criteria would

include reporting compliance with the TFCD requirements, alignment with the UN SDGs and compliance with environmental and social boundaries, developed through concepts such as the Natural Step (TNS, 2018), the Living Building Challenge Standard (Living Building Challenge, 2018) and 'doughnut economics' (Raworth, 2017). To continue to evaluate infrastructure investment without full cognisance of these frameworks would be a rejection of the most recent and urgent call for action from the Intergovernmental Panel on Climate Change (IPPC), contained in the report 'Global Warming of 1.5 degrees C' (IPCC, 2018).

The choice of financing approach for large-scale public / private funded infrastructure not only influences the future stream of financing costs but also has significant broader economic impacts at a national level. These include the imposition of debt ceilings, credit rating downgrades, infrastructure deficits, and even economic growth (Checherita-Westphal and Rother, 2012; Henn *et al.*, 2015).

Financing a large public / private infrastructure project can be complex, with multiple financing instruments required, many economic, environmental and social factors to factor in, and a range of stakeholders with different and sometimes conflicting objectives to reconcile. Different financing approaches result in different costs of financing determined by factors such as investment risk, barriers to entry, and asymmetrical information (Tuladhar, 2003; Guriev and Kvasov, 2009; Snyder and Luby, 2012; Chaudhuri and Gupta, 2014).

But even given this level of complexity, Henn *et al.,* (2015, 2016) researched public infrastructure projects in OECD countries and found that there was no readily available comprehensive framework for appraising financing instruments in terms of their economic costs and value to society. Henn et al., (2015, 2016) therefore developed a multi-criteria analysis (MCA) framework, which was tested on 3 large infrastructure projects (Table 4.1).

This criteria presented in Table 4.1 provides some of the elements that are needed to complete a more comprehensive approach to assessing the cost of finance split into monetary and non-monetary elements. As this was the only finance assessment tool found in the literature search, this table forms the basis upon which a set of new criteria are presented. Some are revisions and refinements of the Henn et al., (2015, 2016) list and others are new criteria needed to fully appreciate the cost of finance when additional climate and sustainability issues are brought into account. Each criterion is described. An improved set of criteria will enable better decision-making when evaluating the true cost of finance for city infrastructure investment and the financial risk of short-term, non-sustainable infrastructure investment locking a place into a fossil-fuel intensive development model.

These improvements are documented in the next section of this thesis and are presented in a series of tables. Table 4.2 presents a detailed costing list, derived from the Association of Financial Markets in Europe (AFME); Table 4.5 presents the revised and comprehensive list of monetary criteria for rigorous

and holistic finance costing. Table 4.6 presents both the revised monetary criteria presented in Table 4.5 and the revised non-monetary criteria. Finally Table 4.7 presents a unique application of the revised and newly formed comprehensive criteria for the City of Birmingham.

**Table 4.1:** Appraisal Criteria to assess Financing Arrangements (Henn *et al.*, 2016). Reproduced with Permission - Henn. L.

| **Appraisal Criteria** | |
|---|---|
| ***Monetary*** | ***Intangible*** |
| **Cost of capital** | **Effectiveness** |
| **Contingent liabilities** | **Efficiency** |
| **Cost of project delay** | **Fairness (equity or equality)** |
| **Credit rating impact** | **Flexibility** |
| **Taxes forgone** | **Accountability and transparency** |
| **Administration and transaction cost** | **Stakeholder support** |
| | **Degree of public control/ownership** |

### 4.4.1 Monetary – Cost of capital

In determining the cost of capital, key factors accounted for in the original model include the cost of using government reserves and government bonds, the cost of loans and equity. Typical interest payment values have been constructed from bank loan costs and high-risk equity investors.

In the UK context, the cost of public capital can be remarkably consistent for periods of time. For example, the Public Works Loans Board (PWLB: a statutory body operating within the United Kingdom Debt Management Office, an Executive Agency of HM Treasury) has maintained a charge rate from a low of 0.90% in 2009 to the current 1.65 – 2.20% in 2019. Although a relatively modest increase over a 10-year period, when large sums are involved, increases can have a significant impact on an organisation's finances. The highest PWLB rate was 7.30%, in 1995. As the current trend is up and likely to remain in that direction of travel, infrastructure finance borrowers must maintain rigorous monitoring and analysis of trends to ensure costs do not get out of control.

Local Authorities can qualify for a 0.20% reduction in the interest rate charged on loans if they provide information on their plans for long-term borrowing and associated capital spending to the PWLB. Interest charges can be reduced by 0.40% for lending to support nominated infrastructure projects that are high value for money - the Local Infrastructure Rate. A list of qualifying authorities is available from Her Majesty's Treasury (HMT, 2019).

Private finance arrangements are far more variable and typically increase dependent on risk and stage of infrastructure development. One major finance provider in Birmingham sees charge rates on average being between 5 and 8%. In instances of increased risk, charges can increase to 20% (Confidential research interviews).

To this cost of capital value, research indicates that there should be added an additional level of detail to cover (as appropriate) shareholder return on investment payments; revenue sharing agreements; commitment fees on reserve financing; and costs associated with any refinancing strategy Table 2 (AFME, 2015).

Further, over the last few years new sources of finance have become more readily available and particularly for those projects that do not equate to ‘mega’ projects. These include debt and equity-based peer-to-peer funding and revolving loan funds (Roelich, 2015). The likely effect of these additional sources of finance is to lower the cost of capital, although there may be some increase in administration and transaction cost. Moreover, of even greater relevance, these relatively new sources of finance enable a wider investment demographic, facilitating greater local investment in appropriate infrastructure, and, in addition, they can be supportive of and aligned with participative budgeting. The accessibility of these funds is determined by several factors, of which climate breakdown-related issues, environment, sustainability and other social outcomes are increasingly important. This trend is exemplified by the establishment of Sustainable Development Capital Ltd (SDCL, 2014), backed by the UK Guarantees Scheme with a £9 million loan (IPA, 2017).

**Table 4.2:** Direct infrastructure finance costs. Source: AFME, 2015.

| | Bank Loan | | Project Bond | |
|---|---|---|---|---|
| | Upfront | Ongoing bp per annum | Upfront | Ongoing bp per annum |
| Loan or bond coupon | | ✓ | | ✓ |
| Interest rate swap | | ✓ | | ✓ |
| Net fixed rate | | ✓ | | ✓ |
| Arrangement, placement/ subscription/underwriting fee | ✓ | | ✓ | |
| Credit enhancement fee | ✓ | ✓ | ✓ | ✓ |
| Other agency, advisory or consulting fees | ✓ | | ✓ | |
| Issuers' legal advisors' fee | ✓ | | ✓ | |
| Arranger and investors' /trustee legal advisors' fee | ✓ | | ✓ | |
| Accounting comfort letter and ongoing audit costs | ✓ | ✓ | ✓ | ✓ |
| Credit rating agencies | ✓ | ✓ | ✓ | ✓ |
| SPV management fee | | ✓ | | ✓ |
| Trustee/agent/custodian's fee | ✓ | ✓ | ✓ | ✓ |
| Miscellaneous fees and disbursements, including printing (if needed) | ✓ | | ✓ | |
| Monitoring advisor's fee | | ✓ | | ✓ |
| Total upfront fees (in bppa) | ✓ | | ✓ | |
| Total ongoing fees | | ✓ | | ✓ |
| All-in cost, including amortisation of upfront fees and ongoing fees | | ✓ | | ✓ |
| Public – political process | ✓ | ✓ | ✓ | ✓ |
| Public – scrutiny and reporting | ✓ | ✓ | ✓ | ✓ |

(Table note: bp – basis point interest rate - one hundredth of a percent).

Cost of capital will differ by type – reserves, debt (private / PWLB), equity or bond. Therefore, in an assessment, bids from providers of all finance types are required and should be evaluated. Because of other finance cost issues that will

be reviewed in later sections of this chapter, it would be wrong to assume that PWLB debt loans with relatively low rates of interest will provide the best financial package for a project. Additionally, because of the increasing complexity and variety of finance solutions and other critical evaluation data that is required – return on investment, revenue sharing, reserve financing fees, refinancing costs – an approach that uses generic cost indicators is rejected.

The cost of capital evaluation therefore requires:

- Detailed and individual finance package appraisal.
- Independently assessed audit of the financial appraisal.
- A non-technical appraisal summary for management.

### 4.4.2 Monetary – Contingent Liabilities

Contingent liabilities relate to many risk variables and therefore Henn *et al.,* (2016) have adopted a systemic risk premium based on a review of practice on several major projects, including the approaches of national governments. An average rate of 1.5% risk premium of the total project sum is applied as a contingent liability cost placed upon society, while lesser rates are applied for costs associated with other forms of finance. In addition, Henn *et al.,* advocate a detailed project finance specific risk analysis.

Most of the cost overruns on large projects fall on the public purse and therefore on society, therefore a 1.5% contingency figure becomes inadequate and something approaching the industry norm, of between 5 and 10% is required.

Yet this still requires further exploration as there are several methods by which cost contingency can be estimated such as ‘expected value’ and ‘range estimating’.

Evidence accumulated on contingent liabilities suggests that an averaged risk premium does not give enough weight to the potential cost implications of using different finance sources. For example, the cost overrun for construction on the Eurotunnel was 80%, leading to an increase in the cost of financing of 180% (Flyvbjerg, 2009). Flyvbjerg has collated a comprehensive dataset of major infrastructure projects that demonstrate a consistent cost overrun of 50%.

Reports on the use of mixed finance packages, such as those within Public Finance Initiatives (PFI) 1 & 2, have concluded that the cost of private finance is double that of public funds (4% public, 8% private; UK Parliament, 2011a). In addition, substantial sums of lost tax revenue from PFI shareholder sales offshore (UK Parliament, 2011b) have imposed further costs on society. An EU report into Public Private Partnership funded projects highlights delay costs and increased prices adding a further €1.5 billion to the completion costs of just nine projects (European Court of Auditors, 2018). Given this recent evidence, an average rate premium risk of 1.5% has now become inadequate and too inaccurate to remain a viable value in, and hence criterion for, assessing contingent liability costs.

The Association for Financial Markets in Europe (AFME) concludes that the most significant contingent liabilities relate to cost overruns and usage guarantees (AFME, 2015). When a project starts to incur cost overrun, standby debt and equity finances may have been put in place for this difficulty. The cost of these standby resources also needs to be evaluated. Until recently there have been very limited options for insurance cover in the case of cost overrun. A new product to the market provides greater options for infrastructure finance and insurance choices – iTWO Project Cost Insurance (MunichRe, 2015). This product is offered for architecturally designed building infrastructure using Building Information Modelling (BIM) 5D technologies. BIM applications in all forms of infrastructure construction are making rapid advances and in due course insurance providers will have enough data to confidently provide appropriate products to cover further components of the infrastructure industry. The cost of such standby arrangements would need to be compared with the cost of insurance.

The other main source of infrastructure project additional costs derives from forecast errors in usage revenues. This cost has become too toxic (Confidential research interviews) for most insurance companies to consider providing cover; particularly after the Brisbane Clem7 tunnel, which went into receivership in 2011, with a penalty of a $121 million (AUD) made on AECOM professional indemnity insurance (Wiggins, 2016). This has resulted in increased demand for government-backed usage guarantees such as that agreed with EDF for power from the Hinckley Point C nuclear reactor (UK Government, 2016).

Significant improvements in estimating the potential for cost overruns and usage, by combining reference class forecasting (Flyvbjerg *et al*., 2016) with other statistical techniques, has been made but contingent liabilities remain a contentious and uninsurable cost increase risk. Therefore, financial costs of general contingent liabilities might be used as an averaged premium risk cost as in the Henn *et al.,* (2016) model but should be combined with specific estimates of cost overrun and usage shortfall impacts on the cost of finance.

The cost of contingent liabilities therefore requires:

- The application of a 10% average rate premium risk (as a minimum) for the entire financial package. (This is at the high end of the industry norm but accumulated experience as indicated above, suggests that this figure should be treated as the baseline and that only when advanced level Risk Analysis and Management for Projects (RAMP - Institution of Civil Engineers) assessments have been completed and regular audit demonstrates that adherence to cost estimates is being maintained, should this figure be downgraded).
- Identification through scenario analysis the effect of cost overruns on all work packages with variable cost contingency levels factored in ranging from 10% to 100%.
- The application of scenario analysis to usage guarantees and forecast / actual rates and impact on finance costs.
- Assess iTWO insurance for infrastructure buildings.

- Research further iTWO type insurance for other infrastructure.

### 4.4.3 Monetary – Cost of Project Delay

A 2018 survey of cost of delays across the UK Construction industry (Cornerstone, 2018) highlighted that nearly all projects experience delay of between 10 – 30% of the estimated delivery time. In most instances this led to an increase in costs of 20%. This risk to the client, insurers and delivery groups was estimated at £10 billion, based on a Martin & Proctor (2018) statistical report for infrastructure spend in 2018. There are several factors that cause delay such as – land acquisition, tendering, contractual issues, ground conditions, technical failures, changes in scope and financing (Confidential research interviews). Conversely a delay on site will lead to a delay in the release of monies and possibly trigger penalty fees and even re-financing requirements, with associated costs.

The recent Crossrail financial cost escalation has been in part caused by delay (NAO, 2019). As far back as 2015, contract compensation discussions had slowed delivery, and required draw down of substantial contingency monies, which ultimately led to a £1 billion increase in costs. Rescheduling and a detailed delivery plan did not take place until the beginning of 2018, with a completion date for the end of the year. Total increase in costs to date is £2.5 billion.

The project delay cost assessment therefore requires:

- The application of an average cost of delay increase on finance costs of 20%.
- The use of scenarios to analyse the impact of up to a 50% increase in finance costs because of delay.

### 4.4.4 Monetary – Credit rating

Credit rating agencies score governments, and the larger corporates and institutions on how likely they are to pay back their debt. A rating affects how much it costs the government or organisation to borrow money in the marketplace. A high credit rating means a lower interest rate (Table 4.3).

**Table 4.3:** Moody's Credit Rating Scale – Moody's 2019

| Long-term[1] | Short-term[2] | Rating description |
|---|---|---|
| Aaa | P-1 | Prime |
| Aa1 | | High grade |
| Aa2 | | |
| Aa3 | | |
| A1 | | Upper medium grade |
| A2 | | |
| A3 | P-2 | |
| Baa1 | | Lower medium grade |
| Baa2 | P-3 | |
| Baa3 | | |
| Ba1 | Not Prime | Non-investment grade |
| Ba2 | | |
| Ba3 | | |
| B1 | | Highly speculative |
| B2 | | |
| B3 | | |
| Caa1 | | Substantial risks |
| Caa2 | | |
| Caa3 | | |
| CA | | Extremely speculative<br>Default imminent |
| C | | In default |

Table Notes: 1 – reflects likelihood of default and financial loss on obligations maturing in over 12 months. 2 – ability to honour obligations maturing in less than 13 months.

The UK has maintained an Aaa confidence credit rating from 1978 until 2013 when Moody's downgraded the credit rating to Aa1. In 2017, Moody's again dropped the confidence credit rating to Aa2 (Country Economy, 2019). The effect of such a drop in ratings is to increase the cost of borrowing by 0.5-1.5% per rating level drop (Grothe, 2013). Therefore, the effect of the cost of borrowing for UK Government, local authorities and other institutions can be as much as a 1 – 3% increase.

Major organisations credit rating is not pegged to the sovereign rating; it is rare for private finance to be able to secure loans at a better rate than government (Opoku-Mensah, 2017; Almeida *et al*, 2017). Costs of finance of major organisations therefore must be analysed carefully to avoid costs associated with a poor rating.

Credit rating also has a significant impact on the cost of raising finance through the issue of bonds. The European Commission (2018) has charted significant changes in market pricing for both financial and industrial bonds, after an announcement concerning credit rating. The cost of borrowing only rose by 0.30% on 2016/17 rates to 2.7% in 2018 (Keep, 2018). However forecast decreases in this cost of borrowing need to be monitored carefully. Within the space of 5 - 10 years the cost of borrowing can double and given a combination of economic and political issues, the Treasury worst case scenario of a 5% increase in the cost of borrowing could have major ramifications for a major infrastructure project.

The credit rating cost assessment therefore requires:

- The application of the current credit rating.
- An assessment of the viability to buy in an improved credit rating.
- Use scenario analysis for potential credit rating changes and factor results into potential cost of finance.

### 4.4.5 Monetary – Taxes (forgone)

Some finance packages, such as tax-exempt bonds, provide a benefit to the infrastructure provider and investors, but at a cost to society. This imposed burden should be reflected in the cost of that finance (GAO, 2002). There are many funds that trade in national infrastructure that house the headquarters ‘offshore’, avoiding substantial tax payments to national governments, estimated to be in the £billions (ESSU, 2016).

In the UK context, Corporate Interest Restriction Guidance (HMRC, 2018) provides details of the Public Infrastructure Exemption draft (PIE). It has been argued that without this tax exclusion, many infrastructure projects would not commence because of a perceived lack of affordable debt financing and difficulty in raising equity. Public infrastructure assets will include:

- tangible UK infrastructure assets that meet a 'public benefit test' (procured by a relevant public body) – airports, ports, waste processing, energy and other key infrastructure quality; or

- buildings that are part of a UK property business and are let on a short-term basis to unrelated parties.

The forecast tax income to the Government from non-exempt companies is £3.9 billion. Given that total UK infrastructure spend for 2016/17 was £438 billion (IfG, 2017), the tax exemption will be very significant. It is difficult to secure data on just how much this exemption is worth – tax relief for interest will be limited to 30% of profits chargeable to corporation tax, excluding interest, capital allowances, tax amortisation and relief for losses. There will be a 'de minimis' allowance for groups of £2 million a year. But without this exemption the British Property Federation claimed that the cost to the real estate sector (a small proportion of the infrastructure sector) would be an additional £660 million (British Property Federation, 2017). This means that certainly £billions of tax returns are not levied on infrastructure companies, leaving society to carry that burden, net, benefits that are derived by society from the infrastructure provision.

The taxes foregone assessment therefore requires:

- The application of a marginal corporate tax rate multiplied by each financial product's tax relief rate.
- The application of an estimated sector-specific tax relief applied in proportion to the scale of the infrastructure finance package.
- Research full range of tax relief benefits that accumulate for infrastructure investments.

### 4.4.6 Monetary – Administration and transaction costs

It is not justifiable to maintain a zero sum for the use of government reserves or bonds as in the Henn *et al.,* (2016) model. Considerable time and cost are incurred at the appropriate government level in officer time, councillor briefing and debate, expert and independent review of the business case, consultation processes, national government approval processes, and public administration more generally, alongside all the efforts required of a public body to ensure that accountability and transparency are maintained. These costs need to be factored into the model, although, without further research, it is at this juncture unknown as to whether public and private sector costs are similar. Henn *et al*., (2016) recommend a 2% cost spread over the project lifetime. The AFME (2015) recommends that all administration and transaction costs are itemised for whatever financial package is used by those offering the finance package.

The administration and transaction cost assessment therefore requires:

- The application of a 2% project lifetime charge for both private and public sources of finance.
- The calculation of accurate charges based on financial package quotes.
- The appointment of an independent third-party assessor of all charges
- The production of a non-technical financial summary of all charges for the project lifetime.

### 4.4.6 Monetary – Planning costs

In the UK context, planning costs need to be evaluated for each source of finance. Section 106 (S.106) and Community Infrastructure Levy (CIL) planning obligation requirements can be agreed to mitigate the impacts of infrastructure developments, and, in some circumstances, they can be used to provide a fund for specific infrastructure development. Generally, S.106 agreements impose an additional cost on an infrastructure development. A typical example would be the Hinckley Point C S.106 agreement that requires an additional £60 million to be spent on the mitigation of project-specific impacts in the surrounding areas. The developer agrees the funding arrangements with the local authority before planning permission is granted. The development budget is £19 billion, so the S.106 agreement is a mere 0.30% of budget. In most instances this is an additional cost on the source of private capital.

The Community Infrastructure Levy is being implemented across the UK although in a variety of ways, and indeed in some areas not at all (CIL Review, 2016). When an infrastructure investment package includes government finance then Section 106 and the CIL can be used to generate alternative sources of finance, as exemplified by the funding and finance of the Crossrail infrastructure project. In this instance S.106 and CIL have been used to raise £600 million (3.70%) towards the £16 billion scheme (Buck, 2017).

It is not possible to provide indicative costs for S.106 / CIL charges as they are site specific and negotiated. However, an indicative percentage cost can be applied.

The planning cost assessment therefore requires:

- The application of a 1 – 3% range for planning costs and run scenario analysis of the implications on budget.

### 4.4.7 Monetary – Transition cost.

The Taskforce for Climate Related Financial Disclosure (TCFD) reports that 90% of banks have maintained a risk planning horizon of just 4 years (TCFD 2017). This means that bank loans that have supported the fossil fuel industry, for example, have not been placed in a medium to high risk category as determined by the ClimateWise 'Transition Risk Framework' (CISL, 2019). In fact, loans to the fossil fuel industry have increased (Ran, 2018). Banks are not alone – even the insurance industry, which has been alerting society to increasing climate and natural disaster risks, has been slow in realigning investment strategies with a transition to liveable, sustainable and resilient infrastructure. Such investments may have locked in shareholders to a 'stranded asset' (Bebbington *et al.*, 2019), imposing future transition costs – both in terms of reinvestment into non fossil fuel-based assets and loss of value of existing equity.

A city seeking infrastructure finance should ensure that the source of that finance has a 'climate aware' investment risk strategy. If the investor partner does, then it will help ensure that the infrastructure is liveable, sustainable and resilient as soon as possible, therefore reducing transition costs. The Prudential Regulation Authority (BoE, 2018) has established that there are three broad categories that define how banks (and by extension, most other investors) are responding to climate risk:

- 30% are being **'responsible'** – a degree of corporate responsibility and reputational risk management is evidenced;
- 60 % are being **'responsive'** – climate change has registered as a short-term risk;
- 10% are being **'strategic'** – a more holistic approach with a longer-term view and establishing a transition pathway that minimises financial instability.

The 'strategic' 10% have analysed possible carbon emission pathways and climate-related risk factors as illustrated in Figure 4.5 and begun to ensure that they steer investments towards a net-negative global emissions position and drop stranded assets in a timely and orderly manner.

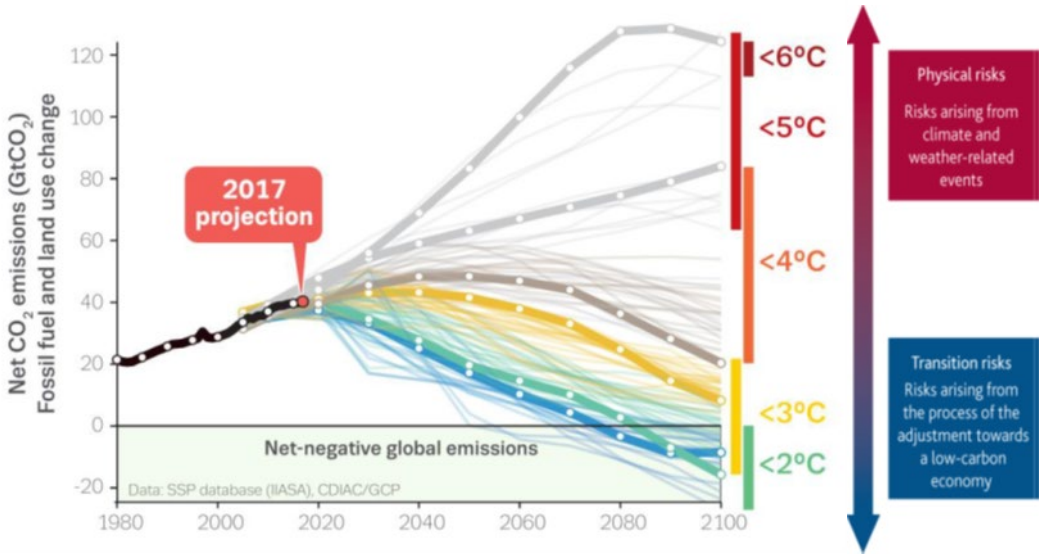



**Figure 4.5:** Carbon Emission Projections. Source: Global Carbon Project (2017) with BoE graphic.

An investment from a source that wants to maximise short-term profit is unlikely to look favourably on an infrastructure project that provides lower rates of return over a longer period, because of needed investment in natural cooling features; new carbon neutral materials; innovative technologies; and a high-quality living environment. Pressure may be exerted at an early stage for profit maximisation, or charges for re-financing become excessive unless design features are dropped, and so on. The whole situation can then be compounded by an insurance firm ranking innovative and sustainable technologies in the high-risk category, therefore increasing costs, whilst placing (known and tested) high carbon features in the low risk category, minimising costs. The city infrastructure finance team need to seek financial providers that are assessed as meeting the 'strategic 10%' category defined by the Prudential Regulation Authority and assess the transition cost that would be imposed upon them if

they risked finance from the 70% of financial providers that have not yet implemented a satisfactorily robust management of climate risks.

In estimating the transition cost for a given city, this research is testing the feasibility of combining several critical factors to help in the assessment of financing infrastructure. It has not been possible to gather all the data required to test this model or to propose specific numbers in each instance. This is a research need for the future. The approach is summarised below and described in the following sections:

**Transition Cost – project finance:** Vulnerability (using city preparedness to cope with vulnerability as the indicator); Carbon Cost and Stranded Asset Cost.

**Transition Cost – city benchmarks:** Contradictory Tax Burden; Missed Opportunities Cost.

#### 4.4.7.1 Monetary Transition Cost – Project Finance: Vulnerability

The United Nations Human Settlements Programme has embarked upon an ambitious research activity to identify and rank the climate change vulnerabilities of prioritised world cities (UN, 2014b). The cities' exposure to climate change features, their sensitivity to impacts and their adaptive capacity provide the key criteria for evaluation. By overlapping the accumulated data sets, the most vulnerable parts of the city have been identified. The next phase of the UN research is to identify vulnerability risk reduction programmes, cost

them and identify funding solutions to prepare the city. Vulnerability risk broadens the risk spectrum out from simply carbon, attempting to highlight the significant cost implications of relevant impacts on the functioning of a city, a business, a business sector, a supply chain, etc. For example, Helmuth *et al.,* (2009) provide a case study of farm owners being able to secure extreme weather event loss insurance based on vulnerability indices.

City preparedness for climate change can also be measured through a range of indices as established by Hiedrich *et al.,* (2013), under the categories of assessment, planning, action and monitoring. The results are shown in Figure 4.6.

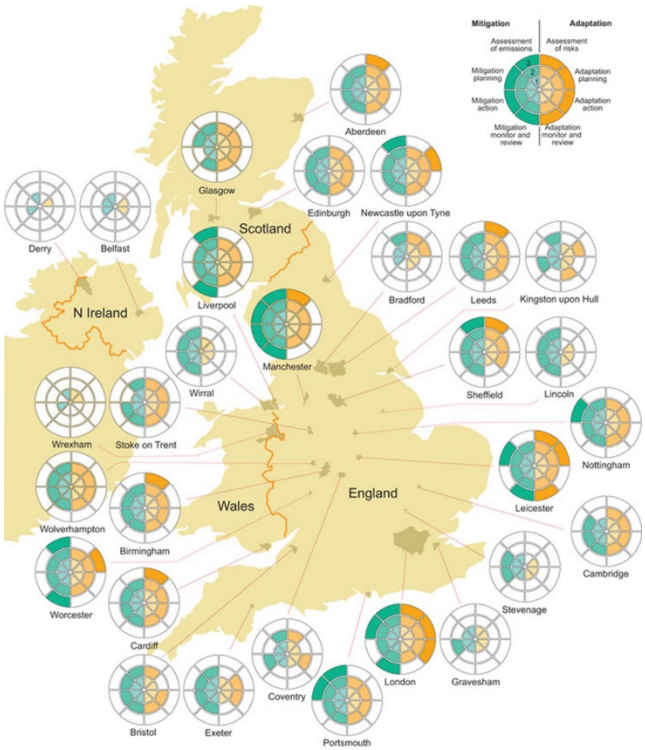



**Figure 4.6:** Urban Areas and Climate Change Preparedness. Source: Hiedrich *et al.,* 2013.

The City of Belgrade undertook an assessment of vulnerability across areas such as heat, cold, drought, and flood that the city had already experienced (City of Belgrade, 2015). Then the applications of scenarios of climatic breakdown were used to assess the change in vulnerability to these risks. Overlaying the data sets allowed for the identification of specific areas of the city, specific communities and natural systems that would be most vulnerable to climatic impacts. Table 4.4 indicates the cumulative vulnerability status of the city to climate breakdown across city infrastructure.

**Table 4.4:** Expected future risks of climate change in Belgrade. Source: City of Belgrade,2015.

| Spring / Summer | RISK | | | | |
|---|---|---|---|---|---|
| | Heat wave | Extreme cold | Drought | Extreme precipitations / floods | Storms |
| Public health/vulnerable groups | Very High | | High | Very High | High |
| Traffic infrastructure | High | | Medium | Very High | High |
| Electricity and heating services | High | | High | Very High | Very High |
| Water supply and sewage | Very High | | Very High | Very High | Very High |
| Social infrastructure | High | | Very High | Medium | Medium |
| Building stock and materials | Very High | | High | Very High | High |
| Tourism | Medium | | High | Medium | Medium |
| Industry | High | | High | Very High | Medium |
| Retail | High | | Medium | Medium | Medium |
| Green spaces | Very High | | Very High | High | Very High |
| Water resources and quality | Very High | | Very High | High | High |
| Air quality | Very High | | High | Very High | |
| Agriculture | Very High | | Very High | Very High | Very High |
| Forestry | Very High | | Very High | High | Very High |
| Biodiversity and ecosystems | Very High | | Very High | Medium | Medium |

Attempts to cost the reduction in vulnerability are complex and costly (Hochrainer-Stigler *et al.,* 2011), yet particularly vulnerable cities cannot afford

not to undertake this work. In the UK headlines have been made by flood damage of £1.6 billion in 2016 (Environment Agency, 2018). The UK Government estimates that assets valued at over £200 billion are at risk of flooding (Foresight, 2004). Vulnerability is a real issue along the coastlines of the UK with significant realignment of flood defences (DEFRA, 2010); and plans to evacuate a village (Wall, 2019).

For the purpose of this thesis insufficient data is available to provide a useable numerical figure for finance costs. However, the climate preparedness index (CPI; Hiedrich, et al., 2013) is used as a proxy for likely vulnerability costs impacting on infrastructure finance.

Vulnerability (V) is measured by a Climate Preparedness Index (CPI). 1 – High preparedness; 2 – moderate preparedness; 3 – low preparedness. On this basis the city of London and Leicester would be ranked with high preparedness and allocated a score of one. Birmingham scores in the area of moderate preparedness and would be allocated a score of two. As investors assess the likely risk of financial investment in different cities under TFCD / PRA requirements and as climate breakdown leads to more extremes, vulnerability scores become a viable and important safeguarding methodology. For example the V20 Group of most vulnerable countries to climate change estimate that for the Philippines, one of the most vulnerable countries in the group, accessing investment costs 10% more when climate risk is factored into the equation (V20, 2018).

Birmingham would not rate a 10% increase in financing cost because of climate risk. Yet the city is impacted in a number of ways, not least flooding in extreme weather events.

To account for Birmingham vulnerability a 0.5% increase in financing costs is suggested as a proxy until more detailed data is available.

#### 4.4.7.2 Monetary Transition Cost – Project Finance: Carbon Cost

There is also the cost of carbon, frequently referred to as the 'social cost of carbon'. This is described as the cost of the harm done to the economy from one tonne of emitted carbon dioxide. (The real cost of carbon, and the associated pollutants emitted with it, are death, ill health, biological extinction and a catalogue of other costs, that we have not even got close to estimating and being able to include in any calculations to date. They are - priceless and many are pre-requisites for human life). This transition cost is viewed by many, as the most important measure that can be imposed to make a rapid de-carbonisation of society. It is a requirement of any UK Government investment that the social cost of carbon is calculated. Yet it is difficult to use the guidance and once found, the current Government guidance states that £12.76 / tonne for 2018/19 is acceptable (BEIS, 2019). UK Government forecasts suggest prices of £120 / tonne by 2030 (High range scenario). Lord Stern states that the EU carbon price is too weak; it should reach US$ 40 – 80 by 2020 and US$50 – 100 by 2030 (London School of Economics, 2016). The Californian Public Utility Commission, often seen as a leading light on carbon policy, has elected to

introduce a US$150 / tonne of carbon price rising to that level by 2030 (2018). Kuika *et al*., (2008) propose €74 – €227 in 2025 to increase to between €132 – €381 in 2050.

Arriving at a specific cost has been fraught with economic difficulty and, perhaps, predominantly by political positioning and corporate lobbying. A range of carbon prices have been proposed, Figure 4.7. But if countries agreed a carbon price and this was immediately implemented in the appraisal systems of infrastructure investment, some forecasts remain incredibly sobering. For instance, an AMCEN/UNEP (2015) report estimates that even with a carbon price supported by other strong adaptation and mitigation measures the residual cost of climate breakdown would be approximately US$100 billion / year if temperature increases were held at $2^0$C by 2050 and US$200 billion if temperature increased by $4^0$C.

This element of the transition cost is herein referred to as the – carbon cost (C). For the purpose of this research the price of carbon is set at the highest researched value of £315 / tonne (Ricke *et al.*, 2018).

| Study into the Social Cost of Carbon | Estimate (per tonne) | Notes |
|---|---|---|
| Nordhaus, 2017[a], Revisiting the social cost of carbon | $35 (£26) | Based on a newer 2016 model i.e. updated after 2014 IPCC report but not updated with more recent research; also excludes consideration of tipping points. |
| Interagency working group on social cost of greenhouse gases, US Government, 2016[b] | $50 (£38) | In addition, the working group identified an estimate to include low-probability, high impact climate events which was $130 per tonne of carbon (see below). |
| Pindyck, 2016[c] | $90 (£68) | This estimate was developed through eliciting expert opinions from scientists and economists. We use $90 here as the mid-point of the $80-$100 he suggests. |
| Interagency working group on social cost of greenhouse gases, US Government, 2016[b] | $130 (£98) | Unlike their lower estimate (above) this incorporates understanding of low-probability, high impact climate events such as passing tipping points. |
| Nordhaus 2017[a], calculation using Stern Report discount rate | $225 (£170) | The Stern Report gave high value to intergenerational equity. |
| Ricke et al, 2018[d] | $417 (£315) | This study uses updated climate models. It also identified the social cost of carbon by country (which relates to vulnerability of countries) and included impacts on future economic growth. |
| **Unweighted average across the above recent estimates** | **$158 (£120)** | An alternative approach of discounting the highest and lowest estimate and averaging the rest would arrive at a price of $124 (£93) |

Sources:
a Nordhaus, 2017, Revisiting the social cost of carbon, PNA, Vol 114, No 7, 1518-1523
b Interagency Working Group on Social Cost of Greenhouse Gases, 2016, Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866
c Pindyck, 2016, The Social Cost of Carbon Revisited, National Bureau of Economic Research,
d Ricke et al, 2018, Country-level social cost of carbon, Nature Climate Change, 8, 895-900

**Figure 4.7:** Proposed Social Costs of Carbon. Source: FoE (2018), Making the polluter pay for the transition to net zero.

#### 4.4.7.3 Monetary Transition Cost – Project Finance: Stranded Asset Cost

Citigroup (2015) estimates that if the global finance system does not move to divest itself from fossil fuels, it could be left with US$100 trillion of stranded assets by 2050. Most of this financial vulnerability is shared amongst seven major financial hubs: London, New York, Singapore, Hong Kong, Tokyo,

Shanghai and Mumbai. For the purpose of this research, the value of stranded assets is equally distributed to each hub – approximately US$14 trillion each.

However, London is consistently ranked as one of the world's leading financial hubs and a brief review of some of the assets that are under management in the UK gives a rather more worrying picture of the degree of stranded assets that might impact on the UK financial centre and overall economy. The UK manages funds valued at £9.1 trillion; banking assets are valued at £10.8 trillion; pension fund assets at £3.1 trillion; insurance funds assets total £2.1 trillion; international bond assets are worth £2.5 trillion; and the list goes on (Citigroup, 2015). This places the UK financial system and the UK economic system at a high level of financial vulnerability to stranded assets. The stranded asset potential for the EU banking system has been estimated to be $1 trillion (Weyzig et al., 2014).

Therefore, the Bank of England has raised the priority of climate-related financial disclosure to the level of significant risk and will be issuing its reporting requirements to the industry shortly (BoE, 2018). The UK share of EU assets is 21% (Armstrong, 2018). For the purpose of this research the UK has been allocated a stranded asset (SA) cost of £210 billion; London accounts for 50% of the UK finance service, and Birmingham 5%, for example (Rhodes, 2018).

Therefore, Birmingham is allocated a SA cost of £10.50 billion. In practice the providers of project-specific finance would be individually assessed using data reported for TCFD / PRA requirements.

#### 4.4.7.4 Monetary Transition Cost – City Benchmarks: Contradictory Tax Burden

For the purposes of this research the contradictory tax burden (CTB) associated with just fossil fuel subsidies is evaluated from a national taxation policy perspective as this is the most significant hindrance to achieving low carbon infrastructure.

Taxes relinquished across the EU amounted to €23 trillion between 2009 and 2011 (Green *et al.,* 2015). These are returned to diverse sectors and for diverse means. One example that can be investigated a little further is the balance between receipts and returns into the fossil fuel industry in the UK.

The UK Government raised £49 billion in revenue through environmental taxes in 2017. Pollution and resource taxes include taxes on the management of waste or extraction of raw materials and accounted for 3% of total environmental tax revenue in 2017. These categories of environmental tax might in future include any new taxes on plastics. Taxes on the production and use of energy contribute 74% of the revenue. 57% is raised through hydrocarbon oil duty – approximately £28 billion (ONS, 2018b).

The UK provides the fossil fuel industry with £17 billion in fiscal support, including tax exemptions, budgetary expenditure, and price or income support. Another £644 million in public financing is provided in the form of grants, loans, equity, insurance and guarantees both, domestically and internationally, while the UK provides £1.28 billion in international support to fossil fuel-based projects (Gençsü *et al*., 2017).

In return, Government revenues from UK oil and gas production for 2017/18 amounted to £1.25 billion (Oil & Gas Authority, 2019). Tax payments received from fuel duty are £28 billion. So, although there is a net gain for the UK Government in terms of tax revenues from oil and gas versus tax benefits for oil and gas, there remains a CTB on society of £18 billion which could be redirected to accelerate the deployment of liveable, sustainable and resilient infrastructure.

As this is a tax burden across the UK population, the cost allocation is based on population number. The population Birmingham is approximately one million.

The Contradictory Tax Burden (CTB) for Birmingham is estimated to be £15,200,000.

#### 4.4.7.5 Monetary Transition Cost – City Benchmarks: Missed Opportunity Cost

A mini-Stern review conducted for Birmingham in 2012 (Gouldson *et al.,* 2012) identified carbon reduction opportunities costing £3.9 billion but returning a

£954 million saving / annum, giving a payback of just 3.8 years. Further opportunities were identified for which, payback periods were found to be longer, but even so, very significant reductions could be made in the transition to a low carbon economy. The same study identified other enormously important benefits such as GVA increase, extra jobs and improved health. Birmingham has yet to implement a significant proportion of the report's findings and has therefore missed transition benefits equating to £multi-billions since the writing of the report in 2012. Just on the single figure quoted above, savings of over £6 billion have been lost. This transition cost is herein termed 'missed opportunity cost' (MOC).

For the purpose of this research the MOC is set at £1 billion / year for Birmingham on a baseline figure of £7 billion (the total MOC since the writing of the Gouldson *et al.,* report in 2012).

### 4.4.8 Revised Appraisal Criteria to assess Financing Arrangements – Monetary

The cost of finance should be a composite of direct project finance costs and costs associated with securing finance that is invested in and subject to the vagaries of macro-economic policy. Financial products and sources of finance that encourage the continuation of a fossil fuel intensive infrastructure are complicit in ignoring the world consensus on moving away from this type of infrastructure. Until the elements of the transition cost are fully mitigated, the financial burden falls on society, not on the provider / investor. The appraisal changes proposed and summarised in Table 4.5 provide a methodology by

which the correct type of finance, sourced from the right type of provider can help steer a city towards more liveable, sustainable and resilient infrastructure.

**Table 4.5:** Revised Appraisal Criteria to assess Financing Arrangements

| **Revised Appraisal Criteria – cost of finance** |
|---|
| ***Monetary*** |
| **Cost of capital – add peer-to-peer; revolving loan funds** |
| **Contingent liabilities – general risk factor supported by specific criteria rates on cost overruns and usage guarantee** |
| **Cost of project delay** |
| **Credit rating impact** |
| **Taxes forgone** |
| **Administration and transaction cost – add public costs** |
| **Planning – S.106 and CIL** |
| **Transition Cost: Project Finance – vulnerability; carbon cost; stranded asset cost** |
| **Transition Cost: City Benchmarks – contradictory tax burden; missed opportunity cost** |

### 4.4.9 Non-monetary – Effectiveness

Effectiveness describes the extent to which a financial product provides steady and reliable access to enough finances in a timely manner, fit for purpose (Wellman and Spiller, 2012).

An effectiveness assessment therefore requires:

- That finance is available to meet project needs, schedule and payments.
- That the finance provider values and aspirations for the infrastructure align with partners and stakeholders
- An alignment of project risks with contract clause terms that enable reasonably and agreed review of prices and finance structure if risks are realised.
- Prior agreement of charges for changes before initiation, with charge rate flexibility ranges.
- That the finance product is consistent with best practice and if innovatory, is subject to appropriate risk control and monitoring.

### 4.4.10 Non-monetary – Efficiency

Efficiency describes the extent to which a financial product minimises lifetime transaction and agency costs, facilitates risk allocation and provides symmetrical information for efficient and effective financial decision-making (Chan *et al.*, 2009).

The efficiency assessment therefore requires:

- That the finance available meets project needs, schedule and payments.
- That the lifetime costs are compared across finance packages, including charges associated with potential risks being realised.

- A continual assessment of the quality of data / management information and financial analysis, available, symmetrically, to all parties.

### 4.4.11 Non-monetary – Equity

Financial instruments should be evaluated for the degree to which they show equity in that costs are shared amongst all beneficiaries equally or in proportion to level of income or use of the infrastructure. Municipal tax bonds require all taxpayers in effect to contribute, but not all taxpayers may use the infrastructure. Debt is paid by both those using the infrastructure immediately and those using it in the future.

The equity assessment therefore requires:

- An evaluation of the financial impacts of the finance package on specific elements of society.
- The provision of a non-technical report on the finance selection impacts on society.

### 4.4.12 Non-monetary – Flexibility

As circumstances change, particularly over the financing lifetime of larger infrastructure projects, the ability to refinance, change payment stages, defer interest payments or make any number of other changes becomes a very important aspect of the financing solution. As this criterion closely matches

those of effectiveness and efficiency, for the purpose of this research, flexibility is combined above.

### 4.4.13 Non-monetary – Accountability

In financing and funding infrastructure, society is paying at some point and therefore society should be able to access full details of the project – its finance, suppliers, investors, risks, rewards and so on. Furthermore, there are increasing concerns regarding the alignment of infrastructure and the UN Sustainable Development Goals, and accordingly the Prudential Regulation Authority will soon announce the specific reporting and audit requirements that it expects in line with the Taskforce for Climate-related Financial Disclosure recommendations. Reporting to these standards should be a mandatory requirement.

The accountability assessment therefore requires:

- Full details of financial products.
- Full public disclosure of project schedules, milestones and progress.
- There should, in addition, be a mandatory requirement for finance providers and the infrastructure delivery vehicle to provide reporting consistent with the TFCD and UN SDG requirements.

### 4.4.14 Non-monetary – Stakeholder

The Henn *et al.,* (2016) model implies that the finance expert's view on the appropriate finance package should be considered. As this is very much an issue of product efficiency, it has been added to that section.

### 4.4.15 Non-monetary – Ownership

This issue is one in which the UK is prominent in its willingness to allow any country full or part ownership of critical national infrastructure. For example, seven out of ten UK water companies are now foreign-owned and have been delisted, creating opaque financing and corporate structures (Smith Institute, 2016). At present the general public is generally accepting of this situation. At a local level, the public and institutions may develop a more parochial view to infrastructure ownership. This can be reflected in the assessment of financial products by allocating preference to UK Government funds or UK investors, with contract clauses included that do not permit the sale of shares and equity responsibilities to foreign entities or multinational investment groups.

The ownership assessment therefore requires:

- That the local ownership preference is established.
- That the ownership structures of finance providers, delivery and operational partners are all evaluated.

### 4.4.16 Revised Appraisal Criteria to assess Financing Arrangements – Monetary and Non-monetary

Table 4.6 shows the revised monetary and non-monetary finance appraisal method.

The final, and ultimately the most important, addition to this model are mandatory requirements of finance providers. They must be reporting to the requirements of the TFCD, aligning investments with the UN SDGs, respecting planetary boundaries and restoring environmental and social capital

To test this method requires access to detailed information, provided over a period of clarification as infrastructure design options; schedules; feasibility studies and finance requirements are developed and although originally planned as part of the research, the research partner was unable to participate.

**Table 4.6:** Revised Appraisal Criteria to assess Financing Arrangements – Monetary and Non-monetary

| **Revised Appraisal Criteria – Monetary and Non-Monetary** | |
|---|---|
| ***Monetary*** | ***Non-Monetary*** |
| **Cost of capital** | **Effectiveness** |
| **Contingent liabilities** | **Efficiency** |
| **Cost of project delay** | **Equity** |
| **Credit rating impact** | **Accountability** |
| **Taxes forgone** | **Ownership** |
| **Administration and transaction cost** | **Mandatory – TCFD reporting** |
| **Planning** | **Mandatory – UN SDG alignment** |
| **Transition – Project Finance** | |
| **Transition – City Benchmarks** | |

## 4.5 Appraisal

The cost of capital is a moving 'feast', that is subject to variation depending on several factors. The detail constructed in the next section of this thesis provides an estimate of costs at a point in time. When an appraisal is conducted, up to date detail will be required and should be provided by the finance source. Independent analysis of the data will be required.

### 4.5.1 Cost of Capital

**Reserves:** For a public body to commit reserves to an infrastructure project a straightforward economic case would require a rate of return in excess of

interest earned on the reserve, capital gain, account balancing, or other values. Rates of return in infrastructure investment vary widely. The World Bank considers economic uplift from infrastructure investments not just in terms of direct rate of return, but also in terms of economic uplift across a region, reporting rates of return from 11 – 29% (World Bank, 2004). Infrastructure investors in the UK are reporting returns of between 9 and 20% (Nikko Asset Management, 2018).

However, a local authority must weigh in the balance alternative uses of that reserve. For example, local authorities in the UK are under massive financial pressure and draw down of reserves has been extensive to meet the requirements of funding basic services. There is no / little direct monetary return to the local authority in using reserves to balance service budgets, yet those reserves were needed and were committed to that activity, potentially losing the authority the opportunity to invest in infrastructure that might lead to an annual income in the future. A figure anywhere between not politically acceptable (NPA) and 10% might be derived reconciling the internal rate of return against average external rates.

A cost of reserve capital is therefore applied: NPA to 10%.

**Bonds:** UK Government bond rates over a ten-year period are yielding 2% in 2019 (World Government Bonds, 2019). International bond yields range from 2 – 10%. Infrastructure bond charges range from 0.5% to 6% (USAID, 2015;

Schroders, 2018). At present charges are at a relatively low rate and therefore costing would have to employ scenario analysis to forecast likely rates.

A cost of bond capital is therefore applied: Mid-range 3%.

**Loans:** A wide range of rates are available dependent on total required, duration, risk and so on. Research interviews highlight a range in the UK market of 1.5% – 20%; 5 – 8% was found to be the average rate, with 20% at the top end. The Public Works Loan Board interest rates range over a 10-year period from 0.90% in 2009 to the current 1.65 – 2.20%. Yusuf *et al.* (2010) found charges across transport infrastructure ranging from 1 – 6%.

A cost of loan capital is therefore applied: Mid-range 5%.

**Equity:** This is the expensive component of infrastructure financing, although generally loans can only be secured if equity has also been invested. The typical ratio is a 25% equity to 75% debt ratio. Equity costs relate to risk, duration and management fees. Costs can range widely from 10 – 25% (Confidential research interviews; Bhattacharya *et al*., 2012).

A cost of equity is therefore applied: Mid-range 15%

**Peer2Peer:** Some platforms have up-front fees of 2.0 – 2.5% and a charge on the outstanding loan of 0.5 – 1.0%; others levy a 10% charge on the interest received. Interest on loans range from 2 - 12% (Money, 2019). Loan amounts

range from a few hundred pounds to several millions. Peer2Peer remains an important source of finance for the smaller scale of the market and makes investment accessible to a far wider demographic. Some believe there is considerable scope to expand this area of investment to secure liveable, sustainable and resilient infrastructure (Confidential research interviews).

A cost of P2P is therefore applied: Mid-range 7%

**Revolving Loan Funds:** Harvard University created one of the first revolving loan funds, now standing at US$12 million / year. Cornwall Council promotes its loan fund, (Community Land Housing, 2018)**,** with 4.5% interest rate. Revolving loan funds normally have outcome-orientated goals and so cost of capital can vary considerably from 0% to normally a point above base.

A cost of Revolving Loan is therefore applied: 4.5%

With the cost of capital combined with the costs identified previously 'The Cost of Capital Appraisal Form' (Table: 4.7) can be constructed to formulate an accurate cost of capital investment in infrastructure. (This research has provided certain data as applied to Birmingham.)

**Table 4.7:** The Cost of Capital Appraisal Form

| Criteria | | | | | | |
|---|---|---|---|---|---|---|
| Cost of capital + AFME table p. 102 | Reserves: NPA – 10% | Bonds: 3% | Debt: 5% | Equity: 15% | P2P: 7% | Revolving Loan: 4.5% |
| Contingent Liabilities | 10% on sum of capital. Include detailed product by product evaluation of potential cost liabilities with attention to direct product costs, cost overruns and usage rates. Run scenarios of cost at 50% and up to 100%. | | | | | |
| Cost of delay | 20% on sum of capital. Analysis on up to 50%. | | | | | |
| Credit rating | Local authority rating generally in line with the Government. Privates sector ratings may differ and therefore may increase cost. Apply current credit rating and evaluate cost of upgrade | | | | | |
| Foregone taxes | • Marginal corporate tax rate x product tax relief rate.<br>• Sector specific tax relief<br>• Infrastructure investments tax relief | | | | | |
| Admin costs | 2% on sum of capital | | | | | |
| Planning | 1 – 3% on sum of capital | | | | | |
| Vulnerability - CPI | London 1; Birmingham 2. Indicates potential extra costs could be incurred when city vulnerability is used as an indicator of risk. A 0.5% increase in financing costs is allocated to Birmingham. (0.25% London; 0.75% to a Level 3 city). | | | | | |
| Carbon | £315 / tonne | | | | | |
| SAC | Birmingham: £10.50 billion | | | | | |
| CTB | Birmingham: £15.20 million | | | | | |
| MOC | Birmingham: Baseline figure (2012) £7 billion. Annual increase £1 billion. | | | | | |

Table Notes: CPI – Climate Preparedness Index; SAC – Stranded Asset Cost; CTB – Contradictory Tax Burden; MOC – Missed Opportunity Cost.

The cost of capital appraisal demonstrates that Bonds, Revolving Loan Funds, Debt and Reserves are at the lower to mid-range in direct product costs. Credit rating may favour local authority reserves and Government Bonds / Loans. All other costs (contingent liabilities, cost of delay, foregone taxes, administration costs and planning) are assigned to all forms of capital. Vulnerability, scored through a City Preparedness Index, shows that London has prepared more completely for climate-related events than has Birmingham and therefore risk is higher in Birmingham and might, in due course, relate to cost of finance and insurance. The cost of carbon is evaluated across all sources of finance. Stranded asset costs are evaluated across all sources of finance that have intensive carbon investments and are allocated appropriately. Contradictory tax burden is a Government policy impact on the financial risks being built up in a tax system that remains favourable to high carbon infrastructure / business. The missed opportunity cost is a city benchmark that can be used to demonstrate to the citizens that progress is being made to secure the benefits of a low-carbon economy.

Non-monetary criteria can be applied using a Likert approach and weighting determined by participants in the infrastructure build. They are subjective, yet critical in the appraisal process. This part of the evaluation would be carried out by informed individuals with wider participative engagement and covers the following issues: effectiveness; efficiency; fairness; accountability; ownership.

The final step in the evaluation (perhaps the first step) is mandatory compliance with TCFD / PRA requirements and the UN SDGs. The Green Book (HM Treasury, 2018) for the appraisal of public investments provides an assessment model that tries to factor in complex issues into an assessment, including a 'strategic dimension', yet the Green Book appraisal method does not preclude investment in projects that still have a negative impact on environmental and social conditions. Without a tool that aligns with the UN SDGs and TCFD criteria, there remains a fundamental risk of investment in the wrong type of infrastructure at a higher cost than necessary, producing infrastructure that is not fit for purpose by the time it is built and quite possibly burdening a city with infrastructure that will require further significant investment, described as the transition cost. This is the additional cost incurred when moving current infrastructure provision capability to what might be termed a sustainable capability – or more accurately a liveable, sustainable and resilient level of capability.

The outcome of the appraisal would be to marry the most cost-effective source of finance with the strategic priorities and values of the user. There may, however, be a limit to the amount of each source of finance, leading to increased diversity. An interesting review of a finance package developed for Crossrail demonstrates the diversity of sources (Figure 4.8). The appraisal process described in the preceding sections would still help prepare the project team for the worst financial risks.

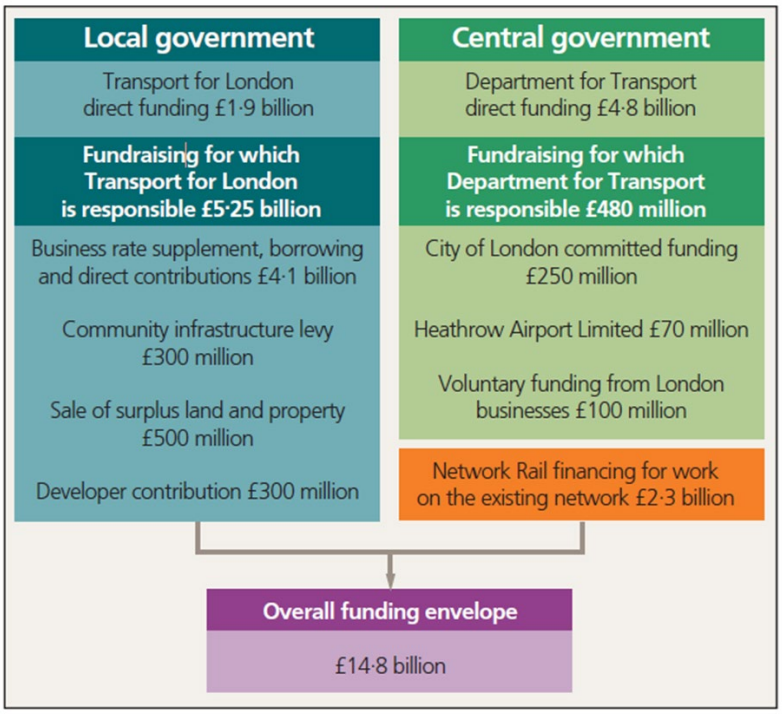



**Figure 4.8**: Crossrail Funding Package. Source: Buck, 2017.

Birmingham City Council has a £1 billion infrastructure pipeline, as does the University of Birmingham. At this scale, a finance appraisal using the criteria presented above helps: identify the various costs of capital; provide a rigorous evaluation of other potential costs; identifies some of the wider macro-economic burdens placed upon the city; and enables a participative approach to evaluating the priority allocation of finance and end ownership. It demonstrates which type of capital might best serve the needs of the people of Birmingham City and University.

## 4.6 Summary

The finance sector is a £multi-trillion business that can continue to invest in a fossil fuel based economic system or has the potential to steer the world economy towards a more sustainable footing. Ensuring that finance organisations and products motivate liveable, sustainable and resilient city infrastructure is an essential part of a low carbon economy of the future.

By evaluating the cost of finance using an enhanced multi-criteria decision analysis, it is possible to select the source of finance and specific finance products that can result in significant cost savings across an infrastructure portfolio. In relation to financing arrangements, the current system is not working effectively and is leading, for example, to unnecessary cost overruns. A prime example concerns contingent liability costs, where research is urgently required to identify parameters that have a closer fit to recent experience than the current more general approach to contingency allows. This alone would result in huge savings.

Critically it is the alignment of finance and insurance organisations with the strategic dimension of project appraisal, represented (in part) by the UN SDGs and the TCFD criteria that bring the most substantial benefit. Organisations providing finance products that adhere to UN SDGs and TCFD criteria will provide direction to infrastructure investment will require net positive contributions from the infrastructure investment towards strategic UN SDG goals and thereby will minimise future transition costs.

This leads to two hypotheses. Firstly, by selecting the right finance providers, infrastructure investors can have further assurance that the costs associated with a transition to a more liveable, sustainable and resilient city will be minimised. Secondly, by evaluating the principles adhered to by organisations providing finance for infrastructure, it is possible to accelerate progress through obstacles encountered in the provision of sustainable and resilient infrastructure and the transformation of our cities. These hypotheses represent important research needs.

This fits into the sequence required for a movement towards more liveable, sustainable, resilient cities described by Rogers (2018) as the creation of the evidence base on which to create sustainable and resilient engineering solutions (which is already strong and growing); making the 'business case for change' (for which there is also ample evidence); creation of alternative business models to enable this change to happen; and then engineering all of the forms of governance (ranging from individual and societal attitudes and behaviours, and societal and practice norms, though to the formal levers of legislation, taxation, regulation, codes & standards) to enable the business models to work and deliver their intended outcomes. The suggested change to current practices – the adoption of a revised Henn *et al.,* (2016) framework – would enable business models that captured all the forms of value (economic, social and environmental) that might be realised from the provision of new or upgraded infrastructure to be formulated and successfully implemented.

This undoubtedly requires a change of mind-sets, particularly in terms of economic models and approaches to funding and financing. However, by adopting such a change, it is argued herein that it would be possible to accelerate progress towards liveable, sustainable and resilient infrastructure and cities.

The process of assessing finance organisations and finance products forms stage 6 of the **LiSRIRC** process in Figure 4.9: **LiSRIRC** – Stages 1 – 6.

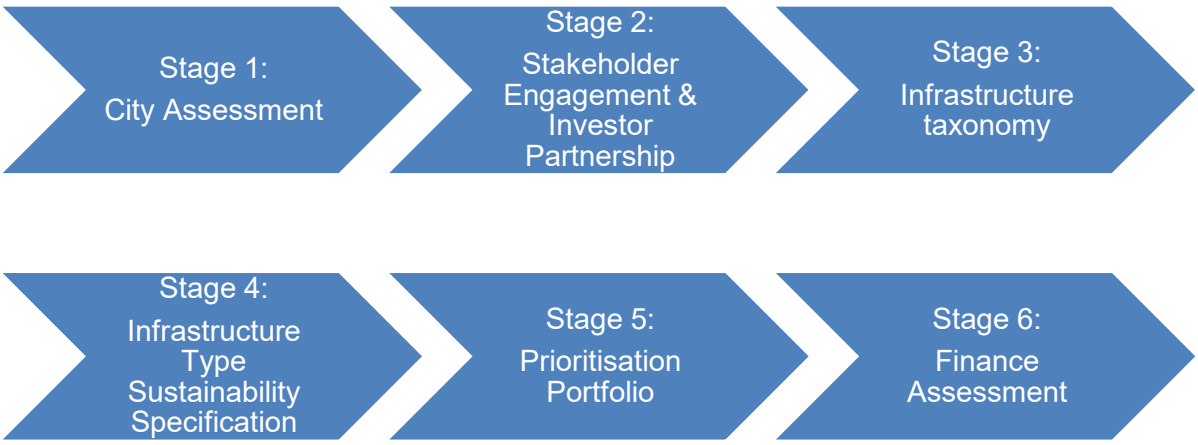



Figure 4.9: **LiSRIRC** – Stages 1 – 6.

The next stage of the LiSRIRC process is to examine the role of insurance in infrastructure – Chapter 6.

# 5. INSURANCE SYSTEMS

This chapter presents key literature on the insurance industry and how it relates to infrastructure. Using a substantial series of research interview material to corroborate points made in the literature and to steer further research, this chapter presents key activity that has or could significantly improve the integration of insurance expertise into the accelerated deployment of liveable, sustainable and resilient infrastructure.

In addition, research interview material, historical data and project information from a live 2019 infrastructure project has been used to verify cost of insurance data, estimating the potential savings in insurance cost if new insurance products were implemented widely.

## 5.1 Introduction

The insurance industry manages over US$30 trillion in assets across the world and is therefore a critical component of the global financial system, guarding assets, wealth and steering economic growth through crisis. Annual premiums amount to US$5 trillion (UNEP FI, 2017). It has had historical roles in formulating standards globally that have reduced risk to individuals – such as in road safety and fire risk. As far back as the 1970's, Munich Re published its first report on climate risks (MunichRe, 2019). The insurance industry is beginning to demonstrate a significant change in its position on climate breakdown. The

‘Principles for Sustainable Insurance’ (PSI, UNEP FI, 2017) were launched in 2012 and commit to:

1. Embedding environmental and social governance (ESG) principles in the insurance industry
2. Work with clients and business partners to raise awareness of ESG.
3. Work with governments, regulators and other stakeholders on ESG issues.
4. Demonstrate accountability and transparency.

PSI membership now includes 107 organisations, representing 20% of the world’s premium total and US$14 trillion in assets. But only 20%.

It is perhaps surprising then to realise that only in the last ten years has the insurance industry taken significant steps to align its interests to reduce risk exposure to carbon. However, that seems to be changing, and rapidly. The BlackRock Global Insurance Report (2018) highlights the main risks perceived by the industry. Regulatory risk is deemed to be the most important; however, environmental risk has moved back into the higher risk category. The insurance industry is no longer producing reports and no action; in 2017, fifteen insurance companies removed US$20 billion from coal investments (Harrell & Bosshard, 2017) and by 2018 this had become 16 insurance companies that have now moved US$22billion out of coal, and the movement is growing (Ogleby, 2018). The insurance industry does not see itself as leading society towards more sustainable outcomes (Confidential research interviews) but it can steer society,

it can incentivise sustainable behaviours and it can make it more expensive to maintain non-sustainable behaviours. With the increasing demand for safe, long-term investments to add to the insurance investment portfolio, insurance companies are also increasingly demanding that climate and resilience risks become a sensible fiduciary duty in evaluation and compliance requirements. An example of the emerging sentiment amongst insurance regulators can be seen through the work of the Californian insurance regulator (Jones, 2018), encouraged by the UNEP FI and PSI. In 2016 the regulator asked 1, 200 insurance companies in the State of California to disclose investments in fossil fuels. A total of US$5 trillion in assets are managed, of which US$528 billion was held in oil, gas, coal and utilities, US$21 billion being in coal. Using the TCFD requirements as a benchmark, the regulator has investigated total climate / carbon related risk in the Californian market and advised the insurance companies to assess further their risk exposure and investment decision-making.

The Taskforce on Climate-Related Financial Disclosures (TCFD) has reported that international financial stability is dependent on investment and insurance decisions factoring in exposure to climate change. Investment and insurance advisors therefore have a fiduciary duty to include climate risk in assessments. Even given this strategic advice the report *Banking on Climate Change* (RAN, 2018) finds that 36 of the world's biggest banks funnelled $115 billion into extreme fossil fuels in 2017, an increase of 11% from 2016. This perhaps illustrates that typical investors, as described above, take time to move away

from traditional areas of investment and they typically steer clear of technologically challenging projects, or early stage innovative investments. The insurance industry has rapidly developed a role here – perhaps incentivised by growing climate and natural disaster-related insurance pay-outs. The report 'Issues Paper on Climate Change Risks to the Insurance Sector' (IAIS & SIF 2018, p.15) notes that "total global economic losses from natural disasters between 2005 and 2015 were more than $1.3 trillion, with total direct losses in the range of $2.5 trillion since 2000; major hurricanes and other natural disasters in 2017 caused insured losses of $138 billion; overall economic losses from natural disasters in 2017 amounted to $340 billion, the second highest annual figure ever".

The insurance industry has become a major investor in infrastructure projects as well as performing a key function in spreading infrastructure risks from clients, contractors, subcontractors and other parties involved in the project to insurers, providing contingent funding in time of difficulty. In tandem with the government's announcement of a National Infrastructure Plan outlining more than £483 billion of planned public and private sector infrastructure investment (IPA, 2016), six major insurers also announced plans in 2013 to collectively invest £25 billion in UK infrastructure. The UK insurers are Prudential, Aviva, Legal & General, Standard Life, Friends Life and Scottish Widows; only three however, Aviva, Legal & General and Standard Life, currently subscribe to the TFCD approach.

The main global investors in infrastructure are public and private pension funds, banks and insurance companies. Insurance company investment in infrastructure must be engineered to comply with several regulatory requirements, particularly Solvency II, the EU risk-based capital regulation for insurance investment, and internal risk regimes to ensure long-term stable returns are delivered (Gatzert and Kosub, 2014). With the debt ratio lowered for infrastructure investments, insurance companies favour the simplest form of investment which is to purchase corporate bonds, corporate equity or infrastructure bonds. However, the market is broadening all the time with opportunities in direct and indirect investments, both portrayed as providing stable long-term returns. The literature review provides evidence to date of such long-term stable returns being provided only through direct investment in infrastructure project bonds (Sawant, 2010). Defaults on bond infrastructure investments are also found to be lower and as a relatively low risk investment option, returns are also found to be quite low.

This move into infrastructure investment coincides with the insurance industry having begun to develop a more flexible approach to infrastructure insurance, moving from single risk insurance placement towards insurance for a package of risks that reflect the lifetime of an infrastructure project. This has developed through Owner/Contractor Controlled Insurance programmes and one of the newest insurance products on the market, in fact only used once to date, is the Integrated Project Insurance (IPI) product (UK Government Cabinet Office, 2014).

Given the two factors described above – the contrasting intransigence of financial and insurance organisations and the accelerating engagement in climate-related and sustainability practices of some financial and insurance organisations – it is apparent that a selection process is required to maximise the movement towards liveable, sustainable and resilient infrastructure and cities. Insurers should be selected as a supplier based on an evaluation of the product, the organisations' strategic approach and cost. Conversely, insurers are looking for the right type of sustainable and resilient infrastructure project to support. Although this thesis focusses on the role of finance and insurance appraisal in infrastructure; all parties engaged in an infrastructure project would benefit from an evaluation approach that conferred attainment of best practice when shown to be striving towards a level of performance that meets the criteria of the TCFD and the UN Sustainable Development Goals (SDGs; United Nations, 2015) and drives forward progress towards a restorative infrastructure. ['Restorative Infrastructure' includes impact minimisation, includes positive attributes and contributes to repairing damage done – environmentally, socially and economically]. Such an evaluation would provide a development partnership with several benefits:

1. Identification of cost-effective products.
2. Identification of products that match the development partnership's attributes and capabilities.

3. A combination of product features and implementation practices that accelerates innovative deployment of sustainable methods and technologies.

4. Appraisal of insurer performance in relation to the TCFD requirements.

5. Appraisal of insurer performance in relation to the UN SDGs.

6. Guidance / mentoring / enforcement of TCFD and UN SDG standards from the investors and insurers.

7. Progress in developing an approach that delivers restorative infrastructure.

And further compelling pressure is being placed upon the insurance industry when it comes to societal responsibility for the human rights of those now vulnerable to the effects of climate breakdown (CISL, 2015). Such communities are most vulnerable to the actions of others, actions that the insurance industry can make expensive through associated premium increases for specific activities and products This can be done by providing policy holders with financial protection, influencing vulnerability risk reduction through conditions and incentives in policy contracts, and enabling financial inclusion with associated local financial reserves for the most vulnerable communities.

### 5.2 Insurance in the United Kingdom

Insurance underwrites the development of UK infrastructure, it spreads, manages and underwrites risk that most individual companies would be unable to fund independently.  And, it's big. The largest market in Europe is in the UK:

it is the fourth largest in the world, contributing some £35 billion in 2014 (ABI, 2017) and an estimated £72 billion in 2018 to the UK economy. Over 300, 000 jobs are supported by this sector, of which over 100, 000 are direct employees; underwriting £250 billion in insurance premiums / year and with total assets of over €1.7 trillion; investing £20 billion into UK investment portfolios (Cherowbrier, 2019).

The Prudential Regulation Authority, which oversees the insurance sector in the UK, published (PRA, 2015) an absolute turn around position on risk to the insurance sector from climate breakdown. The report identified three primary risk factors through which climate impacts were expected:

**Physical risks** – flood, drought, etc.

**Transition risks** – the potential extent and speed of re-pricing fossil fuel intensive assets.

**Liability risks** – claim and re-claim over losses incurred because of climate breakdown.

The PRA states that there is potential for climate change to present a substantial challenge to current insurance business models. The PRA expects all its regulated companies to assess these risks and report on their proactive management of those risks with an initial response to an adaptation

preparedness survey, whilst also highlighting the potential for new business opportunities in insuring renewable energy projects, in supporting infrastructure resilience through awareness and risk transfer, in investment in green bonds and in providing climate leadership in the finance sector.

### 5.3 How insurance works when applied to UK infrastructure

The following statement directed the researcher's attention to the problems experienced in the current insurance approach to infrastructure in the UK: "Our project insurance system wastes about £1 billion a year and invariably leads to the courts" (Klein, 2009), and this figure is likely to be much higher today (LEIA, 2013). Several research interviews highlighted that there is massive overlap and duplication in insurance cover on a large infrastructure project, one interviewee referring to this as the 'holy grail' in improving infrastructure insurance management.

Most project risks are covered by the following types of insurance: professional indemnity (PI), contractors all risk, product liability, employer's liability and public liability. In addition, specific types of contract will require insurance against non-negligent withdrawal of support and insurance of works and existing structures. Insurance is often layered, so that claims use up a specified total allocated in the 'primary' layer and if additional claims are made, they are paid from an excess layer but all within a pre-set maximum limit.

Each organisation involved with project delivery will have insurance policies to cover all aspects of on-site risk, although most risks will fall into certain activities

and on certain contractors, not all. Because of the tiers of contractors used, further duplication of insurance is built up and, in some cases, gaps in insurance cover can be opened if inadequate checks are made on the current policy cover and duration. Even when all these layers of insurance are in place, the default position when something goes wrong is not to admit liability. Insurance companies will generally only pay a claim when liability has been proven through court, arbitration or adjudication. Which-ever root is used it is estimated that for every £1 paid to the insured party, £5 in legal fees are incurred in total (Confidential research interviews).

Typically, contractors purchase insurance for their specific types of work, spreading insurance costs over all their projects. Most contractors buy guaranteed cost or low deductible programmes. Costs are between 1 – 3% of hard construction costs and are loaded as a general percentage into bids (Confidential research interviews).

When looking at insurance costs spread across a range of activities and specific tasks, the levels of complexity in estimating potential savings are very detailed and time consuming. An illustration of the detail required is presented in Table 5.1. Although the data for this table was first compiled in 2005, an analysis of insurance costs over the intervening period concludes that this data is once again approximately accurate for the period 2018/19.

**Table 5.1** Indicative insurance costs across contractor levels and work packages. Permission to reproduce in part only – Integrated Project Initiative.

| | Analysis of value of supply chains | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Work type | | Work type split (S&C) | Work type split (Cat A) | S&C value | Cat A Value | Total value | Estimated Insurance Rating | Design Team | | Main contractor (NB No PPL) | | CAR Estimated insurance rating | CAR Premium |
| | | | | | | | | | | | % | Value | | Value | % | £ |
| 1 | Substructure | | A&I | | 100 | | 2,648,600 | | 2,648,600 | 1.50% | 15% | 397,000 | 100% | 2,649,000 | 0.35% | 9,272 |
| | | | | | | | | | | | | | | | | 0 |
| 2 | Frame (assume steel) | | F&I | | 100 | | 4,047,500 | | 4,047,500 | 1.00% | 15% | 607,000 | 100% | 4,048,000 | 0.35% | 14,168 |
| 3 | Upper floors | | F&I | holorib | 45 | | 1,220,800 | | 549,360 | 1.00% | 15% | 82,000 | 100% | 549,000 | 0.35% | 1,922 |
| 4 | | | A&I | concrete | 55 | | | | 671,440 | | 15% | 101,000 | 100% | 671,000 | 0.35% | 2,349 |
| 5 | Roof | | F&I | holorib | 20 | | 478,400 | | 95,680 | 2.00% | 15% | 14,000 | 100% | 96,000 | 0.35% | 336 |
| 6 | | | A&I | concrete, | 80 | | | | 382,720 | | 15% | 57,000 | 100% | 383,000 | 0.35% | 1,341 |
| 7 | Stairs | | F&I | | 100 | | 535,000 | | 535,000 | 0.75% | 15% | 80,000 | 100% | 535,000 | 0.35% | 1,873 |

| | Sub-contractor | | CAR Estimated insurance rating | CAR Premium | PPL Estimated insurance rating | PPL Premium | Installer | | CAR Estimated insurance rating | CAR Premium | PPL Estimated insurance rating | PPL Premium |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % | Value | % | £ | % | £ | % | Value | % | £ | % | £ |
| 1 | 90% | 2,384,000 | 0.50% | 11,920 | 0.75% | 17,880 | 55% | 1,457,000 | 0.50% | 7,285 | 0.75% | 10,928 |
| | | | | 0 | | 0 | | | | 0 | | |
| 2 | 90% | 3,643,000 | 0.50% | 18,215 | 0.50% | 18,215 | 15% | 607,000 | 0.50% | 3,035 | 0.50% | 3,035 |
| 3 | 90% | 494,000 | 0.50% | 2,470 | 0.50% | 2,470 | 40% | 220,000 | 0.50% | 1,100 | 0.50% | 1,100 |
| 4 | 90% | 604,000 | 0.50% | 3,020 | 0.00% | 0 | 50% | 336,000 | 0.50% | 1,680 | | |
| 5 | 90% | 86,000 | 0.50% | 430 | 1.00% | 860 | 15% | 14,000 | 0.50% | 70 | 1.00% | 140 |
| 6 | 90% | 344,000 | 0.50% | 1,720 | 0.00% | 0 | 30% | 115,000 | 0.50% | 575 | | |

Table 5.2 contains data from a current infrastructure project in Birmingham, UK. It is broken down into several contract packages all with individual insurance policies in place, generally as a blanket cover for the works done and estimated to cover all projects expected in the year. Table 5.2 correlates work packages with company turnover and estimated insurance costs using the contractor level categorisation and cost estimations presented in Table 5.1.

**Table 5.2:** Typical UK Infrastructure contract packages and Insurance Cost. Source: Live UK construction project.

| Infrastructure contract | Value | Insurance cost |
|---|---|---|
| Engineering consultant | £3,800,000 | 2% - £76 000 |
| M&EE | £3,800,000 | 2% - £76 000 |
| Construction & Engineering | £10,000,000 | 0.70% - £70 000 |
| Electrical | £2,600,000 | 1.5% - £39 000 |
| Building & Civil Engineering | £11,500,000 | 0.70% - £80 500 |
| Landscape | £400,000 | 0.35% - £1 400 |
| Concrete and groundworks | £4,500,000 | 1.5% - £67 500 |
| Structural steel | £750,000 | 1.5% - £11 250 |
| Roofing & Cladding | £4,000,000 | 1.2% - £48 000 |
| Windows and glazing | £715,000 | 0.65% - £4 647 |
| Civils | £400,000 | 1.2% - £4 800 |
| Steelwork | £800,000 | 0.65% - £5 200 |
| Groundwork | £800,000 | 0.65% - £5 200 |
| Concrete | £150,000 | 0.35% - £525 |
| Internal finish | £100,000 | 0.10% - £100 |
| **Total** | **£44 300 000** | **1.1% - £490 122**<br>**2% - £886 000** |

Typically, insurance is added into bids as a 2% overhead, although the reality of insurance cost relates to the deal struck with the insurance provider, the amount of business done each year with the provider, risk, management competency and site history as illustrated in Table 5.2 (Confidential research interviews).

The percentage of construction cost / project to insurance premium can range from 0.1% to 6.0% dependent on the above factors and the specific component of the project that a contractor is responsible for. A major engineering contractor with a turnover of £500 million has blanket insurance cover at 0.65% of turnover; while a building cladding company with a turnover of £7.5 million has blanket insurance cover at 1.2% of turnover (Confidential research interviews). Table 5.2 demonstrates that an average 0.90% margin is built into insurance cost bid elements - £395, 878. IPI estimates a 6% - 20% potential saving on insurance costs if an integrated project insurance product is used with the associated best practices. From the data presented in Table 5.2 potential savings are in the order of £29, 407 - £98, 024 at 1.1% or on a 2% blanket bid estimate £53, 160 - £177, 200. In addition, professional indemnity costs of £000 00's would be added for the full potential savings estimate.

Given the complexity of estimation, it is generally felt that the cost of removing duplication and using insurance products such as Integrated Project Insurance (IPI) is best for projects over £5 million (Connaughton and Collinge, 2018). This cost will diminish rapidly as experience grows in using integrated project insurance, although the pre-requisite for savings is for clients to ensure that a pipeline of projects is communicated and contracted in a timely manner.

Although the principle of insurance and re-insurance of infrastructure risks in global markets is critical to the successful implementation of an infrastructure project, an insurance policy has become a shield behind which to hide, rather

than a proactive tool to manage risk. A silo mentality and a protective positioning of commercial and liability issues dominates the culture on site. Policy documents require policy holders to not admit fault when an issue arises, which can lead to months of costly and frustrating negotiation (Confidential research interviews).

There is a rather different perspective when insurers are asked to discuss the problems with insuring the infrastructure sector. Insurers interviewed reported that the insurance policy was a ‘sunken’ cost and a ‘necessary evil’: a document to put away into the bottom draw to only be brought out again when something goes wrong (Confidential research interviews). Some insurance companies are adopting a quality partner role and offering several additional services to support the insurance policy – including risk analysis, health and safety training, surveys and other data collection work (CE, 2016). If insurers were involved at regular review meetings, when there are changes to design or contract requirements, it is reported that the sector believes that 7 out of 10 claims can be avoided. Yet the contractors are reluctant to get the insurer engaged. In some rare instances the insurer / contractor relationship has led to substantive engagement of insurance and risk personnel across the client’s business, reducing risk, reducing confrontation and reducing claim numbers and cost (CE, 2016).

Of note in the CE (2016) report was the insurer desire to be engaged early enough in the infrastructure project to add analysis of the source of financing

and the contractual terms around finance charging if on-site requirements change the insurance scope. An insurer, once understanding the design requirements and the project outcomes, might provide risk-based advice on when and where to ensure contingency is in place, if things change dramatically, or go wrong. Having analysed all the contract clauses related to finance costs, the insurer can best judge where the most likely and most costly realisation of risk might occur and can therefore allocate expertise, funds and insurance cover for those critical control points. It is claimed in the report that for larger projects, enough savings are likely to be made, although neither the size of project nor the sizes of potential savings are quantified.

Where the owner of a major project (typically in excess of £50 million) requires greater control of risks, claims and costs, the insurance industry has responded with the 'Owner Coordinated' (or Controlled) Insurance (OCI) product (Willis, 2019). Typical cover includes works, third party / products and non-negligent liabilities, and delayed start-up. Extended cover can include several elements, such as existing works, pollution / contamination, some indemnities and some contingent liabilities. One of the major benefits of this approach is that all risks are identified and managed by the owner with the support of dedicated insurance company risk assessor personnel. Additional benefits include effective claim management through a single point of contact and an extension to cover operating issues such as loss of income through delayed start-up.

Importantly OCI eliminates duplication of insurance and gaps in insurance, as well as the need to check the validity and detailed cover of all contractor insurance policies across the different works and through the entire duration of the project. Although insurance purchase costs are likely to exceed normal arrangements, reductions in contractor's insurance costs, subsequently reflected in reduced charges to the client, should result in an overall cost reduction. However, contractors argue that they still have insurance issues to cover and their annual renewal blanket cover must be put in place anyway (Confidential research interviews), unless the project is of sufficient size to require unique insurance. There has been some evidence that OCI can lead to a relaxed attitude to risk on the part of some contractors, as the perceived payment for damages is no longer going to impact on the contractor insurance costs or profile.

OCI focusses on the effective delivery of an insurance product that covers a holistic portfolio of risks and management of any subsequent losses or claims. Although OCI can bring improvements, extending the product to cover smaller construction builds would bring even greater benefits, as well as using the single insurance policy approach to steer management practices and contractor behaviours, is what is really needed (Confidential research interviews). It is the mentality of cost and risk perception, as well as the level of management practice, that needs to be affected to ensure that insurance steers the right behaviours in infrastructure management.

But this relationship could be re-engineered if the insurance industry was asked to partner with city institutions in creating an infrastructure masterplan, preparing an infrastructure investment portfolio, defining the priority infrastructure pipeline and evaluating the risks that finance and insurance would then need to manage. In 2016 a workshop held in Ethiopia began to outline a routemap to develop such a strategy, with the close involvement of insurance representatives (CISL, 2017). This theme is developed further in Section 5.4.

### 5.4 Evaluation of insurance to achieve specific infrastructure outcomes

Chapter 4 reviewed the literature on infrastructure finance and particularly developed and demonstrated a comprehensive methodology for assessing the cost of different financial sources, including the implications of Government policy and local authority activity in areas that reduce city vulnerability to climate change and other sustainability issues. Another key development is to add to this model the appraisal of insurance. This should reflect not just the costs of insurance, but the practices that insurance can steer organisations towards implementing. For example, insurance requires building standards to be met and fire regulations to be upheld, and indeed some insurance products provide discounts when certain criteria are met. As an extension of this approach, the insurance industry is considering its role in: helping to ensure that infrastructure provides the necessary transition from high-carbon intensity to lower-carbon or zero carbon practices; determining how the industry can steer entities towards achieving the UN SDGs; the quality of reporting to the requirements of the TFCD; and serving as risk manager, risk carrier and investor. In this endeavour,

the global insurance sector plays a cornerstone role in the management of sustainability-related risks and opportunities (McDaniels *et al.,* 2017).

The financial appraisal method developed and presented in Chapter 4, requires a mandatory selection of finance sources from organisations that comply with the TFCD reporting requirements. This should be extended to the selection of insurance providers as well. The ShareAction report (2018), incorporating the 'Asset Owners Disclosure Project, highlights that AXA, Aviva, Allianz SE, and Legal & General are leading the way in TFCD reporting. Tokio Marine, Legal & General, Credit Agricole, Allianz SE, Generali, NN Group, and Swiss Re are demonstrating the best annual improvements. These listed insurance companies are therefore recommended for use in providing insurance for liveable, sustainable and resilient city infrastructure.

The insurance industry has been monitoring global trends for decades, although with a view that has been heavily reliant on past datasets and the work of actuaries to use financial and statistical techniques to solve business problems, particularly those involving risk. An insurance provider is most confident when an actuary provides a well-established dataset that accurately confirms the likelihood of a specific risk occurring under specific circumstances (Confidential research interviews). The provider becomes increasingly nervous, however, when risks are emerging, unquantified and weakly understood in the marketplace. There is a widely held notion that 'the insurer likes a bit of risk, but not that much' (Confidential research interviews). A recent report suggests that

the insurance sector needs to up its game as change sweeps ‘through and around’ the industry (DAC Beachcroft, 2018). Citing natural catastrophe and climate change as one of the main issues the industry must confront, DAC Beachcroft calls for innovation, new products and new understanding as to the role of insurance. Particularly regarding climate change issues and insurance, the growing gap between insured losses and total economic losses (Munich Re, 2017) has prompted a search for fresh solutions.

One important example of this new search for insurance-related innovation has been highlighted by CISL, (2017). The objective of a workshop held in Ethiopia in 2017 was to establish how the expertise of the insurance industry could be harnessed in the development of city infrastructure to ensure that it was designed, built and operated in a sustainable, financeable and insurable manner. What the workshop established was that there is scope to re-engineer the current relationship of insurer to infrastructure. The insurer has traditionally been added to the infrastructure project team once political decisions, prioritisation and even design are all but completed. This is just too late in the process. And although this workshop was initiated to accelerate the implementation of infrastructure projects in emerging economies, the output from the event is clearly relevant to any economy in the world.

But this relationship could be re-engineered if the insurance industry was asked to partner with city institutions in creating an infrastructure masterplan, preparing an infrastructure investment portfolio, defining the priority

infrastructure pipeline and evaluating the risks that finance and insurance would then need to manage. The workshop began to outline a routemap to develop such a strategy, with the close involvement of insurance representatives (CISL, 2017). Of the significant outcomes and points of mutual interest that developed from the project were:

- The need for collaboration between all partners with the private sector putting aside all commercial interests.

  When the author of this thesis chaired (2006 – 2008) the Yorkshire & Humber Regional Infrastructure Taskforce, commercial sensitivity issues were scoped and initially placed in a confidential 'pending bin'. These were then brought back into discussion at relevant points through independent facilitation and when mutual trust had been developed with the participants. This process took months to get to a point of sharing infrastructure development potential across the region.

- Engaging professional managers of risk from the insurance sector at the earliest possible moment led to a greater mutual understanding of the challenges facing local authority infrastructure requirements and insurance desire for stable and long-term financial returns.

- Early engagement of insurers brought additional depth of analysis in the development of different business models that might make an infrastructure project sustainable financeable and insurable.

- Cities often lack enough capacity and capability to deal with the complexity of financing, insuring and managing major infrastructure projects. There is often a lack of risk analysis, and data are insufficient. Insurance personnel have capabilities across these areas and are reported to be willing to share in the cost of data acquisition and willing to second staff to assist in developing a city infrastructure programme.

Despite these trends, many insurance companies remain stuck in a passive actuarial model rather than pursuing 'shared value' – the concept that monetizing aspects of social conditions and providing insurance against uncertainty, encourages investment in strategies that improve social conditions, although with a small increased risk, and that this improvement in social condition, also increases a community's ability to take on more insurance cover and therefore feel better able to invest repeatedly into the community condition (Jais *et al.,* 2017). Insurers benefit more than any other industry from societal advances; for example, building in incentives for improved behaviours to an insurance policy reduces the risk that damage might occur, and a pay-out claimed. The Shared Initiative report (Jais *et al.,* 2017) provides evidence of the benefits of a strategy, with three key elements:

1. Prevent risk and dynamically reward risk reduction.
2. Close the protection gap for the underserved (CISL, 2016).
3. Invest assets in prevention and protection systems.

### 5.5 Selecting an insurer

Given the preceding research findings this thesis proposes that in selecting an insurance partner when preparing a city infrastructure portfolio, the following criteria should be used:

- Alignment with the UN SDGs
- Reporting to the TFCD requirements
- Demonstrably effective innovation mechanisms and new products
- Willingness to participate at an early stage in the development of a liveable, sustainable and resilient investment ready city portfolio
- Understands and executes a programme with ‘shared value’ at its core.

An insurance provider must demonstrate that it is willing to develop and provide new insurance products that reflect the climate and sustainability emergency situation cities face; products that steer infrastructure investors towards liveable, sustainable and resilient infrastructure and products that reward those that make improvements in sustainability. Some examples of new and emerging insurance products that really do assist sustainable performance are described in section 5.6 which when combined with the practices encouraged by the Integrated Project Insurance approach (described at 5.6.2.2) form the basis of

a new way of using insurance in infrastructure for liveable, sustainable and resilient infrastructure.

### 5.6 Emergence of New Insurance Products

Not only is the insurance industry signing up to the TCFD requirements and looking closely at how it can play a role in delivering the UN SDGs (CISL, 2015), it is developing a strategy of reducing exposure to fossil fuel intensive activity, reducing investment in fossil fuel intensive activity, and beginning to develop products that provide critical infrastructure insurance and encourage innovative practices and sustainable outcomes amongst the key stakeholders.

#### 5.6.1 – Reducing insurance exposure and investment in fossil fuel - intensive activity

In 2017 AXA, SCOR and Zurich all announced that they would no longer provide insurance cover for any new coal-based infrastructure; in 2018, Allianz announced that it would not provide insurance for coal plant and mines and would remove all coal-related risks from its portfolio by 2040, and going even further it announced that any companies that planned to install coal-based energy into their generating capacity would be removed from the Allianz investment portfolio.

Insurance sector divestment from fossil fuel-intensive industry has now reached US$22 billion (Harrell & Bosshard, 2017).

### 5.6.2 – Developing new insurance products

**5.6.2.1 iTWO Project Cost Insurance.** This product has been designed to reduce the risk of cost overrun, initially in building construction (Munich Re, 2019). It uses BIM 5D technology to simulate the construction process for each of the planned construction phases. If the simulation runs smoothly under the established preconditions, insurance cover is offered for the residual risk relating to the physical construction. Cover extends to the cost difference between the virtual simulation and the cost incurred.

#### 5.6.2.2 Integrated Project Insurance (IPI)

This is a new form of insurance-backed alliancing, incorporating single project insurance (Connaughton and Collinge 2018). The insurance policy covers the design and construction team as a virtual company in an alliance with the client for all risks, including third party liability, delay in project completion, cost overrun and latent defects. Integrated collaborative working is a key practice enabled through early stage detailed joint meetings that are used to identify risks, training requirements and contract agreements. All parties have access to detailed risk allocation and reward systems. Financial exposure is capped to the insured limit, based on building information modelling (BIM) simulations and agreement to a sharing of responsibility, penalties and rewards. The IPI way of working requires not just collaborative working, but also mutual no-blame / no-claim undertakings. This also focusses the team on identifying the best solution for the project build, rather than protecting a specific view or obstructing clarity on emerging risks. Unanimous principle-based, decision-making on all key

project issues is sought by a team trained to work together and selected on a competency basis. By stimulating innovation to achieve the best results, more sustainable outcomes are far more likely to be delivered.

The whole process is supported by independent facilitation as well as technical and financial independent risk assessors. With this independent team in place, all meetings and subsequent agreements are facilitated in an open manner and with a single objective of securing the clients objectives in the most effective way possible. If the client can be encouraged to stipulate liveable, sustainable and resilient criteria for the project build, this collaborative team approach encourages an innovative, cost effective and sustainable approach.

With single project insurance the insurance costs of all contractors and sub-contractors can be removed from the overall project costs. This assumes typical blanket insurance policies can be implemented with specific IPI project costs removed from the premium calculated.

IPI is forecast to benefit projects costing more than £5 million and at present up to £30 million. As experience is gained in the use of IPI, it is anticipated that the availability of risk cover and the size of project that is underwritten will increase. When combined with efficiency savings the choice of IPI steers the infrastructure implementation towards reasonable cost savings, much enhanced delivery and improved delivery of planned outcomes (Constructing Excellence, 2016). Initial forecasts of the cost of IPI insurance were 2.5% of project costs

(£294, 000 for the £12 million pilot scheme), but this was subsequently increased to £402, 000, approximately 4% of project costs. As this was a pilot, this still represents good value for money and costs will decrease in future projects.

Notable achievements of the first use of IPI on a £12 million scheme at Dudley College, West Midlands, reported by Connaughton and Collinge (2018) are:

- High quality building delivered 4 weeks over schedule and with a 1.8% outrun cost increase. Pain / share arrangements reduced this to 0.3% cost increase to the client.
- Significant collaboration between all partners, finance and funding sources, insurers and users was facilitated and was successful.
- Sharing of risk and reward engendered a sense of project ownership and joint responsibility for its success.
- Formation of a virtual company, known as the ‘Alliance’, comprising the client and all potential partners with an objective to share all decision-making from design to completion.
- The detailed Alliance contract, included a ‘no blame’ approach, ‘best for project’ decision-making, and ‘pain / gain share’ to an agreed cap.
- IPI product with independent advisors.
- Significant investment in training partner teams in values, cultural alignment, collaborative decision-making, planning, opportunity and risk identification.

- Project bank account to speed up transactions and ensure all participants are paid at the same time on completion of an element of agreed works.
- Central importance of BIM data.
- Soft landing handover – the building was tested thoroughly, extending handover dates, so that the client was able to use the building to full capacity immediately.

The potential for alliance-led integrated project insurance for cost reductions is considerable, but not just in terms of insurance costs. The practices that are encouraged are those that support the principles of sustainability and innovation. In effect the quality of the insurance cover is such that certain practices are encouraged to secure maximum benefit from the approach. It really does not take much on the side of the client or the insurance company to add liveable, sustainable and resilient infrastructure design and delivery to the requirements of IPI.

Although the IPI concept has only one execution to date in the UK (currently a second project is underway at Dudley College using IPI), considerable experience has been built in Australia.

The technically demanding task of allocating risk cover and appropriate clause wording to define adequately comprehensive insurance policies for large and complex infrastructure projects remains a huge cost in developing alliancing

insurance (Australian Government, 2015). The main concern expressed by the Australian Government in using alliancing and single insurance is that a 'de-risked' project might encourage behaviours that would lead to catastrophic mistakes – financial and physical. However, this comprehensive review does not include a key innovation in the IPI model described above. Although a 'no blame' collaborative approach is mandated, there is also a pain/gain share to a specified cap. This incentivises correct behaviours. And this begins to strike at the heart of the leadership context that the insurance industry might be on the verge of adopting if further encouragement is forthcoming from future infrastructure clients. This is insurance that incentivises and mandates sustainable and innovative behaviour from all participants in infrastructure development and deployment.

#### 5.6.2.3 – Flood RE

This is an insurance product devised with UK Government involvement to help 350, 000 householders in flood risk areas to obtain affordable flood insurance with cover at a set price for domestic properties built before 2009. The scheme is funded through an annual levy of £180m on insurance policies of UK homes. Flood RE has its own reinsurance policy to ensure it will be able to cope with a significant event and will remain active in its current form until 2039 (UK Government Regulation, 2015).

#### 5.6.2.4 – Parametric insurance

A parametric insurance policy allows claims without actual damage. In the Mexican State of Quintana Roo, a Swiss Re designed product pays out on data related to the local build-up of a major storm to enable funding to mitigate damage before the storms impact. The insurance product combines local authority and private money, with the insurance company working on the basis that incentivising protective investments will ultimately provide a more resilient community and business ecosystem, in which further sales of insurance are more likely (Swiss Re, 2019).

Weather Index Insurance (WII) in agriculture has grown considerably over the last fifteen years (Daron & Stainforth, 2014). This has been in a response to extreme event adverse impact on rural communities that are not able to afford the traditional claims based multiple perils cover insurance. Index insurance is based on predicted area yield or specific weather parameters being measured and realised (World Bank, 2011). Once the key parameters are realised all farmers in an area that subscribe to the lower premium insurance, are likely to receive a pay-out. At present the formulation of risk premiums has been based on data sets for forecasted extreme events. It is therefore likely that as more extreme events occur, claims will increase, with a corresponding increase in premiums, eventually leading to a price, at which, once again, poorer farmers are priced out of the insurance market.

Such has been the level of extreme events impacting not just on poorer economies and poorer people but also on significant economies, such as

Australia, that some insurance companies that have researched and provided WII are calling for a far deeper Government appreciation of the role of insurance in restoring the livelihoods of people and the economic activity of an area hit by disaster. Suncorp (2019) reports that in 2017, the impact of a cyclone on economic activity of the north of Australia was AUS$7.1 billion, 2.2% of regional GDP. In some localised areas, the level of GDP reduction exceeded 60%. In the first year after impact, the insurance claims and recovery activity added AUS$2.7 billion back into the economy. Almost full economic recovery was restored 5 years after impact. Now Suncorp is researching index-linked insurance schemes supported by incentives to stimulate improvements to property and infrastructure resilience (Confidential research interviews). Working with James Cook University Cyclone Testing Station, Suncorp has identified the key features of property that provide resilience to cyclone impact. If customers improve property to specific standards, Suncorp offer reduced premiums. However in a recent press release, SunCorp highlights the scale of the resilience challenge for Australia and is calling on the Government to support the process with significant investment (Insurance News, 2019).

#### 5.6.2.5 – Sustainable marine insurance

The insurance companies Allianz, AXA, Generali, Hanseatic Underwriters and The Shipowners' Club announced in 2017 that they would not knowingly insure vessels that have been blacklisted for their involvement in illegal, unreported and unregulated (IUU) fishing. IUU costs the global economy an estimated US$10 – 24 billion / year (United Nations, 2017). The group will review all

marine insurance to evaluate and remove exposure to illegal fishing, raise awareness of the issue amongst advisors and clients and will increase pricing if risk evaluations are deemed to have not met a minimum standard.

#### 5.6.2.6 – Local Government Association Mutual Insurance

A new mutual was incorporated in 2018 to provide local authorities with a cost-effective alternative to conventional insurance products. The product would be 100% member focussed and offers significant savings on conventional products: matching (or bettering) cover than currently available; reducing risk without increasing cost; providing a guaranteed cap on losses; and aiming to build a surplus that can be used to reduce product costs or taken as an income stream for members. (The Fire and Rescue Indemnity Company achieved a 12.5% surplus of £471, 428 in its first year of trading.) At present 14 local authorities have signed up as members and although progress has been slow in securing the initial funding from members, there remains optimism that this re-invented form of insurance will ease some of the financial pressure on local authorities (LGA, 2018).

## 5.7 Summary

The insurance industry represents one of the most important sectors for the advancement of liveable, sustainable and resilient infrastructure, yet although aware of climatic and sustainability issues impacting on the industry, it has been reticent in adopting a more dynamic, leadership role. This seems to be on the brink of changing as insurance companies begin to divest from fossil fuel-

intensive sectors; and invest assets in renewable energy projects, delivery of UN SDGs, shared value approaches, and new products; and start to report to TFCD requirements.

Important features of the new products that are emerging relate to costs, incentives and practices.

The Integrated Project Insurance (IPI) product highlights the duplication and blanket cost estimate inclusion in current bid practice. Research and data gathering have demonstrated potential savings in blanket bid estimates and more accurate cost division across infrastructure work packages - potential savings are in the order of £29, 407 - £98, 024 at 1.1% or on a 2% blanket bid estimate £53, 160 - £177, 200. In addition, professional indemnity costs of £000 00's would be added to the full potential savings estimate. Inherent within the IPI approach are a set of collaborative and alliance type principles and practices that will disrupt the current siloed, defensive and opaque insurance practices current in infrastructure projects at present. They enable better delivery, constant review of the intended outcomes and stimulation of sustainable innovation.

Added to this, is the ability of the insurance sector to incentivise behaviour as evidenced by the development of parametric insurance policies and the Principles for Sustainable Insurance integrated into many projects worldwide.

The assessment of finance costs and source of finance for infrastructure should be complemented by an assessment of insurance companies, insurance practices and the innovative process for new product development. Importantly insurance providers must be selected based on alignment with the UN SDGs and they must report to the TCFD requirements.

Finally, a CISL workshop in 2017 (CISL, 2017) scoped the potential for insurance company personnel to engage in the early development of an investment-ready infrastructure project portfolio. Although the researcher has not found any evidence of this model being replicated, it forms a critical component of the approach this thesis is developing and proposing – the **Li**veable, **S**ustainable, **R**esilient and **I**nvestment **R**eady **C**ity – **LiSRIRC** portfolio. To conclude this chapter is the extended LiSRIRC process model Figure 5.1.

Chapter 6 describes a series of obstacles to implementing the **LiSRIRC** portfolio, using the term the 'Valley of Death' (VoD). The VoD is commonly used to describe the difficulty experienced in moving innovative product or service ideas from ideation to commercialisation – many never emerge from the VoD. For the purpose of this thesis, the VoD describes some of the fundamental difficulties that must be overcome to enable the rapid acceleration of the deployment of liveable, sustainable and resilient infrastructure.

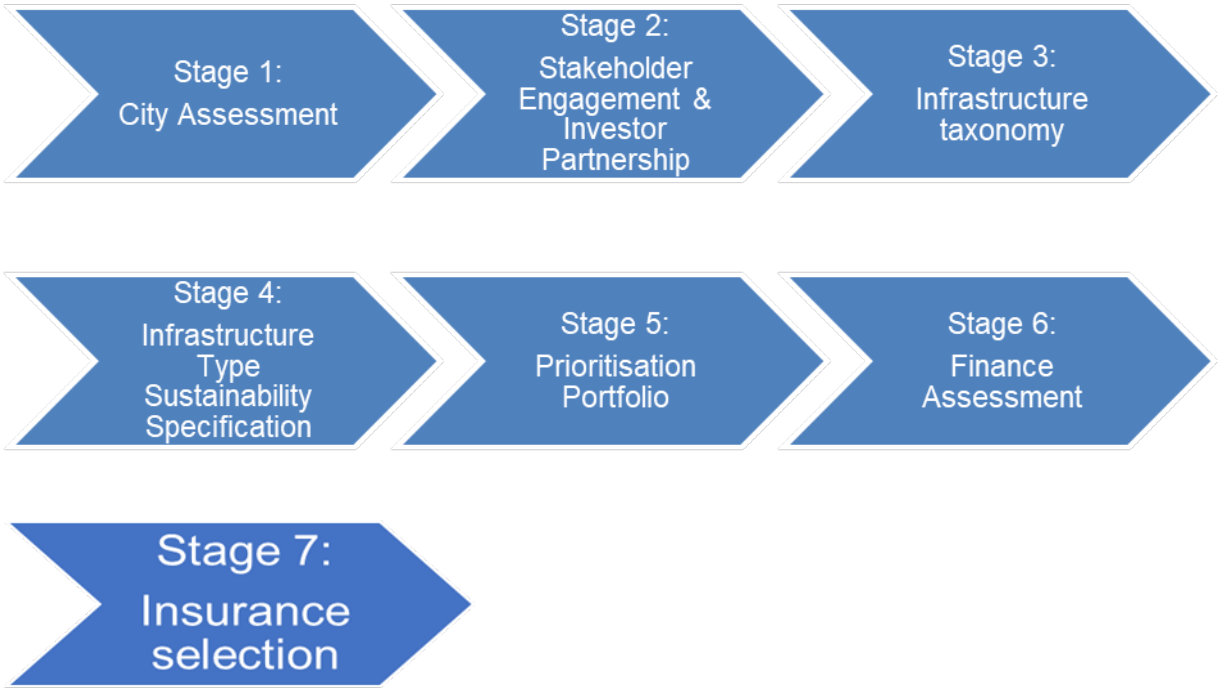



**Figure 5.1**: **LiSRIRC** – Stages 1 – 7.

# 6. BARRIERS TO EFFECTIVE IMPLEMENTATION OF SUSTAINABLE INFRASTRUCTURE

This chapter focusses on the practical steps that are needed to enable an assessment of the cost and source of finance and insurance to deliver the real benefits of a more liveable city. The chapter draws together several themes within the framework of an accepted process that depicts the 'valleys of death' (VoD) in the timeline from ideation to commercialisation of new and innovative products or services. In this chapter the 'VoD' concept is applied to the ideation and deployment of liveable, sustainable and resilient infrastructure.

Particularly, the focus is on the economic paradigm in which infrastructure investment takes place; a paradigm that contains one of the deepest and most intractable of VoDs. This is further exacerbated using inappropriate economic tools such as arbitrage pricing theory and complete misinterpretations of how the principles of economic efficiency, as underpinned by the production possibilities frontier, can be used to assess the suitability of investment decisions.

Given the series of obstacles to liveable, sustainable and resilient infrastructure deployment, this chapter concludes with thoughts about the type of institutional vehicle that might be able to tackle the VoD problem. The 'entrepreneurial state' is proposed as the special purpose vehicle to address the joint objectives of city transformation, regeneration and restoration.

## 6.1 Introduction

As described by Goodfellow-Smith *et al*., (2019a), worldwide infrastructure spending is projected to more than double to $9 trillion per year in the ten years to 2025, totalling $78 trillion (PWC, 2014). The ability of established infrastructure assets to generate stable long-term cash-flow makes infrastructure investment increasingly attractive to pension funds, sovereign wealth funds, insurance and institutional investors. Because of the size of many infrastructure projects, debt funding is often syndicated leading to global trading in infrastructure assets, which can be subject to arbitrage pricing theory strategies. This exposes local assets to international market fluctuations and puts them at risk of being used for short-term financial gain, i.e. it becomes an asset class at risk of management approaches that maximise profit over sustainability and resilience. This exposes the investors to macro-economic, political and regulatory risks (Deloitte, 2016), causing them to insure that investment against deviation from forecast growth.

A shift away from solely economically attractive investments towards the prioritisation of liveability, sustainability and resilience (Leach *et al*., 2017) would require macro-economic policy to reward investment in sustainable and resilient infrastructure. This would mean factoring in liveable city indicators, sustainable technologies and climate related risks, and would need the support of independent regulatory bodies and a stable, consistent regulatory framework to enable this transformation to happen.

There are encouraging examples of positive movements. For example, Demertzidis *et al*. (2015) describes an approach that enables an investor to select projects that have the least climate risk exposure. The Task Force on Climate-Related Financial Disclosures (TCFD, 2017) likewise provides support by concluding that climate change is one of the most severe financial world risks and that ignoring this risk has severe potential consequences for international stability. It therefore recommends transparency in reporting on such risks and their financial impacts and provides a framework for doing so. While this is helpful in emphasising the need for investment advisors to accept a fiduciary duty to include climate risk in assessments, the evidence suggests that many of the world's largest banking organisations are, if anything, increasing their investment in schemes that rely on fossil fuels (RAN, 2018). Action is therefore urgently needed to address this issue, noting that infrastructure systems are typically long-lasting and therefore can both lock in and lock out societal moral conditions and their multiple consequences (Lombardi *et al*. 2012).

The insurance industry undoubtedly has an important role in bringing about such a transformation, since it has become a major investor in infrastructure projects. While the National Infrastructure Plan proposing some £500 billion of planned public and private sector infrastructure investment was emerging (IPA, 2016), six major investment insurers announced plans to invest in UK infrastructure. However only three currently subscribe to the TFCD approach and thus there is a danger that some of this investment will 'lock in'

unsustainable outcomes. A far stronger emphasis on the future of such infrastructure projects is warranted, not only in terms of the lifetime of their operation as currently envisaged, but also in terms of the fact that their contexts are dynamic and inevitably subject to change, and perhaps radical change. The use of far future scenarios is of particular help in this (Rogers *et al*., 2012; Rogers 2018).

Some encouragement is offered in the insurance industry via the development of a more flexible approach to infrastructure insurance, with a move from single risk insurance towards insurance of a package of risks reflecting the lifetime of an infrastructure project. An example, albeit one that is as yet underused, is the Integrated Project Insurance product (UK Government Cabinet Office, 2014), while the HM Treasury Green Book (HMT, 2018) appraisal process also offers scope to move the situation in the right direction. Nevertheless, there are barriers to this movement that are commonly referred to under the umbrella of the 'Valley of Death' for infrastructure investments. This chapter explores this Valley of Death and makes recommendations for how to overcome it.

## 6.2 Infrastructure's Valley of Death

To create liveable cities of the future – cities that are sustainable and resilient, with individual and planetary wellbeing as core guiding principles (Leach *et al*., 2017) requires several key technologies, capabilities and attributes, but above all appropriate finance, funding, insurance and overall delivery models. Much attention has been paid to the former set of criteria (technologies, capabilities

and attributes) in terms of creation of the evidence base from which the 'business case for change' can be formulated (Rogers, 2018), and this rightly continues, while the latter – which first require the creation of alternative business models to deliver that change – have received far less attention, and an adequately-broad appreciation of how these business models might be formulated is only now emerging (Bryson *et al*., 2018; Bouch *et al*., 2018). The process of bringing ideas through to deployment has been characterised as a linear model (Godin, 2015) and to give this model a greater sense of reality, a key feature – the Valley of Death (VoD) – has been added to demonstrate the interdependence of resources, time and risk associated with various stages of the linear innovation model. The VoD at best delays deployment and at worst prevents it.

The VoD describes the process of bridging the gap between early-stage funding and later-stage venture capital-funded product development. A Science and Technology Committee Report – Bridging the Valley of Death: Improving the Commercialisation of Research (STC, 2013) highlights the very major concern that the VoD prevents progress of science from the laboratory bench to the point where it provides the basis of a commercially successful business, product or process; as applied in this thesis: new and/or improved infrastructure (Figure 6.1).

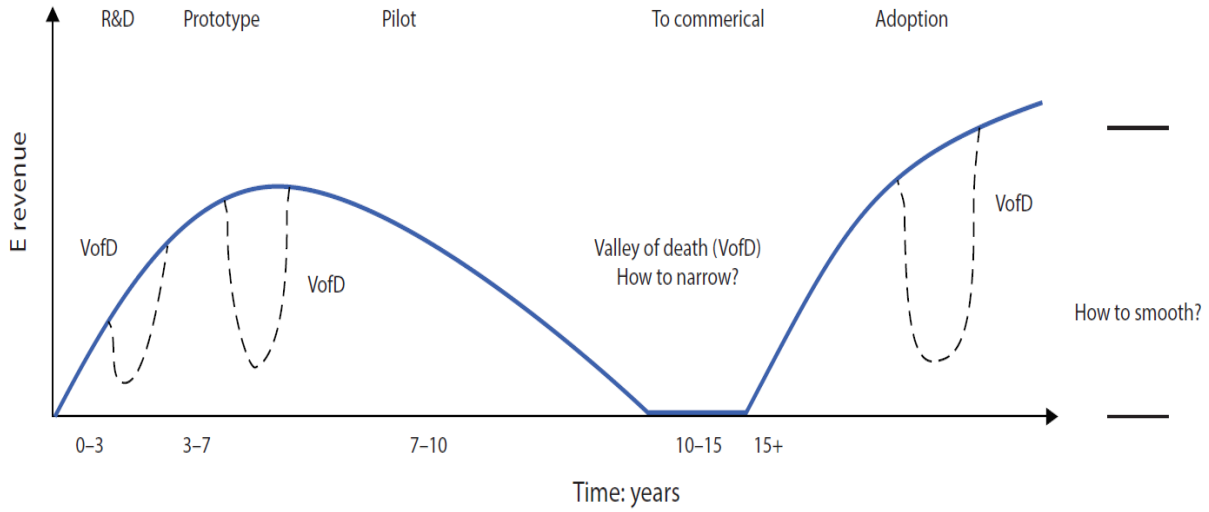



**Figure 6.1:** Innovative Infrastructure Development, illustrating the Valley of Death (after STC, 2013).

The VoD has several features (Wessner, 2005; STC, 2013):

- The idea / innovation will take time to demonstrate an attractive investment if current short-term and reduced perceived risk approaches dominates.
- Risk and viability assessment tools apply inconsistent and inappropriate criteria
- Investors are uncertain of the nature of the risks and regulation has led to banks becoming more risk adverse.
- A lack of clarity on the right types of finance and its availability for innovative infrastructure products as well as supportive grants, research and development facilities and tax regimes.
- Practical linkages to and application of university knowledge.
- Team skills

Although the VoD is often highlighted in the singular, it is in practice a series of obstacles that the idea or innovation must move past. The series of obstacles that influence the infrastructure development and deployment graph are:

- Finance – availability; conditions; return on investment; value capture / realisation
- Funding – business models; value capture / realisation
- Insurance – spreading risk; incentivising specific behaviours
- Risk perception – climate change; poverty; resilience
- Political direction – collaboration rather than siloed competition
- Community acceptance – engagement; societal norms
- Technical capability
- Facilities to pilot / demonstrate
- Formal levers of governance – legislation; taxation; regulation; codes & standards; moral conditions; formal assessment methods

Developing an alternative set of innovation processes and risk metrics in finance and insurance will provide the stimulus for new product development, financing and funding of sustainable infrastructure such as those highlighted in Chapters 4 & 5. These factors tackle critical elements of the VoD. But arguably the biggest obstacle as part of the VoD is the current economic paradigm. A depth of accumulated knowledge and principle has coalesced over the years into a most challenging set of economic assumptions, which many perceive as

just no longer fit for purpose; yet these assumptions govern much of the way in which society invests in infrastructure.

## 6.3 How out of date does a theory have to be, to be downright dangerous?

During his speech in 2016 at the Green Economics Conference, Oxford, UK, and repeated in interviews (Nugee, 2012) Sir Crispin Tickell made this comment: “Out of date economics should be recognised as a dangerous mental condition.” This is the assertion of a former Director of the Policy Foresight Programme at Oxford University and informal advisor to successive British Prime Ministers. His argument is based on the outcomes of the utilisation of economic theory, which over hundreds of years, if not millennia, has resulted in the generation of wealth and improved living conditions, yet remains partially sighted to poverty, inequality and potentially catastrophic environmental change.

The first writings on the concentrated and consumptive manipulation of the human project are derived from the Epic of Gilgamesh in 2700 BC (Sedlacek, 2011). Of course, much has changed since then, and neo-classical economic theory will claim as its root the Wealth of Nations (Smith, 1776). A central theme of Smith’s proposed form of economic theory was: that regulations on commerce are ill-founded and counter-productive; that productive capacity rests on the division of labour and the accumulation of capital that it makes possible; that a country’s future income depends upon this capital accumulation; and that the system is automatic only when there is free trade and competition. An

‘invisible hand’ will effectively allocate resources to maximise profit (Bernanke, 2007). Based on this work, we measure Gross Domestic Product (GDP).

Many economists talk about growth and mean ‘growth of GDP’. GDP is measured in three ways:

- The sum of all income earned by individuals, business and government.
- The sum of all consumption and investment.
- The sum of all output by business and government.

GDP includes air pollution available for trade and consumptive advertising as benefitting the economy; it counts the conversion of forests to tonnes of timber product; and it counts the tonnes of fish consumed – it does not count the value of fish stocks remaining, or trees producing oxygen, or low impact lifestyles, or pollution-free cities. It does not count the consumption of natural capital, nor the natural capital left. Obesity treatment is good for GDP; a healthy lifestyle is good for me. However, it should be remembered that GDP was developed to measure economic development; it should be retained for that function. But if increasing GDP does not deliver development that provides for future generations – nurtures the key resources that enable them to enjoy a satisfactory standard of health and well-being – what will, and when?

“Aligning the financial system for sustainability is not some far-off notion but is already happening. A quiet revolution is taking place … there is little doubt that

the challenge, although considerable, is essentially one of transition" (UNEP, 2015).

In support of this optimistic statement many alternative indicators of development have been developed. Some propose to replace GDP, while others are proposed to sit alongside GDP, providing a far more realistic evaluation of whether development is providing the right kind of conditions for humans to live in and to flourish in future generations. Redefining Progress created the Genuine Progress Indicator (GPI) in 1995 as an alternative to the gross domestic product (Talberth, Cobb & Slattery, 2006). The GPI enables policymakers at the national, state, regional, or local level to measure how well their citizens are doing both economically and socially, with a representative inclusion of relevant environmental issues. The New Economics Foundation proposes National Success Indicators (Jeffrey and Michaelson, 2015): good jobs; wellbeing; environment; fairness; health.

The Organisation for Economic Co-operation and Development has a 'Better Life Index' (OECD, 2015) with 11 indicators, while the United Nations has created a set of 'Sustainable Development Goals' (UN, 2015) with 17 indicators, and there are now several other variants. However, these measures do not define the type of infrastructure that is required. What is perhaps needed is a clear framework for policy makers to understand how to develop infrastructure that delivers on key holistic indicators, and the risk factors that steer investors away from infrastructure that negatively impact on holistic indicators. Moreover,

this can often be done at little or no extra (economic) cost by the application of ingenuity (the core skill of an engineer) to refine engineering solutions to deliver multiple benefits (Rogers, 2018). The need is, therefore, a liveable city infrastructure rating. This might be based on several parameters such as: resilience; low carbon; sustainable resources; flood resilience / alleviation; coolness; beauty; connectedness; social / health space; and collaborative commons. There are many such factors and therefore a selection and refinement process that reflects the urgent needs of a city would also need to be included, following a detailed diagnosis of a city's current challenges in its own unique context (Leach *et al*., 2018). In this light, the key performance indicators (or 'parameters') relevant to that city's journey towards sustainability and resilience should be chosen from a comprehensive array such as that in the Liveable City assessment methodology (CityLIFE$_1$, which contains 345 city performance parameters covering the complete range of liveability perspectives; Leach *et al*., 2017).

These approaches reflect dissatisfaction with the way in which the economic system directs investment. This dissatisfaction extends to some of the tools used in trading infrastructure assets on world markets, such tools as Arbitrage Pricing Theory (APT), a model developed in 1976, and on examination seems wholly inappropriate for any investment strategy, let alone critical infrastructure.

## 6.4 Arbitrage Pricing Theory

Global finance and insurance systems are worth $trillions and are becoming increasingly regulated, risk adverse and modularised. This is primarily as a response to the 2007-08 global financial system crisis: major financial institutions collapsed, the interbank market froze, the price of crucial financial assets fell sharply, and default rates skyrocketed. This crisis has been described as “self-harm caused by over exuberance within the financial sector itself’’ (Haldane & May, 2011, pp.351).

One key driver to collapse came from the growth in derivative markets; particularly the method in which complex derivatives were valued through arbitrage pricing theory (APT). APT allocated a price on future risks, permitting trade in increasingly complex derivative contracts – referred to as ‘asset bundles’ – with risks apparently decreasing as the bundles grew. APT makes several assumptions: ‘‘perfect competition, market liquidity, no arbitrage and market completeness’’ (Caccioli et al., 2009).

Moss (1976) developed this theory as a replacement of the mean variance capital asset pricing model, since Moss felt that this model was too restrictive for modern investment purposes. The optimum investment is one with zero risk and so to achieve a mean variance of zero an assumed zero beta portfolio factor was applied. The effect of this approach was to depress the perceived likely rate of return, whilst reducing perceived risk. However, the model helped investors find a perceived low risk environment into which funds could be

placed. In effect though, Moss had developed a model that highlighted higher risk for better return and then reduced that risk when it was bundled into a collective portfolio. As the bundles of risk grew the perceived risk level diminished and as the portfolio was spread over many markets, the perceived risk dropped further – well in fact risk became zero. As Caccioli points out, this works in the short-term and as long as no one else is doing the same thing. During the period 1963 – 1978, APT had a reasonable correlation with actual asset pricing, enabling the selling and buying of assets in different economies at the right time to make a profit. However, oblivious to the assumptions and flaws of the model, banks and investment houses all over the world took up the arbitrage model with increasing enthusiasm and by 2007 APT formed a key component of the largest global financial crisis on record.

Using APT and the theory of risk neutralisation (Arrow and Lind, 1970), financial institutions have developed on a massive scale, specializing in the screening of individual projects and raising funds building on their expertise and their prominent status in the infrastructure arena. Examples include the World Bank, and the European Investment Bank, supported by a multitude of other infrastructure investment companies. The scale of such lending activity is huge, countercyclical, and is backed by the ability to issue bonds with a modest risk premium. These risk-pooling mechanisms have accumulated large project portfolios and tend to equalize risks among them (Clifton *et al.,* 2014). Some argue that it is only a matter of time before another financial collapse takes

place as infrastructure investment risk begins to materialise across several markets.

APT enables global trade in the financial aspects of infrastructure capital debt and operational revenues. Many investors expect returns exceeding 10% / year; many investors are not prepared to look at returns that might be lower, might take longer, or might be lumpy (uneven revenue streams). Investors are also used to seeing a high rate of return for a relatively low level of risk, spread out over several portfolio markets. Innovative infrastructure simply does not show this pattern of return.

Under this type of economic theory, and using these types of asset pricing models, what types of infrastructure will get investment? They are generally implementation programmes or projects that support GDP measures and short-term financial return, albeit significant infrastructure programmes do require longer-term return periods on investment; the risk formulae presented pre-determine acceptable infrastructure portfolios.

With so many options for developing infrastructure assessment and investment in a manner that aligns with, as a minimum, the UN SDGs, as highlighted in Section 6.3, it would be very useful to evaluate one of the main infrastructure investment tools used in the UK – the HM Treasury Green Book (HMT, 2018) appraisal process. This process offers scope to move investment towards more

liveable, sustainable and resilient infrastructure, yet as can be seen in the next section, there remain some fundamental flaws in its approach.

## 6.5 HM Treasury Green Book Appraisal Process – Investment Decisions in the Current Economic Paradigm

In spite of a developing ambition to encourage investment in sustainable infrastructure, significant funds nevertheless continue to be directed into contradictory infrastructure investments; in effect the existing economic environment has created a series of obstacles that pre-determine the majority of funding decisions towards traditional projects governed by economic benefits and therefore inhibit the ambition. A brief overview of HM Treasury Green Book (2018) illustrates the way in which the current economic paradigm works to influence investment decisions.

The Green Book states that appraisal is the process of evaluating all impacts – social, economic, environmental, and financial – to be assessed relative to continuing with what would have taken place in the absence of intervention, referred to as 'business as usual'. The appraisal is there to help decision-makers understand the impacts and trade-offs of an investment decision. A business case is prepared considering five dimensions:

**Strategic** – outcomes secured compared to non-intervention or 'business as usual'.

**Economic** – the stated focus is the social value to the UK, although the impact on different groups of people or parts of the UK is also factored in.

**Commercial** – procurement and commercial (contractual) arrangements.

**Financial** – the impact on the public sector.

**Management** – factors required for the successful delivery of the proposal, including risk.

The justifications for Government intervention are strategic objectives, improvements to existing policy and addressing market failure or distributional objectives that the Government wishes to meet. Market failure is further defined in some detail as factors that distort economic efficiency. What is this economic efficiency that the Government has determined needs to be maximised?

### 6.5.1 Economic efficiency and the Green Book

Economic efficiency implies that all resources are optimised for perfect allocation to meet the needs of the population, whilst minimising waste and inefficiency (Anderton 2015). Once an economy has reached a point of economic efficiency, increases in consumption in one region or in a specific product would result in harm to another region or an individual's ability to have access to a product. Perfect economic efficiency is unlikely to be realised so the efficiency of the market is estimated as the difference between the notional perfect efficiency levels and reality. This is shown in Figure 6.2 (Goodfellow-Smith *et al.*, 2019b), which illustrates the practice of resource allocation using the 'production possibility frontier' relationship for an economy that is balancing an urgent need for housing infrastructure with the requirement to produce large gold-plated vehicles. Point A denotes housing and gold-plated vehicle allocation

of resources and is described as economic inefficiency. Housing production can be increased to B without damaging the ability to maintain production of gold-plated vehicles, while the equivalent increase in gold-plated vehicle production without increasing housing production would allow expansion to point C. The shaded blocks therefore describe the inefficiencies in resource allocation in an economic system. Any point of production that touches the production possibilities frontier blue line has reached a point of economic efficiency. In reality the perfect alignment that the invisible hand of free market forces is best placed to secure is never attained.

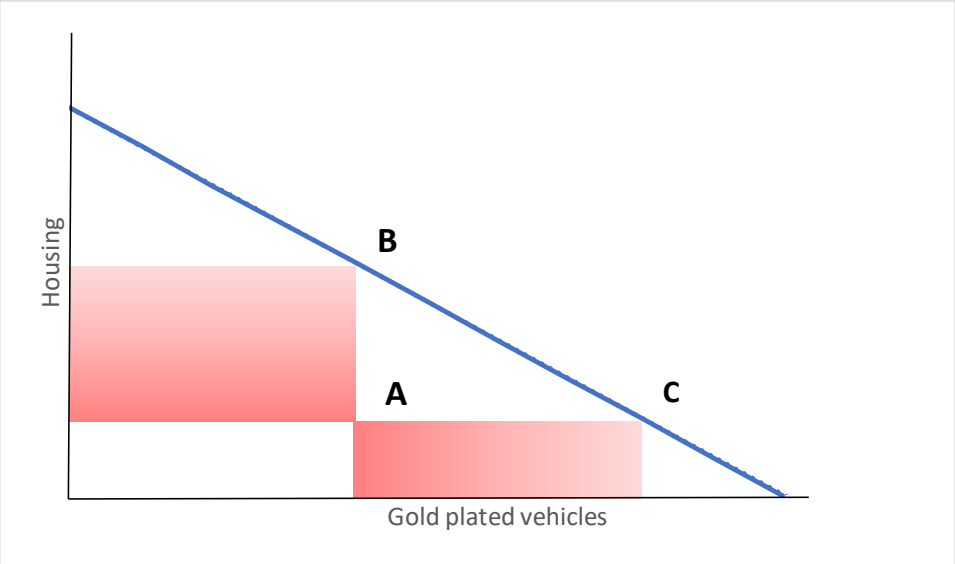



**Figure 6.2:** Economic Efficiency and the Production Possibility Frontier. Source Goodfellow-Smith *et al.* (2019b).

Estimating economic efficiency might be relatively easy at say a village level. X hectares of land can be used to produce y tonnes of food, wood, animal fodder, human accommodation and recreational value and managed in a way to

produce clean water, oxygen and other essentials for all those in the village on a sustainable basis. The equation becomes vastly more complicated over an expanding spatial area and over time, to the point that it is extremely difficult to constrain economic efficiency by access to resources for a specific economy, as resources can be obtained from anywhere in the world if the price is paid. But as world-wide levels of resource become scarce, society's ability to allocate resources requires the moral conditions of economic efficiency to be understood, implemented and complied with (Shultz, 1950). Shultz argues that economic efficiency with the absence of externalities can only be achieved by coordinated social behaviour based on norms held in common; only in this way can harm be prevented.

The current level of economic efficiency is illustrated in Figure 6.3. (Goodfellow-Smith *et al.,* 2019b). This situation illustrates that over consumption by some leads to a set of massive inequalities. For a small number to enjoy overconsumption, the rest of society is burdened with externalities; externalities of pollution, ill health and climatic change, amongst many. The current situation can be described as catastrophic economic inefficiency.

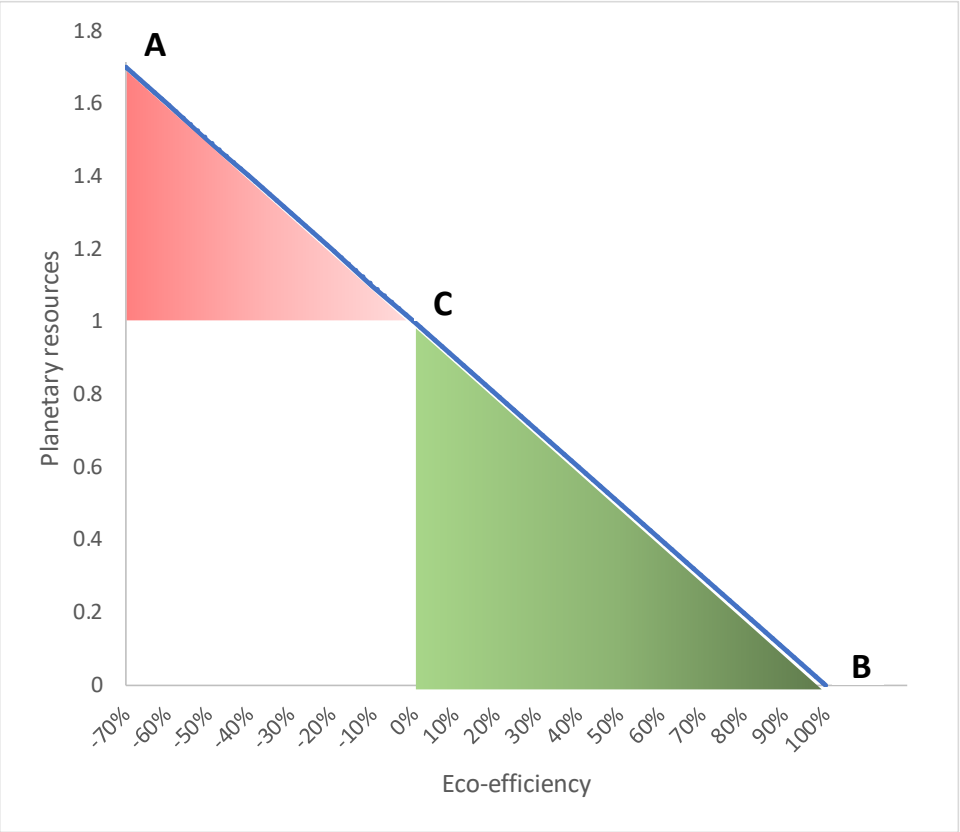



**Figure 6.3:** Catastrophic Economic Inefficiency and the Production Possibility Frontier. Source Goodfellow-Smith *et al.* (2019b).

Point A represents the current level of economic inefficiency where we use 1.7 planets' worth of biocapacity each year – therefore depleting the stocks of renewable resource and the ability of natural systems to render pollution harmless (Global Footprint Network, 2017; Overshoot Day, 2018). Point B represents a fully restorative economic efficiency. Point C represents sustainable use of planetary resources. In simple terms the current economic system is 70% inefficient.

Therefore, when the Green Book states that assessment should include means by which the Government can invest in economic efficiency, the assessors must look to the moral conditions that the Government stipulates on behalf of UK

society. A set of high level objectives, integrated into the Green Book assessment that support the deployment of restorative infrastructure would of course result in substantially different approaches to that evidenced at present. At present an investment that increases carbon emissions or toxic pollution in an area is only mitigated, not eliminated. There has never been a Government investment yet that has been 'Net Positive' (Aeron-Thomas & Le Grand 2015), let alone restorative. Although the Net Positive concept proposes a process of putting more back than taking, restorative economics requires programmes that restore natural and social capital to an established baseline (Cunningham, 2002). And if the UK Government applies climate emergency thinking to the Green Book, then it could provide a very powerful tool in accelerating deployment of liveable, sustainable and resilient infrastructure.

If the moral conditions for investment in economic efficiency included the right of all people to have clean air, then no vehicular infrastructure would be approved that allocated a heavier pollution load on one group of people than another. That pollution would be eliminated or absorbed through green infrastructure or pollution absorption / filtration technology before harm could take place – a form of 'distributive efficiency', first advocated by Lerner (1944).

It can be argued that for the Green Book to help in achieving real economic efficiency, a set of absolute limits to resource consumption and pollution emissions are required, supported by clear moral conditions of economic efficiency that are agreed by society. There is no evidence that the use of the

current Green Book approach will enable radical transformation towards liveable, sustainable and resilient cities. Yet this is just one fundamental obstacle to achieving investment in sustainable infrastructure. There are many; so many that they constitute the veritable 'valley of death' for sustainable infrastructure.

## 6.6 A New Paradigm of Restorative Economics

Building on the research needs identified above, there is a pressing need for a restorative approach to economics and development. One indicator of the urgency of the situation now faced might be Earth Overshoot Day. If we push past a set of ecological ceilings we are in overshoot. Earth Overshoot Day – the date when we have used all the renewable natural resources that the planet can replenish in a year – was August 1st, in 2018; August 3rd, in 2017; August 5th in 2016; August 19th in 2009; and September 30th in 1999 (Global Footprint Network, 2017; Overshoot Day, 2018).

Raworth (2017) has proposed what she has termed the 'Doughnut Economics' approach (Figure 6.4). Raworth describes a set of social boundaries or rights that all people should enjoy. They are energy; water; food; health; education; income and work; peace and justice; political voice; social equity; gender equality; housing; and networks. If we do not provide the basic needs for all in these areas, we have a shortfall in benefit distribution around the world. Raworth is arguing for 'distributive economic efficiency' (Lerner 1944). Moreover, these benefits need to be provided within environmental boundaries,

which are: climate change; ocean acidification; chemical pollution; nitrogen and phosphorous overloading; freshwater withdrawals; land conversion; biodiversity loss; air pollution; and ozone layer depletion.

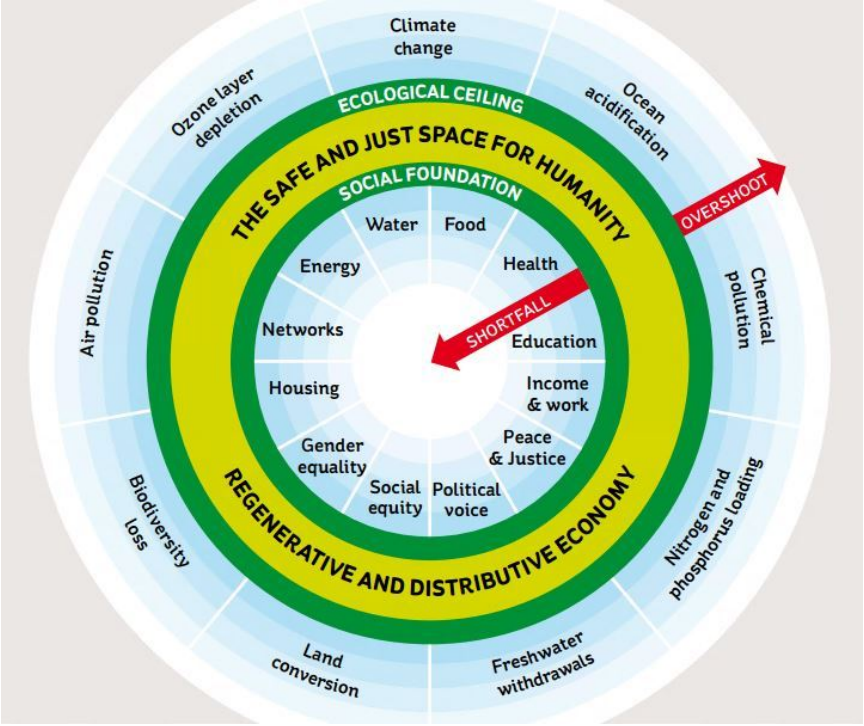



**Figure 6.4:** The Safe and Just Space for Humanity: Source Raworth (2012).

If human consumptive behaviours breach these boundaries, then governments need to intervene to correct behaviours that are causing boundary breaches nationally – a set of moral conditions for economic and eco-efficiency are required. A sense of global collective responsibility also needs to be engendered to secure a true commitment to sustainability, resilience and future generations.

Another important approach to understanding the systemic connections between multiple types of activity, value, and wealth is the Five Capitals Model (Forum for the Future, 2000). In this model, Manufactured Capital and Financial Capital are placed within Social Capital and Human Capital, which in turn are placed within Natural Capital. Without natural capital, all other capitals will ultimately fail. These five forms of capital can be defined as follows:

**Natural capital** – the natural resources and processes provided by the Earth's life support systems, such as water, clean air, soils and carbon sinks.

**Human capital** – the individual potential for personal growth and collaborative relationships amongst communities.

**Social capital** – the value added to the economy through community and individual relationships.

**Manufactured capital** – the economic output of a system that includes buildings, infrastructure and technologies.

**Financial capital** – the assets that can be traded and includes currencies.

To the five capitals model a further two capitals need to be added, illustrated with Figure 6.5. **Restorative capital** allows value to be derived when infrastructure restores the functionality of key natural and social systems. **Regenerative capital** allows value to be derived when infrastructure enables increased and sustainable activity (Mang, 2001).

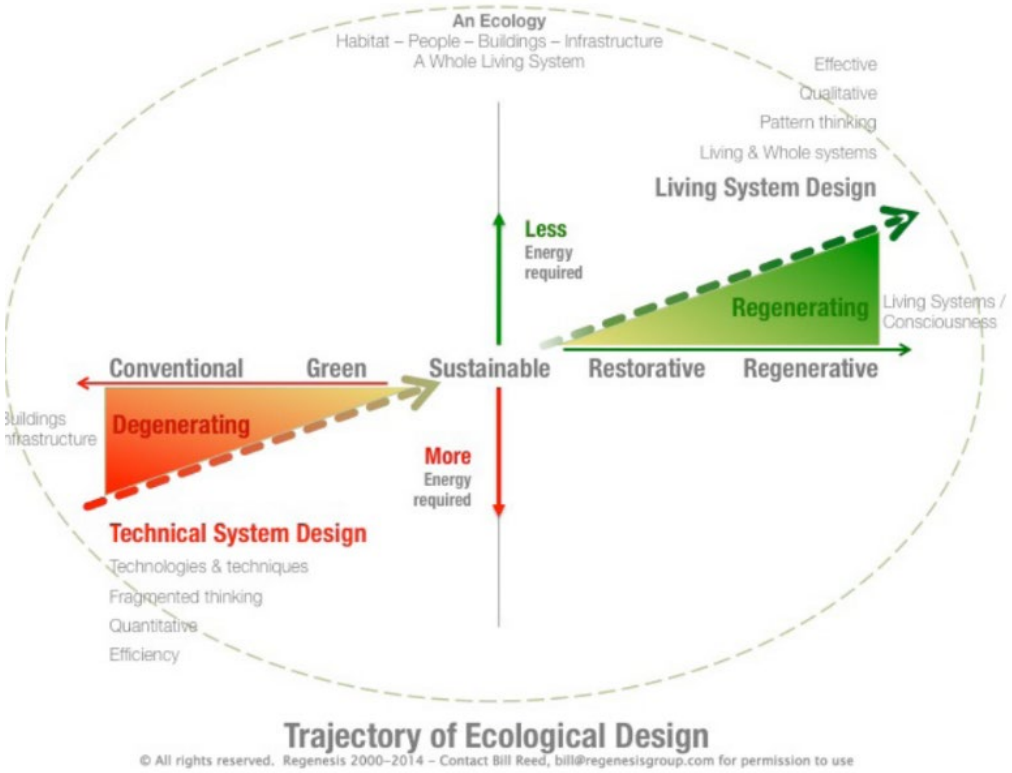



**Figure 6.5:** A Regenerative Approach to Infrastructure Provision. Source: Mang and Reed (2013). Permission Bill Reed.

Regeneration is understood and implemented as a process of growth in an upward trajectory and restoration gives direction to that growth, attaining or protecting a set of sustainable indicators or returning a systems functionality to one that sustains use within planetary boundaries.

Investments in infrastructure should therefore evaluate all the above capitals and their interdependencies and derive value from regenerative capital, leading to full restoration of natural and social capital. Such an integrated and holistic approach to value capture would measure manufactured capital value of infrastructure and the net gain or loss of all other capital impacts. If the

infrastructure provides capital gain, across the spectrum, that is the correct infrastructure investment to deploy.

In determing what city infrastructure should seek to achieve, an objective must be to improve social and natural capital. Restoring social and natural capital requires an agreed baseline for restoration activities to redress and it requires an accepted set of social conditions to be implemented. An assumption is made that a Liveable City (LC) is an attractive objective. To establish whether city infrastructure improves a social or environmental condition (liveability) the city will need to establish: the current state of liveability against agreed criteria; the city contribution to restoring living conditions to within a planetary limit or social condition; and the required numerical expression of the state to which the city wishes restoration to take place.

A restorative programme would need to quantify current City Liveability (CL) as described above and the existing rate of CL deterioration (CLd) or CL improvement (CLi). Simple measures could be used – open space, number of trees, air quality, carbon emissions – and used as headline indicators; or far more complicated sets of data can be used, such as The Thriving Places Index (Happy City, 2017) and UK CityLIFE$_1$ (Leach *et al.*, 2017). These more complicated measures can be used in developing policy and infrastructure interventions as well as communicating a more holistic reflection of how city infrastructure can move the city towards a higher liveability index.

There are some counter arguments to the whole idea of restorative policies for city futures. For example, the author of this thesis worked with Unilever on a programme called Sustainable Water and Integrated Catchment Management (Unilever, 2001). After a survey of catchment management plans for about 100 catchments worldwide, a debate focussed on the fate of the Murray-Darling Basin. The state of this basin was so bad that many felt the process of complete resource use should be pursued to relieve pressure on the adjacent basin. The quality of life for humans and all other fauna and flora in the Murray Darling basin could be sacrificed for the benefit of the adjacent areas. For the purpose of this research, restoration of all cities, regional land and water scapes is retained as the basic principle for policy direction.

Although Raworth (2017) does not use the term, one might envisage an ‘Entrepreneurial State’ (Mazzucato, 2015) intervening to ensure we create a ‘restorative economy’, one in which state interventions restore ecological boundaries and create sustainable enterprise to meet the needs of a stable world population. These interventions would be focussed at those points in the deployment of innovative and sustainable infrastructure that are lagging; those caught in the various ‘Valleys of Death’ along the route to full product / service / infrastructure deployment.

Therefore, to accelerate the introduction of assessment tools that assist in overcoming the Valleys of Death, an adaptive macro-economic policy such as

an approach defined and promoted by Mazzucato (2015) – 'The Entrepreneurial State'– is needed.

## 6.7 The Macro-Economics of the Entrepreneurial State

Keynes in The End of Laissez Faire (1926, p.46) stated of Government macro-economic policy: "The important thing for Government is not to do the things which individuals are doing already, and to do them a little better or a little worse; but to do those things which at present are not done at all". This is at the heart of the approach that Mazzucato (2015) promotes based on experience of USA Government: massive financial and policy intervention at the most uncertain stages in innovative infrastructure development to ease the innovation towards the point at which the private sector investors felt brave enough to put their money in.

The narrative for some time now has been that government is bureaucratic, slow and incompetent, whereas industry and commerce are fast, reactive, risk taking, innovative and clever. Mazzucato believes that the opposite is true. Her contention is that this image has been used to downsize the state through an increased number of activities being outsourced – in effect "chopping away at the very brains of the State" (Mazzucato, 2015 p.4) – leading to a depletion of intellectual resource and ability to build internal competencies and capabilities.

Getting governments to think big again about innovation is not just about throwing more taxpayer money at more activities; it requires fundamentally

reconsidering the role of the state in the economy. Mazzucato believes that the fundamental shifts required are as follows:

- Empower governments to envision a direction for a technological change and invest in that direction.
- Abandon the short-sighted way in which public spending is usually evaluated.
- Allow public organisations to experiment, learn and even fail.
- Establish ways in which government and taxpayers reap some of the rewards from success.

This reinforces, and in many ways crystallises, the findings on future city thinking that have emerged over the past five years (Rogers *et al*., 2014; GoFS, 2017a, b), which provides the evidence base for making this change, and crucially helps to put into place the final piece(s) of the jigsaw in the sequence described by Rogers (2018): engineering all of the forms of governance to enable the new business models to work. The role of government in strategic intervention is one of risk taker or perhaps as an instigator of significant change. Government should be given credit and reward when investments help achieve significant objectives. This is 'The Entrepreneurial State' – 'The Adventurer' (Say, 1803).

The State must lead by creating new markets – the new 'techno-economic paradigm'. Government not only invests in the risk phase of new technologies,

but can stimulate the market through specific contracts to utilise cutting-edge technology and in subsidies to get technology into the marketplace quicker. However, if Government plays an inconsistent role, the results can be devastating. In the UK the Government provided incentives for solar installations, and then switched them down and then switched them off. The result was a 'boom and bust, and die' industry, with over 12,500 jobs lost in 12 months (STA & PwC 2016).

Mazzucato's view of state intervention is one of vision and massive intervention at the riskiest point (briefly equating this as the Valley of Death). The key features of the VoD that Wessner (2005) identified would be addressed: attention would be focussed on securing critical outcomes that would make the investment attractive – resilience, pollution reduction, biocapacity increase and a reasonable financial return would be achieved; clear calculation of variable risks would be made available quickly; a clear route to appropriate finance and business models would be mapped; the linking of city aspirations (Rogers and Hunt, 2019), city technical know-how and infrastructure innovation would be well resourced; and the finance and insurance sector would be supported by public bodies in securing the finance risks.

Moreover, when Government intervenes, rewards should be channelled back to Government and to the taxpayers. A macro-economic policy has Government as the entrepreneur, the adventurer, taking society forwards into a new paradigm. That paradigm must be one that avoids the damage caused by the

current economic paradigm. In fact, a new paradigm might be one that restores vital social and environmental systems across the globe.

## 6.8 Summary

Whatever tools are devised to assist in improving infrastructures' contribution to liveable, sustainable and resilient cities, the research interviews conducted and analysis of approaches used across the world during the course of the author's research, highlight that the Valleys of Death to innovation and sustainability can be overcome by the following interventions:

- systematically analysing the number, type and severity of the VoD across the sustainable infrastructure deployment line
- identifying appropriate interventions to remove, lessen the impact of or speed progress through the VoD
- supporting the United Nations in its endeavours to develop a financial system and economic model that is more appropriate to the needs of a planet rapidly approaching systemic breakdown
- prevent the use of out of date economic tools, such as Arbitrage Pricing Theory
- use the principles of Production Possibilities Frontier: economic efficiency to measure the reality of the current economic system's inefficiency
- use appropriate economic measures in assessment methods, such as the Green Book (HM Treasury, 2018)

- deploy the economics of regeneration and restoration
- enable an entrepreneurial state to tackle the VoD for liveable, sustainable and resilient city infrastructure.

These activities form the next stage in preparing a **Li**veable, **S**ustainable, **R**esilient and **I**nvestment **R**eady **C**ity portfolio – **LiSRIRC**, shown in Figure 6.6.

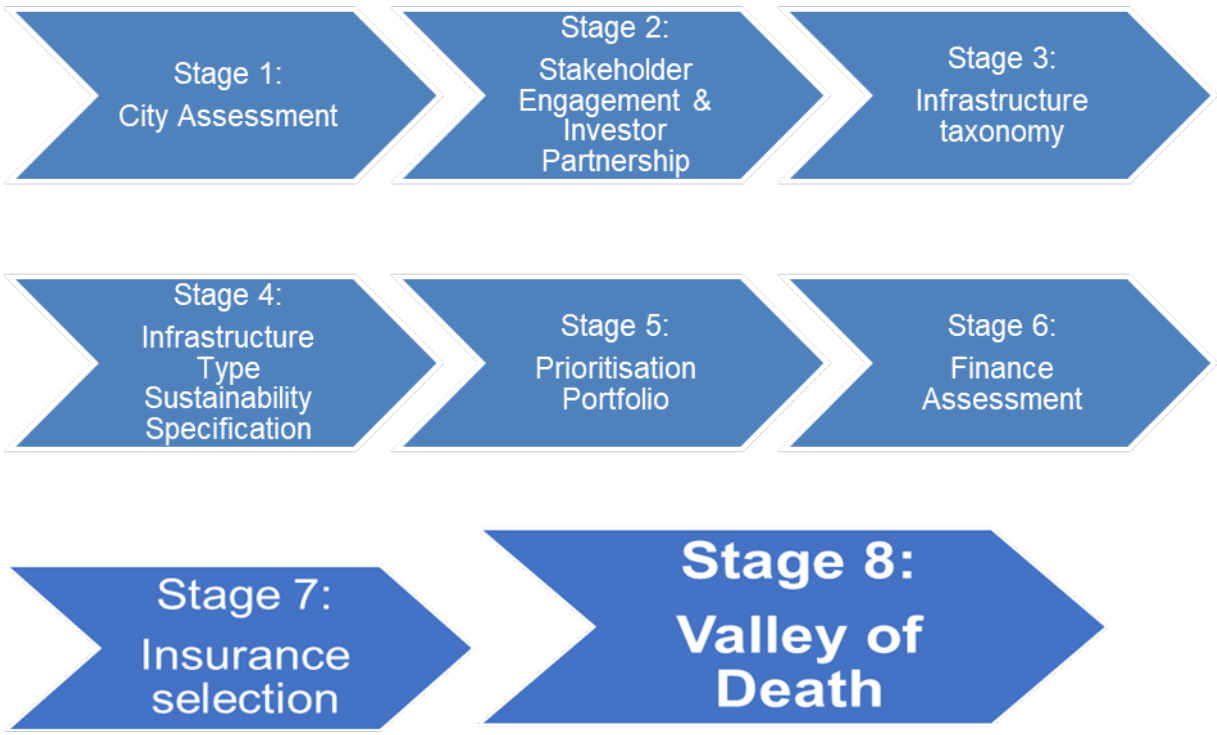



**Figure 6.6**: **LiSRIRC** – Stages 1 – 8.

Chapter 7 explores the practical way LiSRIRC can be integrated with and add value to existing infrastructure management approaches.

# 7. A ROUTE MAP TO IMPLEMENTING SUSTAINABLE INFRASTRUCTURE

## 7.1 Introduction

As important as it is to try to find ways that will improve liveable, sustainable and resilient infrastructure, it is imperative to find the right method to deploy any new approaches. Infrastructure projects are complex, difficult and subject to much scrutiny. Massive financial mistakes (Crossrail – NAO, 2019), and even more serious, significant loss of life (Grenfell – UK Government, 2018), mean that infrastructure project managers are under pressure to perform well and deliver on all milestones, probably more than at any time in history.

In this context it can prove to be very useful to find ways in which to sensibly integrate new approaches into existing infrastructure project management approaches. To this end, this chapter provides a brief review of the Infrastructure Project Authority's Project Initiation Routemap (IPA, 2016), and the Institution of Civil Engineers' – Risk Analysis and Management for Projects (RAMP, ICE 2014). As it is city infrastructure transformation that this thesis hopes to contribute to, correlating the implications of this research with the report 'How to transform infrastructure decision-making in the UK' (IfG, 2018), and the National Infrastructure Commission Annual Monitoring Report (NIC, 2019) will help clarify the practical integration aspects of this research.

“Project management is the application of processes, methods, skills, knowledge and experience to achieve specific project objectives according to the project acceptance criteria within agreed parameters. Project management has final deliverables that are constrained to a finite timescale and budget” (Association for Project Management, 2019). Project management is a complex interplay of technical tasks; social, economic and environmental considerations; team and individual management; and timescales, resources and desired outputs. Add to this politics, the profit motive and scale and it becomes understandable that mistakes can be made. Indeed, according to the Institute for Government (2018), the UK consistently makes poorer decisions about infrastructure than many competitor economies, particularly in the areas of time, quality and cost. The recommendations of this report will be reviewed and correlated with this research in Section 7.4.

## 7.2 Project Initiation Route Map

The Infrastructure Project Authority (IPA) was established in 2016 as the UK Government’s centre of expertise for project development and delivery. The original focus concentrated on the project initiation and now extends across a range of modules – requirements, governance, procurement, execution strategy, organisational design and development, risk and asset management. The IPA (2016) claims success in over twenty major projects to date.

The IPA routemap is itself designed to overcome some of the common mistakes in UK infrastructure delivery reported by a Cabinet Office review (NAO, 2012), which highlighted several critical factors including:

- lack of clarity on success criteria
- lack of clear management and leadership structures
- poor engagement with stakeholders
- proposals evaluated on initial (sometimes very early) price and not long-term value
- poor integration of different teams, work packages and planning

Over-optimism was another frequent cause of project management failure (NAO, 2013).

In response to these criticisms the IPA routemap adopts an approach that establishes the complexity and context of the delivery environment; scopes the current capability of partners / contractors and the desired capability requirements; and finally determines how to fill the capability to complexity gap. A question and grading approach to complexity and capability is employed by the participants. There is no integrated mention of using facilitation or independent assessment / audit. This is a fundamental flaw that is highlighted using a Crossrail case study (IPA 2016, p.20), where the supposed rectification of a lack of capability in decision-making had been put in place. On p.37, different assessment strategies are mentioned, but the use of independent

assessment is hedged in terms of potential costs. As it now transpires, decision-making ability did not improve at Crossrail; perhaps independent assessment at an early stage would have drawn out many of the issues that the NAO (2019) Crossrail report has described. The alignment stage is to address any capability gaps identified when assessing complexity. This is a comprehensive planning and diagnostic tool, capable of being used at regular intervals through the project cycle to ensure that mitigation activities still represent changing complexity / capability requirements.

The focus is clearly on project management initiation of a defined project, so the key initial stages of **LiSRIRC**, as developed in this thesis, are not covered by this project management system. However, the outcomes of employing the **LiSRIRC** process would contribute core material into the analysis of complexity – for example in the sections dealing with strategic importance, stakeholders, requirements / benefits, financial impact and value for money.

In these terms **LiSRIRC** is clearly a policy and portfolio tool that delivers substantive information for the complexity analysis of infrastructure projects in six key areas.

One of the additional modules that supports the Routemap is the ‘Risk Management Module’ (IPA, 2016). This provides an excellent review of two main approaches to identifying and quantifying risk. The module is consistent in stressing that risks need to have appropriate contingencies made available, with

different controls as determined by the partners. Insurance is not mentioned apart from a brief aside in a table on p.17. In managing the risk component of an infrastructure project, it seems that the financial implications of dealing with risk are factored into the Routemap risk management component. However, managing those risks through appropriate insurance products and re-assessing finance and insurance clauses to ensure that risks identified are covered effectively and efficiently are just not being made. There is therefore a strong rationale to add components of the **LiSRIRC** approach to the initial assessment of financial and insurance sources and products, with an ongoing review of the financial implications of emerging risks, not just in terms of mitigation cost, but also in terms of additional finance and insurance costs.

The IPA risk management module also cross-references (p.14) to the Institution of Civil Engineers 'Risk Analysis and Management for Projects' (RAMP) process.

## 7.3 Risk Analysis and Management for Projects (RAMP)

RAMP is a framework for analysing and managing the risks in all kinds of projects with an emphasis on financial and strategic aspects (ICE, 2014). In addition, RAMP looks at overall project risk at an early stage and therefore is useful in determining whether alternative projects would better suit the context or organisational goals, budget or other influence. RAMP promotes further benefits of using the system including whole life through processes, more

consideration of risks at conception / planning and design, and reduced contingency as risks are actively managed in a comprehensive manner.

On p.14 of the framework introduction is a very useful table that begins to highlight future best practice in risk management. Several of the comments relate to integrated teams, regular risk reviews, regular challenge of assumptions and financial risk analysis, all aspects that **LiSRIRC** advocates in developing finance and insurance provision. Particularly RAMP advocates that a series of risk and financial scenarios are developed and reviewed on a regular basis; this is also an important feature of the finance and insurance selection process advocated by the research presented in this thesis.

Although the RAMP process is heavily weighted to analysing risk and then placing a financial figure on the mitigation route, it fails to ask the questions about how this might relate back to the release of finances and what costs are incurred with the use of contingency funds. P.59 – 60 does ask relevant questions about whether insurance cover has been selected to cover the most significant risks, but does not relate insurance to additional costs, what type of insurance would best suit the project, what practices certain insurance products encourage and what costs are associated.

A powerful concept developed within RAMP is to ensure a comprehensive and well documented overall project risk register. This should be reviewed on a regular and continual basis, not only to ensure risks are being managed but to

review potential opportunities for the project through innovating out of risk. This might generate new products and new ways of working.

This harmonises with the approach to finance and insurance selection advocated through the **LiSRIRC** process, in which providers are selected on the basis of the approach to the project and the encouragement of innovation that might deliver more liveable, sustainable and resilient infrastructure outcomes.

RAMP also lists the potential risks of an infrastructure project, p.133–134. Several of these relate to financial impacts. This is another useful feature that focusses the risk manager and can help stimulate deep thought about other areas not covered. However, this list of risks fails to include siloed working practices, liability fear, blame culture and other frailties of current onsite construction practice.

RAMP would provide a useful framework in testing the viability of projects developed within the **LiSRIRC** process. By running the scenario evaluation (p.104) with potential risks for each project as early as possible, prioritisation can be based on risk and the financial implications of dealing with those risks.

## 7.4 The Institute for Government (IfG) and National Infrastructure Commission (NIC)

In ‘How to transform infrastructure decision making in the UK’ (IfG, 2018), three critical elements for transformation are highlighted – time, quality and cost.

### 7.4.1 Time

The IfG suggests that the UK Government is slow in making decisions on infrastructure and slow in securing stakeholder support. By strengthening the NIC and creating an office of public engagement, infrastructure decision-making could become more effective.

The **LiSRIRC** process provides an effective means to create local / city / regional infrastructure portfolios. Using participative processes, participative budgeting and early engagement of risk / insurance professionals, an investment ready portfolio can be developed and made available to the NIC to adopt as part of a national framework as appropriate.

### 7.4.2 Quality

A range of potential projects should be created into a portfolio from across government departments and from sub-national authorities. The capacity and capability of sub-national authorities is questioned. Cost benefit analysis, cost and time estimates, and project assessments need to be far more consistent. Decision-making should be transparent, and open to peer review and Parliamentary challenge well before initiation.

The **LiSRIRC** process provides an effective means to create local / city / regional infrastructure portfolios. The IfG identifies the issue of re-building sub-national authority capability to manage infrastructure projects, an issue identified as imperative in the development of the **LiSRIRC** process. And in

providing project assessment, the IfG singles out inadequacies in the Green Book (HM Treasury, 2018). **LiSRIRC** calls for a realignment of the Green Book with the UN SDGs, regeneration and restoration. Peer review, audit and independent assessment are all issues that need to be added into the management of infrastructure, highlighted by both the IfG and the research into developing **LiSRIRC**.

### 7.4.3 Cost

The IfG concludes that in the UK, cost estimates are wrong far too often. It suggests that gathering data on cost outturns against estimates, delivery times against estimates, size of project teams and project duration should be managed by the IPA and that the data should form a mandatory component of project management. This is a sound recommendation although Flyvbjerg (2009, 2014) has already begun to develop such a data set. The IfG strongly suggests that the financial appraisal system needs systemic improvement with three key areas of concern – over-optimistic cost estimates, a bias towards private finance and ineffective negotiation and management of private finance contracts.

At the heart of the **LiSRIRC** process is a careful appraisal of the finance options for infrastructure, the cost initially and in reaction to changes during the course of the project, and the behaviours that are encouraged by the provider of finance and, of course, insurance too.

There are clear and powerful synergies identified in the recommendations of the IfG and the research that has led to the development of the **LiSRIRC** process described in this thesis.

The National Infrastructure Commission (NIC) in its annual report (NIC, 2019) has achieved a level of coherence and depth of study in infrastructure needs for the UK not previously seen. Over its short existence since 2015, it has pulled together strategic plans from sub-national authorities and combined these with national level strategic issues to create a costed plan to meet UK infrastructure needs. To complement this strategic level of infrastructure planning, the NIC would benefit from a robust process by which sub-national infrastructure projects are developed to support the national plan and in addition are developed to deliver the unique requirements at a sub-regional and local level. This need becomes very evident when exploring the detailed issues relating to just one major national level project, the Cambridge-Milton Keynes-Oxford Arc (NIC, 2019, p.11). Several of the issues that need local support are well behind schedule. The reasons are not identified but are likely to be related to capacity, finance availability and the release of funding to local authorities to manage these integrated infrastructure functions. These are all issues that the **LiSRIRC** process is designed to tackle, bringing in capacity from risk and insurance professionals and aligning potential infrastructure projects with several different types of investor.

## 7.5 A Routemap to Sustainable Infrastructure Initiation

**LiSRIRC** provides a process by which a portfolio of potential infrastructure projects can be brought together using advanced stakeholder participation and participative budgeting. Using the tools for finance and insurance evaluation, appropriate sources can be identified and quantified as determined by the outcomes required of each infrastructure project. Financial scenarios are required to be developed at an early stage to test some of the potential costs. These features all provide important information that could be used by the IPA Routemap, and support recommendations of the IfG (2018) and the NIC.

RAMP provides a comprehensive approach to risk analysis, with an emphasis on early conceptual analysis and ongoing, active risk management. This makes RAMP useful in adding a prioritisation filter to the **LiSRIRC** process before an infrastructure portfolio is put to the marketplace.

In terms of managing the infrastructure delivery, a combined IPA and RAMP framework is desirable. In terms of developing an infrastructure portfolio and preparing a prioritised infrastructure pipeline, then the **LiSRIRC** process fulfils some of the key recommendations of the IfG (2018) and supports the NIC (2019) request to Government for sub-national preparation of infrastructure plans to support national level investments.

**LiSRIRC** also aligns the investment and insurance approach with the UN SDGs (UN, 2015), promoting regenerative and restorative infrastructure analysis as a

critical approach that could be integrated into an updated Green Book (HM Treasury, 2018).

A simple routemap to sustainable infrastructure deployment is illustrated in Figure 7.1.

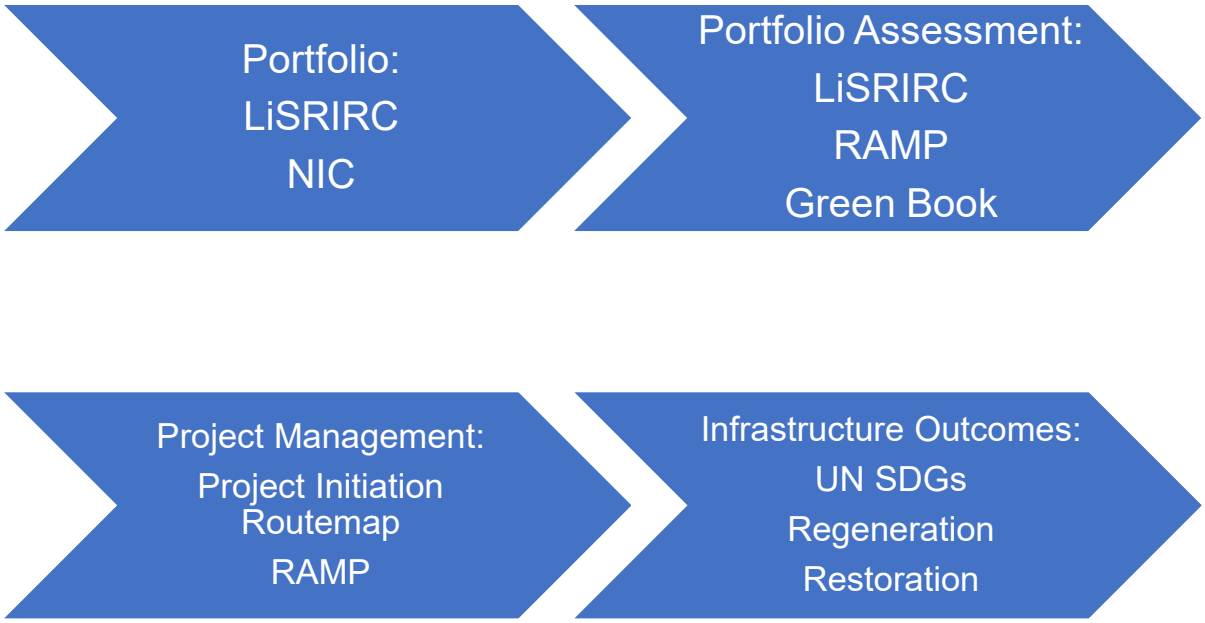



**Figure 7.1:** A Route Map to Implementing Sustainable Infrastructure

## 7.6 Summary

The recommendations of the IfG provide a firm foundation upon which to build the **LiSRIRC** process as a solution for many of the issues highlighted in its 2018 report. **LiSRIRC** is particularly suited to the development of a strong, citizen and partner development of a portfolio of investment ready projects that will fulfil sub-national infrastructure requirements and integrate with the NIC portfolio.

Integrated with RAMP and the Project Initiation Routemap, this forms the last stage in the overall LiSRIRC process depicted in Figure 7.2.

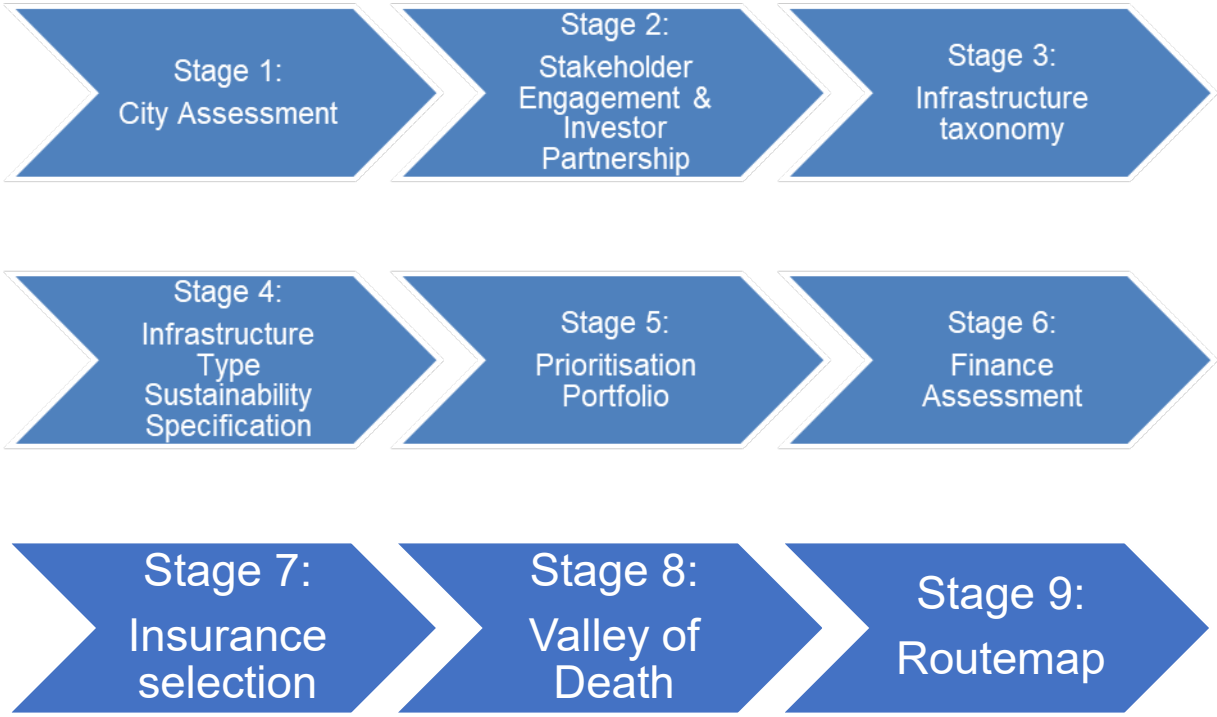



**Figure 7.2 LiSRIRC** – Stages 1 – 9.

# 8 CONCLUSIONS

## 8.1 Introduction

This is the conclusion to a doctoral study, but it feels like the beginning in instigating change in UK infrastructure provision. I sincerely hope that these findings will endure the test of time and that some will be adopted. The most challenging concepts are those that strike at the heart of knowledge and principle on economics that have grown relatively unchallenged, for nearly one hundred years. It is not the principle of economics that is wrong as outlined in the 18th century, but the way in which society has engineered a different motive in the beginning of the 20th century to that originally envisaged. Short-term profit motives now dominate and crush the original longer-term wealth creation and distribution principles set out in reasoned and I suggest, quite liberal terms.

Society has not lost the concept of infrastructure provision to give benefit to all but has decided that a poorly resourced, financially constrained and asset stripped local authority is the best means by which to deliver societal benefit – where there is no profit. Where infrastructure can provide profit, solutions for public / private investment partnerships have far too often left the public footing the bill for private sector incompetence and profit stripping.

However, this research highlights above all else that there is a powerful reawakening of moral imperative in the financial and insurance sectors, with

some corporate entities finding a sensible way to support this process and align with the UN SDGs.

Section 8.2 provides a summary of the key findings of this research. Section 8.3 describes the research contribution this work makes, section 8.4 lists the research limitations and 8.5 suggests potential areas of further research.

## 8.2 Summary Conclusions

The main aim of this research is to determine ways in which finance and insurance can be used most effectively to accelerate the deployment of sustainable techniques and technologies to create liveable, sustainable and resilient cities.

Finance is a powerful tool that has been diverted from its original intent for wealth creation and wealth distribution into a narrow concept of short-term profits, concentrating wealth amongst a few. In effect a direct contradiction of the original economic thoughts that are supposed to be the foundation of economic activity today. Concepts such as Arbitrage Pricing Theory and Production Possibilities Frontier have been used to establish a principle and then forgotten when activity no longer adheres to that principle. Unfortunately, this is having significant impact on the world's ability to maintain the very economic powerhouses, the cities that have been built up. There is now overwhelming evidence that city impacts are causing significant harm across the world and that this harm is accelerating as population concentrates,

increases in size and increases in demands. Innovation and material substitution are not keeping up with the pace of material demand.

World investments in renewable energy systems alone are US$ multi trillion off recommended levels. Developing the renewable energy systems of the future is compromised whilst subsidies into the fossil fuel system exceed US$6 trillion / year, dwarfing subsidies for renewable energy.

Yet a proliferation of benchmarking systems have now been developed to rank sustainability in cities and some are detailed enough to provide policy steers to cities to develop infrastructure interventions that will further sustainability ambitions.

The following conclusions are drawn from all the chapters in this thesis and arranged in sequence against the appropriate thesis objective.

**Conclusion 1.** Evaluating City Infrastructure for Liveability. Careful examination of many ranking systems leads to the conclusion that there are two excellent examples that fulfil different requirements: The highly visual Thriving City Index (Happy City, 2017) and the highly detailed, data driven approach created by the Liveable Cities programme team (UK CityLIFE$_1$; Leach *et al.,* 2017).

**Conclusion 2.** The common determinant in implementing both of the above evaluations is full and comprehensive stakeholder participation. This should

include active public participation in identifying the technologies and techniques that would meet their needs, developing the infrastructure projects that will transform people's lives and actively engaging in participative budget allocation. In effect, what the author describes as creating an investment ready city portfolio.

**Conclusion 3.** Citizen participation in allocating budgets to sub-national level infrastructure, supporting national level infrastructure where appropriate, is the most empowering and dynamic process engaged in by leading cities, such as Paris.

**Conclusion 4.** To support this process a taxonomy for investment is required. The basis of this is now being developed by the Climate Bonds Initiative (2018).

**Conclusion 5.** A taxonomy for investment should be supported by infrastructure sustainability specifications. The work of Zavadskas (2018) indicates that substantial activity on this is progressing on multiple fronts.

**Conclusion 6.** Finance and insurance investment needs a recognised, long-term and stable asset into which to invest. Infrastructure can provide this when developed by the citizen, aligned with an investment taxonomy (Conclusion 4) and when experts from the finance and insurance industries are engaged at the very beginning of the process of developing an infrastructure portfolio. Investor partnerships should be established at the city level.

**Conclusion 7.** Combining these steps (stages 1 – 5) together begins to form a process that the author has entitled **Li**veable, **S**ustainable and **R**esilient **I**nvestment **R**eady **C**ity (**LiSRIRC**) – an infrastructure portfolio.

These conclusions have been developed from research question: How to identify what needs to improve in a city? Leading to – **Objective 1:** Link city assessment tools with identification and prioritisation of infrastructure investment.

With massive investment in infrastructure required to avoid the worst impacts of climate breakdown, there needs to be a way of ensuring that every piece of infrastructure is sustainable (see above) and that the main mechanism for infrastructure delivery – the financing and insurance sector – meets sustainability criteria and avoids steering society into a hard-wired, fossil fuel-intensive infrastructure system.

**Conclusion 8.** A multi-criteria assessment of finance characteristics, including cost is required. Firstly because very few programmes have a consistent and detailed approach to evaluating finance costs and secondly because the issues of transition, carbon, vulnerability, stranded assets and missed opportunity costs, amongst other criteria incorporated into the approaches presented in Table 4.7 have not been effectively included in the financial assessment of infrastructure investments to date.

**Conclusion 9.** The process of assessing finance organisations and finance products should form stage 6 of the **LiSRIRC** process (Figure 4.9).

**Conclusion 10.** The insurance industry has long felt the pressures of climatic change and is now waking up to imminent climate breakdown.

**Conclusion 11.** Insurance companies have become major players in infrastructure investment.

**Conclusion 12.** Insurers should be selected as a supplier based on an evaluation of the product, the organisations' strategic approach and cost.

**Conclusion 13. I**nsurers are looking for the right type of sustainable and resilient infrastructure project to invest in. All parties engaged in an infrastructure project would benefit from an evaluation approach that conferred attainment of best practice when shown to be striving towards a level of performance that meets the criteria of the TCFD and the UN Sustainable Development Goals (SDGs; United Nations, 2015) and drives forward progress towards a restorative infrastructure. ['Restorative Infrastructure' includes impact minimisation, includes positive attributes and contributes to repairing damage done – environmentally, socially and economically.] Such an evaluation would provide a development partnership with several benefits:

- Identification of cost-effective products.

- Identification of products that match the development partnership's attributes and capabilities.
- A combination of product features and implementation practices that accelerates innovative deployment of sustainable methods and technologies.
- Appraisal of insurer performance in relation to the TCFD requirements.
- Appraisal of insurer performance in relation to the UN SDGs.
- Guidance / mentoring / enforcement of TCFD and UN SDG standards from the investors and insurers.
- Progress in developing an approach that delivers restorative infrastructure.

**Conclusion 14.** Insurance duplication in infrastructure projects wastes over £1 billion / year in the UK.

**Conclusion 15.** Typically, insurance is added into bids as a 2% overhead, although the reality of insurance cost relates to the deal struck with the insurance provider, the amount of business done each year with the provider, risk, management competency and site history. The percentage of construction cost / project to insurance premium can range from 0.1% to 6.0%, dependent on the above factors and the specific component of the project that a contractor is responsible for.

**Conclusion 16.** Insurance cost savings can be made on the blanket typical 2% insurance cost bid inclusion and on total insurance costs through different products and practices.

**Conclusion 17.** Siloed and defensive behaviours on infrastructure project sites lead to additional expenses and thwart innovation and shared values. Closer engagement with insurers and other site partners would lead to reduced costs, innovation and better project outcomes.

**Conclusion 18.** Insurers should be selected on the quality of their approach to UN SDGs and TFCD reporting. AXA, Aviva, Allianz SE, and Legal & General are leading the way in TFCD reporting. Tokio Marine, Legal & General, Credit Agricole, Allianz SE, Generali, NN Group, and Swiss Re are demonstrating the best annual improvements. These listed insurance companies are therefore recommended for use in providing insurance for liveable, sustainable and resilient city infrastructure.

**Conclusion 19.** In selecting an insurance partner when preparing a city infrastructure portfolio, the following criteria should be used:

- Alignment with the UN SDGs
- Reporting to the TFCD requirements
- Demonstrably effective innovation mechanisms and new products

- Willingness to participate at an early stage in the development of a liveable, sustainable and resilient investment ready city portfolio
- Understanding and executing a programme with ‘shared value’ at its core.

**Conclusion 20.** Historically insurance companies have incentivised certain standards and behaviours. The industry is developing climate and sustainability-related parametric and other new insurance products that should be encouraged and developed to the full.

**Conclusion 21**. Insurance companies should allocate personnel to engage in the early development of an investment-ready infrastructure project portfolio. This forms a critical component of **LiSRIRC (**Figure 5.1).

These conclusions have been developed from the following research questions. How does finance and insurance work at present in delivering city infrastructure? This led to – **Objective 2:** Define normative finance and insurance models for infrastructure build.

Is there a method available to evaluate finance and insurance options against infrastructure requirements and desired outcomes? This led to – **Objective 3:** Develop an appraisal and selection tool of finance and insurance products and providers that would support more liveable, sustainable and resilient city infrastructure.

Can the providers of finance and insurance be assessed against sustainability / best practice criteria to enable appropriate selection? Does selecting high performance sustainability rated providers lead to more sustainable infrastructure? This led to – **Objective 4:** Research and develop a set of criteria that would align an appraisal tool with sustainable outcomes.

**Conclusion 22.** There is a series of obstacles that influence infrastructure development and deployment bracketed together and herein termed the 'Valleys of Death' (VoD):

**Conclusion 23.** APT and PPF directed policy should be taken out of circulation as failed tools.

**Conclusion 24.** HM Treasury Green Book use of economic efficiency as a main driver for investment decisions needs rejection, as adherence to this approach has the following effect: catastrophic economic inefficiency. The current economic system is 70% inefficient (Figure 6.3).

**Conclusion 25.** Regenerative and restorative economics, based on planetary boundaries and social conditions, and the five capitals model need to be urgently implemented to speed liveable, sustainable and resilient infrastructure across the VoD, integrated into the Green Book.

**Conclusion 26.** Sub-national authorities need to have the capabilities and capacity to act as an ‘entrepreneurial state’.

These activities form the next stage in **LiSRIRC** (Figure 6.6).

These conclusions have been developed from research question: An effective tool is all well and good, but what systemic factors would enable liveable cities to be engineered at a faster rate? This led to – **Objective 6:** Define the economic paradigm and describe elements of city dweller engagement through which securing liveable cities could be enabled.

**Conclusion 27.** The **LiSRIRC** process encapsulates key recommendations made by the IfG (2018). It reflects expert knowledge gained through over 40 research interviews and harnesses the latest literature review. It provides the process by which a robust portfolio of projects can be assessed using the RAMP approach from Institution of Civil Engineers and managed through delivery phases using the Infrastructure Projects Authority Routemap and more detailed RAMP processes.

This conclusion has been developed from research question: Project managers are busy enough; is there an established management framework into which this entire process can be integrated? This led to – **Objective 5:** Propose an effective and practicable delivery approach for more liveable, sustainable and resilient city infrastructure.

## 8.3 Research Contribution

Infrastructure project management systems frequently admonish the idea that deep thinking time should be allocated to the project concept and design to ensure that the desired outcomes are achieved. Finance and insurance have simply been seen as a cost in that process. This research demonstrates that proper appraisal of finance and insurance can secure cost savings, but that, actually, it is the practices that can be encouraged, and indeed, mandated by investors and insurers, that will enable transformation of city infrastructure.

This research pulls together a number of disparate activities that impinge on infrastructure and places them into a process that will enable the creation of an investment ready city infrastructure portfolio, and integrates this process with established infrastructure project management tools.

The generation of a series of financial costs and strategic level benchmarks incorporating vulnerability, stranded asset cost, contradictory tax burden and missed opportunity cost are unique to this research. They provide a powerful indictment of current economic thinking and a powerful inducement to tackle climate breakdown and the requirements of a liveable, sustainable and resilient city.

Using established economic tools, this research demonstrates that adhering to them has, and will again, lead to catastrophic economic inefficiency.

## 8.4 Limitations

This research is proposing changes that on one level are straightforward. “Here is a system for appraising the costs of finance and insurance of an infrastructure project. If you use it well, there are savings to be made.” But on another level, some points of appraisal strike at the foundation of current thinking. For example, only companies that align with the UN SDGs and the TFCD reporting requirements should be used to provide finance and insurance. When evaluating the use of finance and insurance, does it and the infrastructure that is being constructed reduce carbon, reduce vulnerability, reduce the risk of stranded assets impacting on the local / regional / national economy and are missed opportunities now being realised? These are all strategic level questions, or factors, that have so far been marginalised and progress against addressing them is slow. It is therefore prudent to expect that this research will find its implementation tricky.

However, the signs are very encouraging. Finance and insurance sectors are re-aligning activity and at a very fast pace; the UK Government is realising that we are facing a climate emergency and has become the first country in the world to sign a legal agreement to reach zero carbon emissions by 2050. If these changes are to succeed, then this research could form a fundamental component to assist in the transformation in which infrastructure will play a major part.

One of the most significant barriers to this research reaching its full potential has been the failure to bring a research partner through to testing the system on a live project. The initial partner, WLEP backed out, a member of staff at Birmingham City Council became non-cooperative, even with senior level endorsement for involvement, and securing the interest of University of Birmingham staff was too late in the process to enable a meaningful test (although the support of UoB staff provided critical input to the research programme). Although this is clearly a limitation to the research, there was an upside. This was that more attention was paid to the wider practices that would enable improvements in infrastructure construction activity – particularly those associated with insurance.

## 8.5 Future Research

1. When consideration was given to testing the finance and insurance appraisal model, it became clear that the level of detail required was significant and that the factors that made up the appraisal would change as the project advanced and risks were more carefully analysed and managed. These variable factors were too complex to enable a meaningful test to be completed. Therefore, a research priority is to find an infrastructure project that would be willing to engage, pre-initiation, and test the system on that. Perhaps at Birmingham City Council or the University of Birmingham.

2. By selecting the right finance providers, infrastructure investors can have further assurance that the costs associated with a transition to a more liveable,

sustainable and resilient city will be minimised. This should be tested on practical projects and an evidence base for change created.

3. By evaluating the principles adhered to by organisations providing finance for infrastructure, it is possible to accelerate progress through obstacles encountered in the provision of sustainable and resilient infrastructure and the transformation of our cities. This likewise should be tested in practice.

4. Regenerative and restorative economic models based on planetary boundaries, social conditions and the five capitals.

5. Establish a sub-national / city level investor partnership, supported by public participation and budgeting.

6. Establish the compatibility of the LiSRIRC process with the ICE RAMP process and the IPA Project Initiation Routemap.

7. Trial an independent audit and facilitation system for infrastructure risk analysis, management and reporting.

8. Test training packages that develop the advanced working practices and values that are required to ensure the principles of the Integrated Project Insurance approach reach its full potential.

## 8.6 Summary

The finance and insurance industries include members that are fully awake to the potential risks to infrastructure worldwide, and by implication their exposure to stranded assets and collateral damage, however, the majority are partially awake – at best. This provides a monumental stimulus to re-thinking economics and revising the way in which infrastructure is delivered. Together these factors could combine so that there is a stronger possibility that cities will be transformed into liveable, sustainable and resilient places. With successive major infrastructure projects failing to meet cost estimates and schedules, the construction industry working with margins of around 1–3% and a siloed, defensive and aggressive atmosphere pervading the sector, many are waiting for the change that is required. With many Government papers all concluding that change is required, and with the National Infrastructure Commission impatient for action across a multitude of infrastructure tasks, there is, without doubt, opportunity to feed in a robust process such as **LiSRIRC**.

Is that enough to enable this research to find practical deployment? Well, an approach to a major investor, a major bank and a major insurer (which meets the criteria that this research advocates) that are ready to be involved in developing a city-wide infrastructure portfolio, will be a major test and one that this researcher will endeavour to realise.

## Appendices

## Appendix 1 Questionnaire

**INTERVIEW SHEET:** …….. **Infrastructure Type:** …… **Year:** ……. **Implementation Cost £** …….. **Op Cost £** ……..

**Project Description:**

| | |
|---|---|
| % ROI: F/A | Period: |
| Budget: F/A | % Variance: |
| £ variance/cost of variance: | |
| Total Investment: £ | Value of Asset: £ |

| **Funding Sources:** | Capital | Revenue: | Insurance Sources: | |
|---|---|---|---|---|
| …….. | £ | £ | …… | £ |
| …….. | £ | £ | …… | £ |
| …….. | £ | £ | …… | £ |
| …….. | £ | £ | …… | £ |
| …….. | £ | £ | …… | £ |
| **Totals** | **£** | **£** | | **£** |

Grant – Amount/Cost Equity– Amount/Cost Debt– Amount/Cost

Other – Amount/Cost

**Total Costs of capital: £**

| **Deadlines:** | **Project team:** | **Benefits:** | **Beneficiaries:** | **Additional Costs:** |
|---|---|---|---|---|
| Initiation date | WLEP | | | Contingency: £ |
| Milestones | Contractors | | | Liability: £ |

| | | |
|---|---|---|
| Political | External | Admin.: £ |
| Spend | Finance | Transaction: £ |
| Completion | Legal | Credit rating: £ |
| Other | | Tax Breaks: £ |

**PROJECT SHEET:**

**Current Ownership:**

Finance

Insurance

Debt

Equity

Revenue

Asset

**Project reports: File reference**

RA's -

ERA's -

EIA's –

Imagery: -

Press: -

Management: -

**Full project description:**

(Detail finance and insurance negotiations/value objectives and capture strategy/assessment processes/risk evaluation)

## Appendix 2 Revised Questionnaire

**Organisation: …… Date: …… Reference No: 1**

| Focus | Framework | Bracket Challenge | Bridge (Qual/Quan) |
|---|---|---|---|
| **Finance** | | | |
| **Insurance** | | | |
| **Practices** | | | |
| **Data** | | | |
| **Comments** | | | |

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