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Green Infrastructure's contribution to economic growth: a review

A Final Report for Defra and Natural England

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Executive Summary

Research question: What contribution does Green Infrastructure make to economic growth?

The purpose of this report is to assess whether investment in Green Infrastructure increases economic growth, based on the available evidence. We take Green Infrastructure (GI) to mean a planned approach to the delivery of nature in the city in order to provide benefits to residents¹. This includes features such as street trees, gardens, green roofs, community forests, parks, rivers, canals and wetlands. Economic growth is defined as an increase in economic activity as measured by Gross Domestic Product (GDP). Specifically we are interested in whether investment in GI increases GDP *compared to what would have happened without the investment*. We approached the question in two ways, firstly considering the weight of evidence supporting relevant logic chains and secondly reviewing case studies.

Logic chains

In section 2 of the report we review the evidence supporting six logic chains relating to inward investment, visitor spending, environmental cost saving, health improvement, market sales and employment generation. A diagram on the next page shows the full logic chains, their relationship to benefits provided by GI (known as ecosystem services) and the relationship between them.

A central issue with regard to new economic activity is whether it is new activity or has been displaced from elsewhere. Genuinely new activity is a contribution to national economic growth. Where GI contributes to the attractiveness of a location and this results in economic activity relocating there from elsewhere within the UK, there will be a significant contribution to local economic growth, but a net impact of zero to the UK as a whole. Where the new activity is from outside the UK it will increase UK national growth. Whether the sectors concerned are primarily national or global is therefore a key issue when looking at increased attractiveness. It is also possible that improving locations could lead to new activity, which has not been displaced from elsewhere, but this is extremely difficult to demonstrate empirically.

This report makes no attempt to assess evidence that would definitively prove or disprove these logic chains. This would be inappropriate given the complexity of urban economic development and the impossibility of carrying out controlled experiments. Instead the review assesses the strength of the evidence to support the logic chains. In terms of local economic growth, all six logic chains were supported by the review of the evidence:

- 1) Inward investment: The evidence shows clearly that increasing the attractiveness of an area through investment in high-quality parks, increases inward investment and property values in proximity.
- 2) Visitor spending: The attractiveness of the area and the quality of parks impacts on the number of visitors attracted to, and spending in, the local area.

¹Natural Environment White Paper (Defra, 2011) defines 'green infrastructure' as "a term used to refer to the living network of green spaces, water and other environmental features in both urban and rural areas. It is often used in an urban context to cover benefits provided by trees, parks, gardens, road verges, allotments, cemeteries, woodlands, rivers and wetlands." (p31). For this report, we use the term to mean 'the planned network of living systems either within urban areas or located outside but affecting the quality of life in urban areas'.

- 3) Environmental cost-saving: GI provides important regulatory services such as pollution filtration, flood risk reduction and the mitigation of temperature extremes. There is good evidence that GI can therefore reduce damage costs and is often a more cost-effective way to meet environmental targets than mechanical solutions. Reduced damage and costs should allow greater investment in productive activities.
- 4) Health improvement: Mental ill-health and stress are significant health issues in the UK and there is strong evidence that access to green space has a positive impact on these issues. The UK also suffers from a significant burden of ill-health due to people not meeting recommended levels of activity. The evidence is strongly suggestive of the quality of the outdoor environment being an important factor in encouraging daily exercise. There is also good evidence that health improvements feed through into increased productivity.
- 5) Market sales: There has been a recent upsurge in interest in the production of food in urban areas. This contributes directly to GDP, but at a tiny scale compared to the city economy.
- 6) Employment generation: Developing and maintaining GI provides jobs, and it is estimated that 5% of all the jobs in England are the Green Space sector.

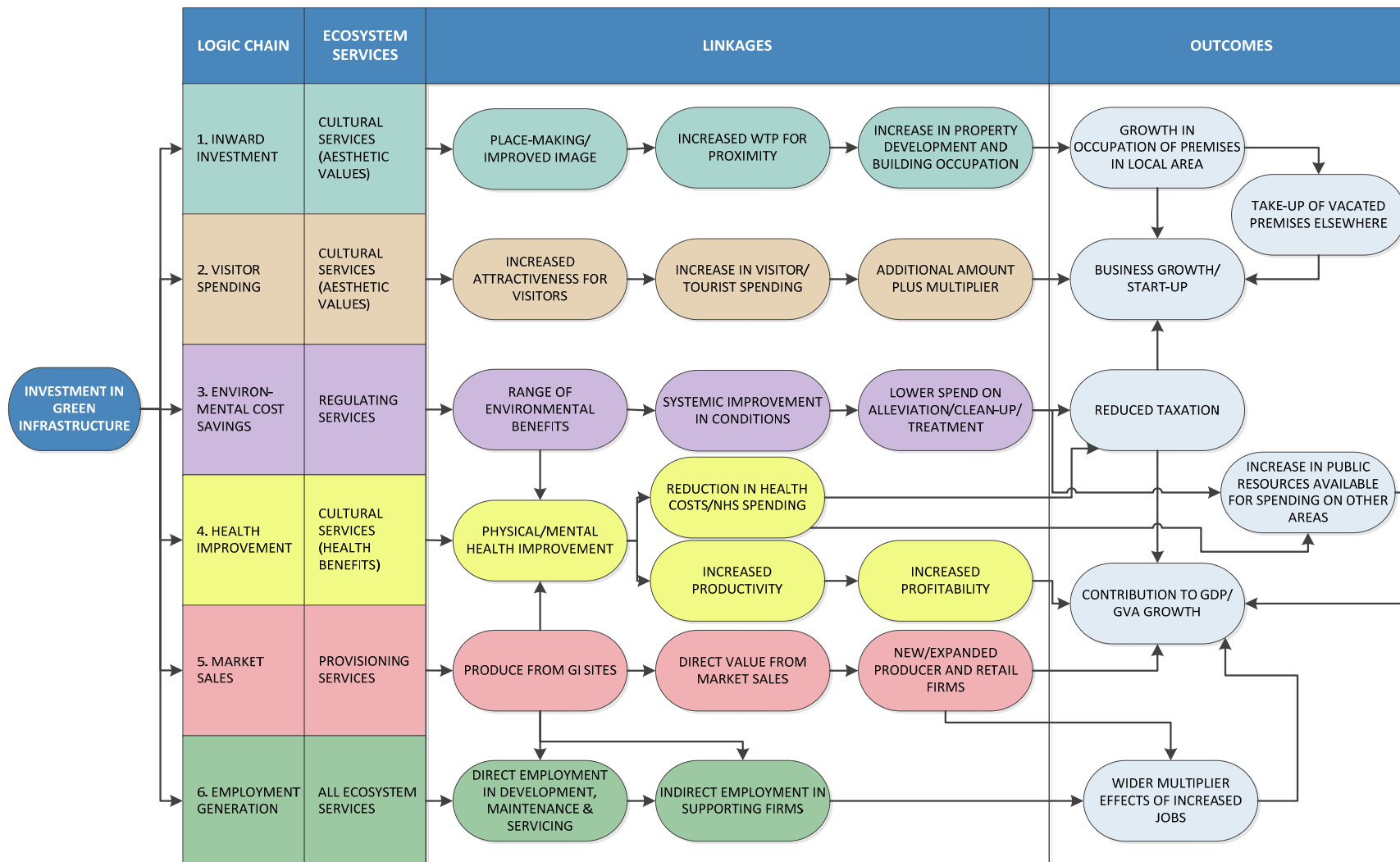
In terms of impact on national economic growth, once displacement has been taken into account:

- 1) Inward investment: Empirically it is very difficult to untangle how much of the economic activity is displaced from elsewhere. In terms of economic theory we can be confident of a contribution to net national economic growth when the investment originates from outside the UK. This is certainly possible, for example with high-quality business parks and office accommodation aimed at the financial and technical sectors. Improving areas and facilities may also generate new, not displaced, economic activity, but it is difficult to show this empirically.
- 2) Visitor spending: Empirically it is difficult to untangle how much of the visitor spending had been displaced from elsewhere, but economic theory would lead us to be confident of a contribution to net national economic growth when visitors are from outside the UK. UK cities receive large number of international visitors, but it is very difficult to assess the specific contribution of GI to the attractiveness of these cities as destinations. Improving areas and facilities may also generate new, not displaced, visitor spending, but it is difficult to show this empirically.
- 3) Environment cost-saving: This is an absolute benefit and not subject to displacement and therefore makes a contribution to national economic growth.
- 4) Health improvement: This is an absolute benefit and not subject to displacement and therefore makes a contribution to national economic growth.
- 5) Market sales: This is direct market activity, rather than attracting business. It may displace some food production. It will make a contribution if the food production displaced is from abroad or if the food is higher value added than the alternative. The figures involved are however negligible.
- 6) Employment generation: Empirically it is very difficult to untangle how much of the employment is additional. In order to boost the national economy, the green space sector would need to be growing significantly in value and employment terms, which is not currently anticipated.

This leaves environmental cost-savings and health improvements as direct contributors to national economic growth. The impact may be significant, but will be too long-term and

diffuse to attribute robustly. Inward investment and visitor expenditure may also contribute to national levels of economic activity where they are attracting people and businesses from abroad, but again it is likely to be impossible to attribute this directly to GI.

Figure 2.2: Green Infrastructure and Economic Growth Logic Chains



Case studies

	Glasgow Green Renewal	Birmingham Canalside	Philadelphia Land Care	Stream Restoration, Seoul	Highline Linear Park, NYC
Change	Park Improvement	Canal and canal-side improvement	Greening of vacant residential lots	Restoration of stream with footpath, man-made wetland and forest	New elevated urban public park
Investment	£15.5 million	Not quantified	Small - not quantified	Not quantified	\$153 million
Anticipated outcome	<ul style="list-style-type: none"> • Job creation; • tax revenue; • land values; • Visitor spending. 	<ul style="list-style-type: none"> • Job creation; • Land values; • Visitor spending. 	<ul style="list-style-type: none"> • Property value increase. 	<ul style="list-style-type: none"> • Businesses relocate to area; • Tourism spend; • Health benefits. 	<ul style="list-style-type: none"> • Businesses relocate to area; • Jobs created; • Health benefits.
Outcome	<ul style="list-style-type: none"> • 47% increase in Council Tax receipts; • 28% increase in the number of employees in area; • 230 jobs supported; • 15% increase in rateable value from business. 	<ul style="list-style-type: none"> • 30 FTE jobs created plus 77-96 jobs supported through visitor expenditure; • 25.7 - 57.1 million property value uplift. 	<ul style="list-style-type: none"> • Significant increase in property value in some areas. 	<ul style="list-style-type: none"> • Number of workers increased by 0.8% against a decrease of 2.6% in other areas of central Seoul; • £1.3 million contributed to economy by foreign tourists. 	<ul style="list-style-type: none"> • 103% increase in property values near the park between 2003 - 2011; • 4 million visitors.
Other causal factors considered?	Impact of wider regeneration of the East End of Glasgow not considered.	Impact of the wider regeneration of the area, the state of property market and some additional public funding all relevant and not considered.	Other causes of changes to property prices were considered and the model controlled for these.	Before and after comparison does not allow for displacement or other factors.	Before and after comparison does not allow for displacement or other factors, such as macro-economic conditions.

Section 3 of the report looks at five case studies. The table above summarises the findings.

All five of the case studies above were clearly a success in commercial terms. They were all successful and popular, attracting new business and investment to areas that had previously been perceived as unattractive, or even dangerous. The logic chains around attracting investment and visitor spending seem to be operating in these cases.

However, in real life situations it is often impossible to control for other influencing factors and to accurately attribute the improvement. Wider regeneration investment and the stage in the macro-economic cycle are obvious alternative causal factors. In practice, projects are more likely to be successful when these external factors are contributing. Also in practice GI is often part of a wider investment package and it is impossible to unpick the specific difference made by GI. It is also unrealistic to quantify whether or not the new economic activity is additional from a national perspective, as explained above.

The only case study above that has made a significant attempt to control for other factors is the Philadelphia Land Care Scheme, which uses house prices in similar districts for a comparison. Controlling is easier in this case because there are many similar interventions and thousands of house price sales to compare, so this methodology is not applicable to large iconic programmes. The Philadelphia evidence shows clearly that people value the improved attractiveness/perceived safety of their neighbourhood and this is important. It may also be evidence of increased economic activity but the link to economic growth is not clear.

The Glasgow, Seoul and New York case studies all provide people with access to attractive green space for exercise and recreation, which can be expected to contribute to improved health and later improved productivity. The Seoul case study is unique in that it involves the restoration of a natural system (and the development of some man-made natural systems). For this reason it is the only case study that illustrates the reduced environmental costs logic chain, reducing air pollution and peaks of summer temperature. This contributes to both the attractiveness of the location and the health of residents, which can be expected to have a long-term impact on productivity.

Conclusions

The importance of GI to the attractiveness of cities and neighbourhoods to people and investors is relatively well understood by city planners and developers. This is the impact of GI with the biggest short-term effect, and the most measurable at the local level. Whether this attractiveness factor makes any contribution to net national growth is very difficult to assess empirically, but theory predicts this is likely to be the case when there is expenditure or investment that otherwise would have been made outside the UK.

The contribution of GI to a healthy productive population is well evidenced, as is its contribution to environmental resilience and the cost-effective meeting of environmental targets. Neither of these logic chains suffer from displacement effects and therefore can be expected to make a contribution to national economic growth. However, the economic importance of these 'health and environment outcomes' can be missed, partly because they operate over a longer time frame, and partly because it is difficult to attribute particular economic activity to their effects.

Finally, the challenge of linking GI to specific economic activity is not unique to GI, but a feature of all infrastructure. Like other infrastructure, effective GI is essential to the healthy economic functioning of the city.

Green infrastructure ...

...encourages inward investment to an area:

- 95% of real estate developers and consultants across Europe believe that open space adds value to commercial property^a.
- On average, developers would be willing to pay at least 3% more for land in close proximity to open space, with some putting the premium as high as 15-20%^a.
- Within two years of Bryant Park (New York) reopening, commercial leasing activity in adjacent streets had risen by 60%^b. Within 10 years, commercial rents had increased more than twofold, a rate much faster than for equivalent properties further away from the park^b.

Figure 0.1: Bryant Park, New York

*Source: Bryant Park Corporation*

- The improvement of the Glasgow Green park landscape and amenities increased the attractiveness of the surrounding area, leading to additional council tax revenue of between £800,000 – 2 million^c.

Figure 0.2: Aerial photograph of Glasgow Green

*Source: Glasgow City Council*

- Before the development of the High Line Park (New York), properties in the surrounding area were valued 8% less than the median in Manhattan, reflecting the economic decline of this once industrial (meat packing) district. Between 2003 and 2011 the values near the park increased by 103%, surpassing the New York average^d.

Figure 0.3: High Line, New York



Photograph courtesy of <http://www.nycgovparks.org/parks/highline/photos>

...attracts increased visitor spending in an area:

- Spending by visitors to the Mersey Forest was £252,000 net gross value added (value of all economic activity in the area) per year^e.

Figure 0.4: Sefton Park, Mersey Forest



Photo by: McCoy Wynne

- £15 million investment in Glasgow Green attracted visitors who spent £30 million net additional worth of sales in the wider economy^c.

- Birmingham canalside development generated net visitor (boater) spending of £115,000^f.

Figure 0.5: Canal Development



Source: Birmingham City Council

...saves environmental costs:

- Pollutants removed by trees in Mecklenburg County, North Carolina (USA) amounted to an economic welfare benefits of US\$4 million, based on the cost saving of preventing the pollutants from entering the atmosphere^g.
- Sheltering effects of trees could save 3-9% of energy bills^h.
- Unearthing of the Cheonggyecheon Stream in Seoul and related greening of the area reduced the temperatures by 3 - 6 °C compared to those on a parallel road four to seven blocks away. The same changes led to a 35% reduction in the small particle concentration in the air, leading to noticeable improvement in air quality in the areaⁱ.
- Increasing green cover by 10% in urban residential areas reduces run-off from a 28mm rainfall by almost 5%. This reduction is almost 6% if the tree cover is increased by 10%^j.

...provides health benefits:

- A park in Portsmouth may be providing potential savings of £910,000 to the NHS as a result of improved health associated with outdoor recreation and improvements in environmental quality^k.
- The World Health Organisation's Health Economic Assessment Tool (HEAT) for cycling and walking estimated the average economic benefit of 100 people starting to walk one kilometre per day to be worth £31,000 per year (or £305,000 over a 10 year period)^l. This benefit is due to reduced risk of premature death due to exercise.
- The overall economic benefit of prolonging life is even larger as found by a study that examined health and economic data between 1960 and 1990: on average, 1 year improvement in a population's life expectancy contributes to an increase of 4% in economic output^m. The share of contribution due to green infrastructure is not possible to calculate with existing evidence but the overall benefit is clearly substantial.

...generates employment:

- 'Green space sector' (public parks departments, nature reserves, botanical/zoological gardens, landscape services and architectural services) directly employ 122,000 people in the UK, which is 5% of all jobs in the countryⁿ.
- After improvements in a rundown industrial estate in Wakefield, involving environmental improvements, 16 new businesses relocated to the estate, employing 200 people^o.
- Glasgow Green generated almost £8 million in terms of additional wage and salary payments, as well as 35 full time equivalent jobs^c. The increase in jobs in the area was 28% between 1998 and 2006. The increase in employees in other parts of the city for the same period was 13%^c.

a. Gensler et al, 2011; b. Ernst and Young, 2003; c. GEN Consulting 2006; d. Moss, 2012, and NYCEDC, 2011; e. Regeneris Consulting, 2009; f. Ecotec, 2003; g. US Trust for Public Land, 2010; h. Rawlings et al, 1999; i. Hwang, 2004; j. Gill et al., 2007; k. Bird, 2004; l. www.euro.who.int/HEAT; l. Bloom et al, 2004; n. CABE, 2010; o. Burton, 2008

Key conclusions for local decision makers

- Green infrastructure potentially delivers a large number of benefits. However, not all green infrastructure projects can deliver all benefits. First, the benefits required in a given area should be identified, then the project should be designed specifically to deliver them.
- It will take some time for the benefits of green infrastructure to become reality. Funds should be available not only for the initial outlay but also for continued maintenance and improvement over time.
- Factors that will enable green infrastructure to deliver benefits or enhance these benefits should be identified. For example,
 - physical and mental health benefits will only come about if there is an information campaign or other incentives to motivate people to use green infrastructure for outdoor recreational activities. Otherwise investing in green infrastructure alone will not be sufficient.
 - To improve the environmental quality benefits, green infrastructure should be supported by further additions to sustainable green installations like sustainable urban drainage systems, green roofs etc.
- Green infrastructure project budgets should cover investments in such supporting factors.
- Most of the evidence in the literature is on one-off projects. It's not clear how the benefits may be changing as the size of green infrastructure in a given area changes. It could be expected that some benefits may diminish as this size increases, while others may remain the same or increase. The relationship is case specific and important to establish to ensure that projects that are most needed in an area, and hence is likely to contribute most to the local economic growth and human welfare, are selected.
- We don't have complete and robust evidence for all benefits of green infrastructure. Lack of sufficient evidence need not be an obstacle, however. Stakeholders should be engaged in the development of a project, expressing their need for evidence. Early involvement in the project will contribute to making the most use of all qualitative, quantitative and economic evidence that's available.

Key conclusions for national decision makers

- Green infrastructure contributes to both local economic growth and the welfare of the local and visitor population (mental and physical health, environmental quality). This review shows that there is evidence on this contribution and qualitative evidence on people's preferences and experience of using green infrastructure.
- Most of the evidence is the product of comparisons of various factors before and after a green infrastructure project or comparisons of the areas with and without green infrastructure. This applies to both economic growth and wider human welfare benefits.
- To what extent green infrastructure provides an *additional* contribution to national economic growth is not possible to estimate with the available evidence. This gap is important for national policy making, and also identifying the priority green infrastructure features in different areas if making a national plan.
- Additionality (or displacement) analysis is notoriously difficult for most national policies, not only green infrastructure. Therefore, ways to analyse the case for green infrastructure investment will have to be explored, e.g. consider evidence on the wider human welfare impacts (environmental quality and physical and mental health), qualitative evidence and stakeholder engagement.
- In any case, a general improvement in the attractiveness of UK cities is desirable, and much of the mobile investment is global, rather than national, which means increased attractiveness can make a national economic growth contribution.
- In addition, green infrastructure clearly makes a contribution to the resilience, and sustainability, of economic growth in a particular place, through reducing important risks such as flooding and the urban heat island effect. This report does highlight this benefit, but does not focus on it, focussing instead on the pathways to growth in productivity.
- There is compelling evidence that green infrastructure projects that are integrated in with other projects or strategies such as urban regeneration are likely to engage stakeholders and provide more benefits faster. Therefore, it will be efficient to encourage such integration at both the local and national levels.

Better evidence for the future

The following are suggestions on ensuring better evidence is produced for future assessments of the role of green infrastructure investments as a catalyst to, in particular, national economic growth:

- An agreed standard set of common indicators of such an assessment to enable easier comparison of similar types of green infrastructure or similar benefits across different locations;
- 'Vacancy chain' surveys to ascertain the fate of premises vacated by firms who move to the area surrounding the green infrastructure installation. This will help determine the

extent to which business relocate from elsewhere, and hence, the extent of displacement.

- Visitor surveys to determine alternative areas that were visited prior to (or instead of) a new green infrastructure to determine the extent to which green infrastructure encourages new visits rather than re-direct visits from elsewhere.
- Analysis of where savings due to green infrastructure's contribution to environmental management are then spent. However, unless there is a direct transfer of funds between different items, the standard methods of public resource allocation or reallocation are likely to make such assessments virtually impossible.
- Further analysis on the effectiveness of ecotherapy approaches to dealing with mental health issues. These would offer a ready-made context for more detailed exploration of the connection between use of green infrastructure, health improvements and economic outcomes.
- Sustained monitoring of total employment in the green infrastructure sector to assess whether it has increased or decreased over recent years, and to keep track of future trends. It would also be useful to have an occupational breakdown of these jobs, so that placing a reasonably accurate economic value on them in terms of their contribution to the economy is facilitated.

Making the most of the available evidence

- There will be a large and mixed group of stakeholders involved in any green infrastructure project. These may include beneficiaries, funders (public sector at local and national level, private sector, community groups) and those who stand to lose from projects.
- All stakeholders will have different objectives and requirements in terms of what robust evidence means. This means balancing compliance with European, UK, devolved government and local laws and regulations in addition to communicating with, and enlisting support from, the diverse stakeholders involved.
- The assessment of benefits should focus on finding and communicating the benefit that will be most 'real' to the local population.
- It has been proven useful in all communication strategies, and green infrastructure related ones are no exception, to tailor arguments to fit the different concerns of different stakeholder groups. For example, when talking to policy makers the cost savings could be the key argument, while when talking to community members recreational and health opportunities may be the focus.

1 Introduction

1.1 Green infrastructure for economic growth

Sustainable economic growth is an objective of government policy aiming to address both environmental sustainability and economic recovery goals. Achieving this objective requires (among other factors²) enhancing the benefits provided by the natural environment and reducing the costs of its degradation. Experience across the world shows that one way to do this is to reconnect people with nature and create places that enhance services provided by nature (especially in urban areas where this connection has been significantly reduced). This reconnection can be achieved by increasing the presence and quality of street trees, gardens, green roofs, community forests, parks, rivers, canals and wetlands and so on in urban areas. These features are increasingly being referred to as **green infrastructure**³.

The case for investing in green infrastructure can be made with evidence on how better connection between people and nature, and an environment that builds on the services provided by nature, could improve human welfare and contribute to local economic growth, i.e. increase in economic activity. For example:

- Being surrounded by green infrastructure and using it for recreational activities makes people happier and healthier:
 - *Healthier and happier people work more productively;*
 - *They also have less need for medical intervention, saving the public medical expenditure;*
- Visitors (and businesses that cater for them) are likely to be attracted to more beautiful and cleaner areas:
 - *Visitors to an area bring extra spending to the area supporting existing businesses and encouraging new ones;*
 - *More and growing businesses in an area means more employment, more income and more economic activity;*
- The beauty and cleanliness of an area attracts businesses to move there as they also attract more customers and workforce; enhance the workforce's mental and physical health, and make it easier to retain them. In turn,
 - *More and growing businesses in an area means more opportunities for visitor spending, more employment, more income and more economic activity;*

² HM Treasury's five drivers of productivity include: improving the skills, enterprise, innovation, investment and competition. These also recognise the importance of increasing resources and creating new markets.

³Natural Environment White Paper (Defra, 2011) defines 'green infrastructure' as "a term used to refer to the living network of green spaces, water and other environmental features in both urban and rural areas. It is often used in an urban context to cover benefits provided by trees, parks, gardens, road verges, allotments, cemeteries, woodlands, rivers and wetlands." (p 31). For this report, we use the term to mean 'the planned network of living systems either within urban areas or located outside but affecting the quality of life in urban areas'.

- Greener areas regulate environmental processes, for example by reducing flooding risks and naturally cleaning pollution:
 - *This means happier and healthier people;*
 - *Less public (and private) spending on avoiding environmental risks and cleaning up environmental pollution.*

1.2 Evidence on the benefits of green infrastructure

The kind of evidence that could be appropriate to demonstrate the above relationships depends on the decision-making context and culture, the type of investment, the type of benefits provided, and the analytical methods used to collate and interpret the evidence.

In general, three types of evidence are possible and useful in their own right or in combination⁴:

- *Qualitative evidence* such as expert judgment, anecdotal evidence or qualitative social research that demonstrates the links between outdoor activity, aesthetics, cleaner air etc. and improvement in human health, reasons businesses state for relocating to greener areas of a city etc.
- *Quantitative evidence* such as changes in air quality, ambient temperature (reduction in heat island effect for example), noise levels, bird counts etc., numbers of visitors to a new park and any spending they may make while visiting, number of businesses relocating to an area, number of people they employ etc.
- *Economic evidence* such as visitor spending, reduction in medical expenditure due to improved health, income from new businesses etc.

All three types of evidence are found in the literature.

Social research focuses on the physical and mental health benefits of green infrastructure (Van Den Berg et al., 2007; Cooper et al., 2008), as well as on associated behavioural change, reductions in crime and anti-social behaviour (Kuo and Taylor, 2004), and educational and skills-related improvements (Taylor et al, 2001).

Economic research has tended to focus on benefits of green infrastructure that do not involve direct market transactions (e.g. improved health, environmental cost savings). There is a much smaller volume of research that addresses the question of whether or how green infrastructure contributes to economic growth of an entire city or country, through encouraging more businesses, visitors, spending and jobs, with very few studies based in the UK.

1.3 The focus of this study

The objective of this study is to review the economic literature to find evidence of green infrastructure supporting sustainable economic growth, through improving human health

⁴ For example, qualitative evidence is necessary to understand what kind of quantitative evidence can be collected, and both qualitative and quantitative evidence is necessary to find and analyse economic (monetary) evidence.

and happiness, attracting visitor spending and businesses with associated income and employment benefits and saving costs from avoided environmental damage.

The size of the economy is measured in the total value of goods and services purchased in a year. It is therefore equivalent to national income and is formally defined and measured using Gross Domestic Product (GDP) (or Gross Value Added - GVA) (for definitions, see the Glossary at the end of the report). Economic growth can therefore be increased either through the increased consumption of resources by the economy, or increases in the quantity of machinery (capital) or labour, or increased efficiency in the production of goods and services. This increase is measured by economy-wide models that use market transaction data.

Economic growth is a government priority, but government also recognises that purchasable goods and services are only one of a bundle of factors that contribute to economic welfare. This report will highlight many instances where green infrastructure improvement contributes *directly* to human welfare (the ultimate goal of public policy), but this benefit is not captured in GDP statistics because this benefit occurs outside the market (an 'externality').

Using the indicators (GDP and GVA) that measure market economy alone, it is difficult to see how green infrastructure could contribute to economic growth. However, in advanced economies, the 'people' factor is central for several reasons. Firstly, creative thinking by people drives the improvement of science and technology, and their diffusion and uptake by entrepreneurs. Secondly, there are creative, high-value added sectors where differentiation of product by quality is now essential to value added. Thirdly, the quality of leadership, management and teamwork are essential to success or failure in the modern marketplace. These factors make the health and wellbeing of the workforce, which can be improved through green infrastructure, critical to driving economic growth.

This study sets out a 'logic chain' that incorporates both those indicators that use market transaction data, such as spending, income, jobs, and those that use non-market data on as well as human health and environmental damage costs. However, the focus of the evidence review from the literature and case studies is more on businesses, spending and jobs to increase the visibility of this kind of evidence. This does not mean the health and environmental benefits of green infrastructure are less important.

In fact, much of the evidence for the value of green infrastructure is about improving the attractiveness of particular places, either to the workforce, or to inward investment. The evidence for this effect is strong, but in terms of national economic growth, we need to take *displacement* into account. Displacement is the extent to which any increase in economic activity is not additional, but has simply moved from elsewhere. Nevertheless, a general improvement in the attractiveness of UK cities is desirable, and much of the mobile investment is global, rather than national, which means increased attractiveness can make a national economic growth contribution.

Green infrastructure clearly makes a contribution to the resilience, and sustainability, of economic growth in a particular place, through reducing important risks such as flooding and the urban heat island effect. This benefit is not subject to displacement in the same way, because clearly reduced risk everywhere must be beneficial, and it is easier to observe the contribution of green infrastructure to such environmental factors. This report does highlight this benefit, but does not focus on it, focussing instead on the pathways to growth in productivity.

1.4 The contents of this report

The report presents the evidence we could find regarding the benefits associated with green infrastructure. We also aim to show at which decision level (local or national) such evidence can be useful and how decisions to invest in green infrastructure have been made in the absence of complete economic evidence.

Section 2 shows the 'logic chain' of the ways in which green infrastructure is likely to provide human welfare and economic growth benefits. We review the academic and grey literature for evidence to populate this logic chain and also provide evidence from city-wide green infrastructure plans.

Section 3 provides in-depth review of five case studies:

- Glasgow Green renewal;
- Birmingham City Centre canalside development;
- Philadelphia (Pennsylvania, USA) land care programme;
- Seoul (South Korea) Cheonggyecheon river restoration; and
- New York City (USA) Highline Linear Park development.

Finally, Section 4 concludes this report with a discussion on what the current evidence tells us, what the gaps are, recommendations about future action and commentary on what is reasonable to expect of economic evidence in this context.

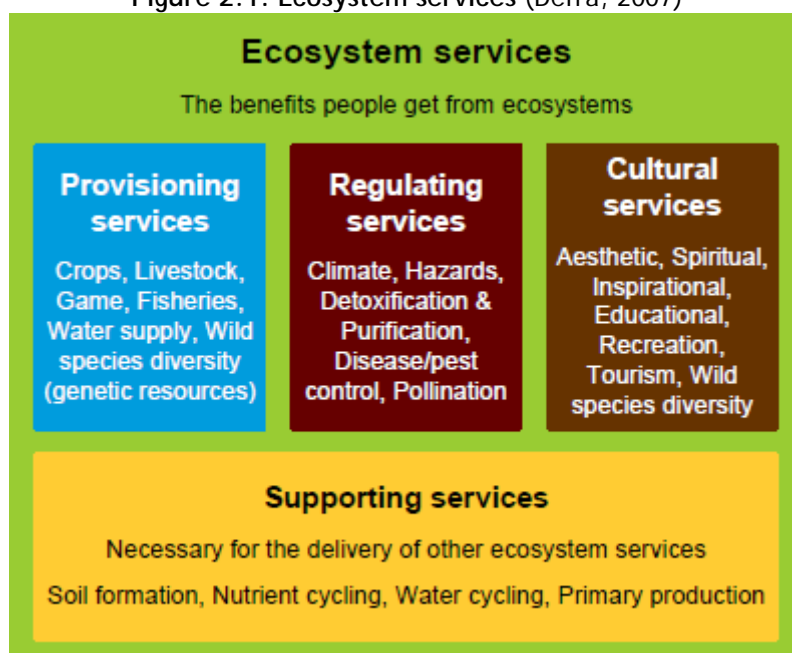
2 Logic Chain Evidence Review

2.1 Introduction to the evidence review

Most research that explores the economic aspects of green infrastructure contains either explicit conceptual models setting out various dimensions of economic impact, or does so implicitly through the methodology adopted to demonstrate and estimate the value of the resulting benefits. Some of this work has taken the form of evaluation or assessment frameworks as an essential first step in guiding researchers and practitioners in exploring the social and economic benefits of green infrastructure (examples include Amion, 2008; Ecotec, 2008; Green Infrastructure North West, 2010). These reports are rich in conceptual thinking, but as their publication dates suggest, opportunities for extensive empirical application have been limited.

The conceptual basis to connect green infrastructure with economic growth may be summarised in a series of 'logic chains'. These trace the linkages between investment in green infrastructure and economic outcomes via the ecosystem services it provides. Ecosystem services are the benefits provided by the natural environment (ecosystems) for humankind. They include provisioning services (food, fibre, fuel), regulatory services (water, carbon, nutrient cycles), supporting services (underlying functions like soil formation) and cultural services (aesthetic values, recreational activities and related health benefits). Figure 2.1 sets out these ecosystem services in diagrammatic form.

Figure 2.1: Ecosystem services (Defra, 2007)



As Figure 2.1 shows, there are links between different services. In fact this is a simplified chart - in more accurate representations it becomes very difficult to follow the vast number of arrows showing the multidirectional relationships between each ecosystem service. Where there is complexity like this, there is a risk of double-counting the value or influence of a given ecosystem service. This is why analysis should value the 'final' goods and services (e.g. health benefits from recreation) rather than all services' contribution to them (e.g. in this example, supporting services should not be valued separately if

recreational services already are). This need to focus on final goods and services is also emphasised in the UK National Ecosystem Assessment (UKNEA, 2011).

Table 2.1 summarises the key ways in which the logic chains link with ecosystem services and economic outcomes. Figure 2.2 displays the chains in more comprehensive diagrammatic form. In the rest of this section each logic chain is explored in terms of economic growth for all types of green infrastructure defined in Section 1.

The focus in this review then is on economic activity, and, by association, economic growth (i.e. an increase in the level of that activity). Benefits such as human health and environmental improvements are included in the assessment solely with respect to their contribution to these ends, rather than in terms of their monetary value (the approach used in cost benefit analysis). Assigning economic significance to project effects in this way is undoubtedly an important technique for assessing the likely return on public expenditures, but it is difficult to trace any association between the values generated and the focus of this review, changes in the level of economic activity.

Table 2.1: Key links in the green infrastructure - economic growth logic chains

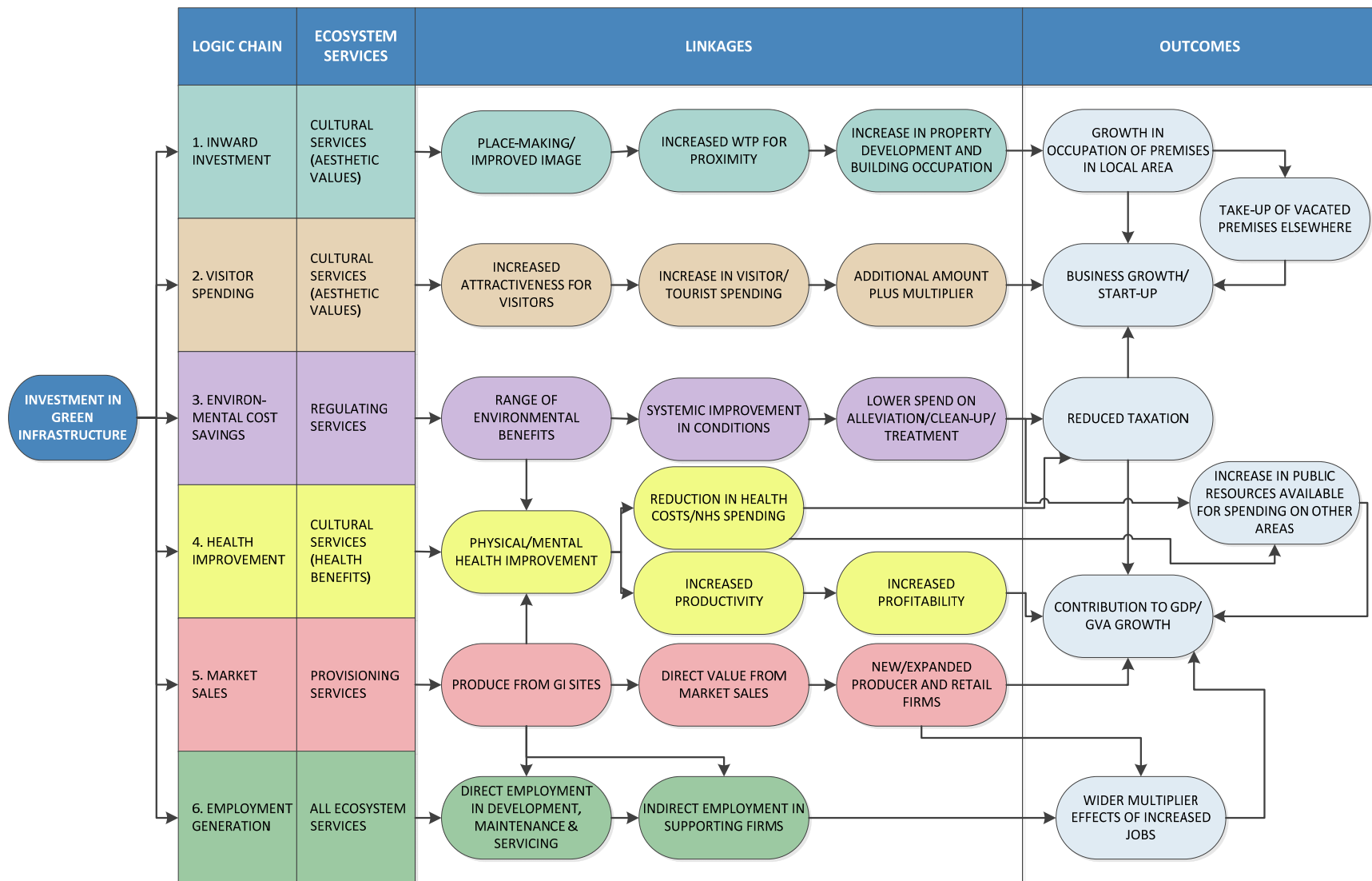
Logic chains	Ecosystem services of green infrastructure	Economic Outcomes
<ul style="list-style-type: none"> • Inward investment: <i>increase in investment in a given area</i> • Visitor spending • Environmental cost savings: <i>reduction in the need to spend to reduce environmental risks or cleaning up environmental pollution</i> • Health benefits • Market sales: <i>of the products grown on green infrastructure</i> • Employment generation: <i>due to increased spending and new businesses</i> 	<ul style="list-style-type: none"> • Provisioning services (food, fibre, fuel) • Regulatory services (water, carbon, nutrient cycles, watershed protection, flood risk management etc.) • Supporting services (underlying functions like soil formation) • Cultural services (health benefits, aesthetic values) 	<ul style="list-style-type: none"> • Growth in occupation of premises in local area / take up of vacated premises elsewhere • Business growth / start-up • Reduced taxation • Increase in public resources available for spending on other areas • Contribution to gross domestic product / gross value added (the market value of goods and services produced in an area) growth • Wider multiplier effects of increased jobs

The rest of this section reviews the literature and research evidence relevant to each logic chain. Before then, however, it is useful to highlight some important preliminary points:

- While the starting point of the model or logic chain is investment in green infrastructure, this can be interpreted in two different ways: either as a single site, or as a network of green spaces or other installations across a town, city or region. In spite of the contrasting scales involved, in all cases the aim is the isolation of new or improved green infrastructure as an independent variable and the ways in which it determines or influences changes in the wider economy.

- An alternative, broader approach is to treat green infrastructure as part of an integrated area-wide development scheme (e.g. 'working in the park', waterfront development schemes or even sub-regional revitalisation programmes). Here the task is to ascertain the economic impact of this wider package, and occasionally the contribution of green infrastructure to this.
- Implicit in these models is the existence of one or more 'trigger mechanisms' that set the logic chain in motion. These might include a change in the perceptions of residents, investors and visitors with respect to the increased attractiveness of the locality, and the associated recreational and business opportunities that this provides. However, these 'triggers' have tended to receive little detailed attention other than occasional acknowledgement of their existence.
- A few studies adopt a more comprehensive view, still focusing on green infrastructure but treating it as just one of a wide range of factors involved in economic, investment and/or locational decision-making. As a consequence, green infrastructure becomes subsumed within a more systemic depiction of the economic process, rather than acting as the initiator of a chain of events. Analyses from such a comprehensive angle tend to omit any attempt to separate the impact of green infrastructure on economic growth and human health and wellbeing from all the other factors at play.
- The six logic chains identified are essentially a convenient way of clarifying the economic processes at work. They are not intended to be interpreted as standalone mechanisms: clearly there are too many interrelationships and potential spillover effects between them for that. For example, growing and new businesses in the local area can lead to increased employment opportunities, which in turn can have multiplier effects from spending by new employees.

Figure 2.2: Green Infrastructure and Economic Growth Logic Chains



2.2 Inward investment

Key linkages:

- Well designed and maintained green infrastructure makes an area more attractive.
- The more attractive an area the more people want (and move) to live, work, shop and spend their free time in that area.
- People are willing to pay a premium for properties in closer proximity to good quality green infrastructure.
- More people move into attractive areas which increases spending in the area and boosts the local economy and encourages further investment in the surrounding areas.
- Improved attractiveness means more businesses are interested in moving to an area, and they find it easier to attract and retain workforce and customer base.
- There are many other factors that encourage people and businesses to move into an area besides the presence or improvement of green infrastructure. While it is difficult to quantify the contribution of green infrastructure, there is sufficient evidence to show that it does have a role to play.

For this logic chain, green infrastructure is generally viewed as an integral and crucial part of the wider urban fabric, making a key contribution to the attractiveness of a locality to potential investors, employers and residents. In this sense it is associated with the cultural services, aesthetic values and health benefits of green spaces.

Increasing property values

The enhanced attractiveness of an area because of green infrastructure is expressed in individuals' willingness to pay higher amounts for property with ready access to green spaces. These higher amounts reflect the scale of the competition for this access (limited green space, increasing demand for it), which is reflected in higher residential and commercial property values.

For existing green spaces where there has been no substantial recent investment, this will involve a premium when compared to average asking prices for similar types of property in the area. Where new green infrastructure has been created or existing green spaces have been improved, the uplift involves above average increases in property values.

Hedonic analysis has been used to produce extensive evidence of the positive effect of green infrastructure on the value of residential property. This method analyses property sale data and explains the difference in sale prices by separating out various attributes that are thought to affect the price. In this context, it can identify the price premium associated with the presence of and access to green infrastructure in an area. The method and studies have been well summarised elsewhere (Troy and Grove, 2008) so there is no need for detailed repetition here.

The estimates of the size of the premium vary between under 1% and 19%, though the majority fall within the 5 to 10% range (Garrod and Willis, 1992; Garrod, 2002; Luttik, 2000; Dunse et al., 2007; Luther and Gruehn, 2001; GLA Economics, 2003; CABE, 2004; 2005; Prastholm et al. 2002).

The large scale study of the amenity value provided by various environmental resources across Britain, carried out for the UK National Ecosystem Assessment (NEA) by Mourato et

al. (2010), showed that these variations were associated with differences in the type and quality of green infrastructure, the variable structure of local property markets and the local economic context. In terms of the latter, the study of Baltimore by Troy and Grove (2008) is instructive: they found a similarly positive association between proximity to a park where the crime rate in the surrounding area was less than four times the national average, but there was a negative effect on property values where the crime rate was above this threshold.

At this point it is worth noting other work that has been undertaken on the relationship between green infrastructure and crime rates more generally. Several US studies have concluded that there is generally a positive link between the existence of greenery and vegetation and lower incidence of certain crimes (especially gun crime, assault and burglary, but not theft) (Kuo and Sullivan, 2001b; Branas et al. 2011; Wolfe and Mennis, 2012). This was also found for the presence of trees in a public right of way, and of larger trees within the grounds of a property. However, smaller trees that obstructed views were associated with higher levels of crime (Donovan and Prestemon, 2012). There is also some evidence that increased provision of greenery helps to improve residents' perceptions of neighbourhood safety (Garvin et al. 2012). Most of the evidence relating to reduction in crime is still relatively recent. It is not clear whether the crime reductions are overall reductions in crime from a city-wide perspective or whether crime is displaced to other areas. This depends on the causal mechanism, which is not yet established. For example, if the causal mechanism is green spaces attracting more potential witnesses, crime is likely to be displaced to less scrutinised spaces; if however greenery improves mood, there may be a city-wide reduction in violent crime.

Returning to higher residential property values, in general their downstream economic implications receive little attention in the literature. One exception relates to the increase in taxation revenue that results. However, such analysis has largely been confined to the US, where local property taxes are based on annually updated 'fair market' values (Trust for Public Land, 2008a, 2008b, 2008c, 2009a, 2009b, 2010a, 2010b, 2010c, 2011a, 2011c; Harnik and Welle, 2009). Apart from small amounts of Inheritance Tax and Stamp Duty in the UK, any capture of increased house values is likely to be limited because of the infrequency of revaluation in relation to setting Council Tax bands. The main way in which such revenue streams are likely to increase is via the stimulation of new development in the surrounding area.

Most studies in this area assume that higher residential property values are automatically beneficial, representing a 'boost' to the local economy. Where they indicate the improved attractiveness of a hitherto rundown area, the associated population growth is likely to lead to increased local expenditure on goods and services and some associated revival in the local economy, as well as an increase in property-based taxation revenue, including Council Tax receipts (see Glasgow Green case study in Section 3.1 of this report based on GEN Consulting, 2006).

Increase in property development

Similar effects should occur where the green infrastructure investment has encouraged developers to build new housing units. For example, the Forestry Commission (2005) found that enhanced property values in the area surrounding Bold Colliery Community Woodland in St Helens, Merseyside amounted to about £15 million, and that it had also stimulated new development worth a further £75 million. However, there has been little analysis of the wider economic impact of such enhanced values on areas where the population

remains relatively stable. Indeed, what enhanced property values mean in economic development terms for different types of area remains largely under-researched.

Figure 2.3: Four Acres, St Helens, Mersey Forest



Source: Mersey Forest Team

Benefits for businesses

Another argument advanced in the literature is that quality green space can help attract and retain a motivated and skilled labour force⁵. Intuitively this would appear to make sense, hence the premium on house prices noted above, indicating a higher willingness to pay on the part of in-movers to the surrounding area. However, there is little in the way of concrete research on the extent to which the labour force in an area has increased its proportion of higher skilled workers as a result of green infrastructure. Indeed, a survey conducted in Sweden by Nedomysl and Hanson (2010) found that it is primarily the availability of jobs which is important in attracting skilled labour to an area; environmental and cultural amenities play more of a contributory (though still essential) role. Of course, these results may reflect the difficulty of using proxies for and framing questions around green infrastructure in terms that potential survey respondents can understand, as the authors freely admit.

In terms of commercial and industrial property, a survey of real estate developers and consultants across Europe found that 95% of respondents believe that open space adds value to commercial property. On average developers would be willing to pay at least 3% more to be in close proximity to open space, with some putting the premium as high as 15-20% (Gensler et al., 2011). Indeed, a study by Phillips (2000) found that lease rates of properties facing the new green space at Post Office Square in Boston, Massachusetts commanded a 10% premium over those without a park view. The same study found that park restoration at Union Square in New York in 1985 helped to stimulate private housing investment in the area, and contributed to stabilising previously declining commercial property values adjacent to the park.

The expansion of existing businesses and incidence of new start-ups serving the population living in the vicinity of the green space in question are unlikely to occur unless there is

⁵ A skilled labour force is one of five regional development drivers according to HM Treasury (2001), the other four being: investment, innovation, enterprise and competition.

sufficient additional trade to justify them. While there has been little substantive research on this question, there is some evidence such as from the Glasgow Green case study, which found that the local new business formation rate had been much higher after the park reopening than that for Glasgow as a whole. While this is not strictly an additionality analysis, in the absence of a counterfactual, comparison to similar sites is the best that can be done. More generally, businesses occupying premises close to Glasgow Green felt that the location was attractive to customers, and that it also helped to improve staff morale and retention (see Section 3.1).

It is not clear whether the Glasgow Green regeneration also prompted investment in new or refurbished commercial property. There is some evidence on this from elsewhere, with higher occupation rates being reported in various studies. However, issues of displacement, i.e. whether increases in occupation rates are genuine or they are offset by decreasing rates elsewhere, tend to remain unexplored. Evidence in this area is generally presented in terms of improved or new green infrastructure acting as a magnet for established businesses, especially those that are looking to expand anyway.

According to Ernst and Young (2003), a good example of this is Bryant Park in New York, which over two decades had deteriorated into an unkempt and blighted open space and had become a haven for crime and drug-dealing. In the late 1980s it was revitalised with \$30million of public and private funding, with new planting, walkways, lighting, seating, public art and open areas. The site also has food kiosks and a café/restaurant. A key ingredient in maintaining its popularity has been the management plan developed and implemented by a specially constituted corporation representing local resident and business interests. The immediate surrounding area has since become much more desirable, particularly to office-based businesses: in the two years after the park reopened, commercial leasing activity in adjacent streets had risen by 60% (Phillips, 2000). Within 10 years commercial rents had increased more than twofold, a rate much faster than for equivalent properties located further away from the park (Ernst and Young, 2003).

Figure 2.4: Bryant Park, New York



Source: Bryant Park Corporation

Office developments involving client/customer meetings generally look for proximity or view of urban park, as this is important in terms of image. Others may prefer business parks which combine accessibility to transport networks with a green environment. A prime example of this is provided by Arlington Business Parks, whose out of town office parks command at least city centre retail values (CABE Space, 2005). Similarly, environmental improvements in industrial areas via collaborative Business Improvement District (BID) initiatives indicate that a green setting is increasingly important for other types of business too (Symes and Steel, 2003).

A key issue here is the displacement, i.e. the extent to which the take-up of new or existing business space involves firms moving from elsewhere. Linked to this is the question whether these moves are associated with business expansion, and whether this would have happened anyway in the absence of improvements to green infrastructure. In cases where the area concerned is in need of regeneration, such moves can be beneficial regardless of whether businesses move from elsewhere.

One way of avoiding displacement is for the former premises of migrating firms to be re-occupied by new or existing firms. This process has not been explored in the literature directly associated with green infrastructure. However, there are a few studies that have used vacancy chain analysis to trace through the effects of building new business parks and industrial estates (Robson et al. 1999; Francis and Thomas, 2006). Not surprisingly these found a mixture of former premises being taken up by both new and existing firms, with some still remaining empty two years after the original occupiers moved to their new location. In other words, there was some displacement, but the moves also opened up available space for new and expanding ventures.

The scale of the research effort to unearth the evidence underpinning these studies underlines the difficulties of assessing additionality in terms of inward investment and business development. While it would be difficult to unravel the knots that this entails in order to claim unreservedly that green infrastructure acts as a prime stimulant for net new investment in an area, clearly the available evidence indicates that it does have a role to play. Rather than searching for the definitive but elusive answer, future research could focus on how important green infrastructure is for different types of business and how such requirements can be maximised by public policy interventions.

2.3 Visitor spending

Key linkages:

- Well designed and maintained green infrastructure makes an area more attractive.
- It attracts people from the local area and elsewhere to travel to green infrastructure features and make use of them.
- The direct and indirect expenditure for and during such visits contributes to the local and regional economy. Direct expenditure accrues to those businesses operating on the green infrastructure (e.g. events, cafes in parks) and indirect expenditure accrues to others in the vicinity (e.g. shops, hotels, taxis etc. in the town).
- The jobs created through the extra spending and the multiplier effect can also be calculated.
- This logic chain focuses mainly on the spending data but recognises that this is closely linked to other benefits of improved green infrastructure that do not involve spending (informal recreation, views from home and work place, lower crime rates, cleaner air, greater opportunities for exercise and so on).
- The literature reviewed here focuses on city parks and woodlands. Other green infrastructure features like street trees and vegetation, green walls, constructed wetlands around and within buildings such as shopping centres etc. will make cities more beautiful. More beautiful cities attract more visitors. However, such cross-city comparisons are not provided in the literature.

In immediate terms, good quality green infrastructure provides a range of amenities, facilities, attractions and activities that attract people to make use of it⁶. These may be local residents or visitors from further afield. In the wider context, it also contributes to the ambience of an urban setting, and in doing so plays its part in attracting people from elsewhere to spend time in the locality. Part of this equation is also the improved security (and associated lower crime levels) that tend to arise as a result of increased and improved greenery (see section 2.2 above). It is the direct and indirect expenditure associated with these trips that form the main contribution to the local and regional economy under this logic chain. Here the link is once again with the aesthetic aspects of cultural ecosystem services, with the non-material benefits of an attractive environment acting as a magnet for visitors from outside the local area, and their presence in turn having wider economic effects.

Before examining the available evidence, it is worth making two caveats explaining why analysing the spending data alone will underestimate the welfare increase that green infrastructure provides:

- The first is that, according to TNS Research International (2010), the majority (75%) of visits to the natural environment involve no expenditure on the part of 'consumers'. Part of the reason for this might be that these visits are made by local residents. In most analyses these would be excluded from the economic impact calculations, on the grounds that any money they did spend would essentially constitute regular expenditure and would accrue to the local area even if they chose not to make use of the green infrastructure (GI) in question. This is in line with a standard 'export base' approach to modelling local economies, where only the spending of visitors and money from other external sources are classed as an additional injection of money.
- The second caveat is that the majority of green infrastructure features are free of charge to those who make use of them. This means that there is little market-based intelligence, in the form of revenue streams, upon which economic impact analysis can be based. It also means that in many cases the data on (say) users of a park is very limited, and may not distinguish between different types of visitor. Of course there are exceptions to this, defined spatially (e.g. some nature reserves) or temporally (e.g. one-off events), where admission may involve payment of an entry fee. In such cases visitor characteristics and origins can be easily captured, and combined with broader survey data on hotel occupancy and average spend per trip to enable inputs to the local economy to be estimated. However, such analyses are likely to cover only a small part of urban GI, given the freedom of access to most green spaces and the relative infrequency of charging events.

The main link in this logic chain is between the net additional amount of spending made by visitors attracted by the GI and associated amenities, and the benefits it provides in terms of extra trade for businesses and the jobs associated with it. These impacts may be direct, in the sense that they accrue to firms operating outlets or running events within the GI; and indirect, in that visitors may well make use of a range of ancillary services in the wider urban areas, such as shops, cafes, restaurants, hotels, guest houses, taxis, cultural pursuits, etc. One potentially confounding factor for any impact analysis is the extent to which this wider 'package', rather than just GI features, forms the basis upon which visitors have been attracted to the area. In such circumstances, isolating the role of GI in attracting visitors and their wider economic impact becomes very difficult.

⁶ Note that not all green infrastructure is there for recreational purposes. But recreational use and related visitor spending is the focus of this section.

Nevertheless, some studies have attempted to assess the role of GI in attracting visitors to an area and their spending. Examples from the UK include the following:

- GFA Race and GHK (2004), who estimated that since 1995 an additional 330,000 visitors had entered the area covered by the National Forest, spending £128 million annually and creating over 500 new jobs. These figures indicate a substantial economic impact on this measure alone.
- Regeneris Consulting (2009) concluded that the direct increase in economic output in Merseyside from tourism spend by visitors to the Mersey Forest was £252,000 net GVA per annum. It may be that the more expansive and less densely populated urban forest environment makes it difficult to achieve larger economic impacts. In more tightly confined, dynamic urban settings, such downstream effects may be easier to capture.
- In the case of Glasgow Green, for example, the original £15m investment created an attraction where subsequent visitor spending was estimated to have generated around £30m net additional worth of sales in the wider economy, almost £8m in terms of additional wage and salary payments, as well as around 35 extra FTE jobs (see Section 3.1).

While UK research in this area is rather thin on the ground, there are several studies of the economic value of parks in US cities undertaken by the Trust for Public Land (TPL, 2008a, 2008b, 2008c, 2009a, 2009b, 2010a, 2010b, 2010c, 2011a, 2011c)⁷. These follow a common methodology agreed at a conference of park experts and economists in 2003.

Perhaps because of the much richer and consistent data available to them, these US studies have been able to undertake 'gross to net' conversions to produce estimates of additional economic activity. These reports also look at the economic contribution of a whole network of parks and recreational spaces to their host cities, thus capturing impacts for the city economy as a whole, rather than just the partial role of individual GI elements. Moreover, they do this across a basket of economic indicators, not just in terms of visitor spending. The full results of these analyses are reproduced here (see Table 2.2), for convenience and to set the visitor impacts in their broader context. Overall the figures show that in major cities, non-market benefits are often much higher than the benefits through market transaction (a point made in Section 1). Areas where tourism is a central component of the local economy, such as Nassau/Suffolk Counties (Long Island) and Virginia Beach, gain much more in terms of additional income from visitor spending.

In terms of these tourism effects, the key column here is that labelled 'net income'. This has been calculated by extrapolating the results of small-scale surveys indicating the proportion of tourists visiting the city who make use of its parks, and then assuming that half of these made the visit primarily because of these green spaces. This is then linked to known spend profiles for different types of visitor, provided by the local tourist board. The total generated by this process is then subject to a flat-rate factor of 35%, held to be the average surplus left over after all expenses have been paid. This can be taken to represent the 'net income' amount available to fuel further activity in the local economy.

⁷ These reports from TPL were found to provide convincing evidence for the New York City's investment in green infrastructure, including the Highline Linear Park described in Section 3.5 (personal communication, Andrew Newmann, Programme Manager, Million Trees NYC, 14 March 2013).

Table 2.2: Estimated annual monetary value of benefits of US city parks

City/Area	Pop'n (m)	Park area (acres)	Prop'rty tax (\$m)	Sales tax (\$m)	Net income (\$m)	Health benefits (\$m)	Water/ drainage (\$m)	Air quality (\$m)
Wilmington DE	0.07	444	1.08	0.13	0.72	4.32	0.41	0.04
Seattle WA	0.61	5,400	14.77	4.39	30.03	64.09	2.31	0.53
Philadelphia PA	1.53	10,334	18.13	5.18	40.26	69.42	5.95	1.53
Mecklenburg Co NC	0.92	17,600	3.91	4.37	18.77	81.49	18.89	3.89
Boston MA	0.63	4,755	8.26	1.92	6.71	78.04	8.67	0.55
San Diego CA	1.33	47,352	3.92	8.58	40.03	45.12	3.40	5.92
Sacramento CA	0.47	5,220	0.42	2.61	9.23	19.87	0.84	0.36
Denver CO	0.62	6,200	4.08	3.05	18.03	64.96	0.80	0.13
Nassau/Suffolk NY	2.83	135,300	58.20	27.30	614.40	163.50	23.88	18.86
Virginia Beach VA	0.44	33,640	2.22	8.43	295.00	38.47	1.52	4.52

Sources: Trust for Public Land (2008a; 2008b; 2008c; 2009a; 2009b; 2010a; 2010b; 2010c; 2011a; 2011b). Calculation of health, water/drainage and air quality benefits is discussed in Sections 2.3 and 2.4.

NOTE: Base years used in these analyses were as follows: Wilmington 2008 (property values 2007-8); Seattle 2009 (property values 2008-9); Philadelphia 2007 (property values 2006-7); Mecklenburg 2009 (property values 2005-9); Boston 2007 (property values 2006-7); San Diego 2007 (property values 2006-7); Sacramento 2007 (property values 2006-7); Denver 2008 (property values 2007-8); Nassau/Suffolk Counties 2008 (property values 2007-8); Virginia Beach 2010 (property values 2009-10).

Other studies in the US underline the potential scale of consumer spending linked to GI. Thus, a synthesis report the National Recreation and Park Association (2004) quoted a study of the eastern part of San Francisco that revealed park users spend approximately \$250 million annually at associated food outlets, retail stores and service providers; whilst the development of the 45 mile long Washington and Old Dominion Railroad Park in Virginia has been accompanied by the emergence of a raft of associated businesses, such as bike and running stores, cafes, restaurants, antique shops and overnight accommodation, mostly in towns along the route.

There is clearly a need for more UK-based evaluation studies in urban settings along the lines of the Glasgow Green example, or even the USA TPL approach if data availability will allow it. This is particularly the case for places where public interventions are seeking to contribute to economic and social regeneration. It would be good if local additionality estimation formed a part of such work, thus enabling the demonstration of net regeneration benefits to areas adjacent to green infrastructure schemes, which have encouraged an increase in visitors from elsewhere. However, any additional evidence of the regeneration impact of green infrastructure investment would be welcome. As part of this, figures on visitor spending (where available) could be used to estimate the amount of additional money flowing into the local economy and, by extension, assessment of the extra needed to stimulate business expansion (in the form of additional employees and/or extra outlets) on the one hand, and new start-ups on the other.

Again, any increase in visitors to any area because of investment in green infrastructure is likely to be subject to some degree of displacement. Where the effect is an improvement of the economic base of a disadvantaged area, this should be seen as positive, in that it will help to alleviate poverty and deprivation amongst the local population. Unfortunately few studies have examined whether visitors travel to such destinations primarily because of the green infrastructure, or whether these trips are additional to the ones made to

other places. Nevertheless, any contribution they make to local economic growth in areas of need will be worthwhile in itself, regardless of whether or not it also helps to expand the national economy (for this it would have to involve an overall increase in trips by both national and international visitors).

2.4 Environmental cost savings

Key linkages:

- Green infrastructure provides regulatory ecosystem services such as climate regulation and alleviation of urban heat island effects, carbon sequestration, contribution to biodiversity, regulating air quality and reduction of flood risks.
- The benefits of these services lead to two types of cost savings:
 - the cost of the damage they avoid is saved (e.g. planting trees near a building reduces the heating bill for the building);
 - spending on wider environmental services across a city or region can be reduced by using green infrastructure in preventive ways (e.g. providing flood risk reduction via absorption of rainfall in green spaces or in wetlands to store rain water instead of building flood defences).
- Linking these savings to economic growth requires answering the question of how the saved money would be spent instead. For example, lower public spending on environmental protection, clean up or alleviation of damage can lead to reduced taxation, or the money saved can be diverted to other public spending. Both could lead to further income and spending in the economy.
- The available studies that estimate the environmental cost savings do not follow through the logic chain to investigate what happens to such savings.

Often the most immediate and clear impact of green infrastructure (GI) is its role in providing regulatory ecosystem services such as climate regulation and alleviation of urban heat island effects, air quality, and flood risks, as well as carbon sequestration and contribution to biodiversity. This section assesses the evidence for interventions that generate each of these services in turn.

Although there is a relative abundance of qualitative and quantitative (scientific) evidence to demonstrate these services, few studies have taken the analysis further to consider their economic impact. One exception is the role of GI in regulating air quality. There is evidence that trees can have a substantial impact on air quality by removing pollutants from the air, including sulphur and nitrous oxides, ozone and particulate matter (Beckett et al. 1998; Broadmeadow and Freer-Smith, 1996):

- In a study of Mecklenburg County, North Carolina, the Trust for Public Land (2010a) found that pollutant removal by trees amounted to an economic saving of US\$4 million, based on the cost of preventing the pollutants from entering the atmosphere, for instance by changing production processes. This study was replicated for other US cities, as shown in Table 2.2, above.
- A similar study by McPherson (1993) found an annual average value of \$3.25 per healthy 40 foot deciduous tree in terms of air pollution absorption, and a further \$2.81 per year for CO₂ sequestration.

These studies give a useful valuation of cost savings, but do not go further in exploring impact on the economy. The inference from such findings would be that cost savings to businesses or the public purse may lead to savings being spent in business expansion and

job creation, but the literature does not take steps to establish this through further analysis.

Studies that explore the regulatory services of GI also include valuation of carbon reduction. The values used (e.g. shadow cost of carbon) measure the value of the damage that would have been caused had the carbon been released. As such they are not indicators of how this damage (cost) saving can contribute to economic growth. As the cost of carbon emissions increases, low carbon infrastructure may become a more important locational factor for firms (see Deloitte, 2009), but there is no evidence of the role of GI in this at present. The same issues apply to the other areas of environmental cost-savings explored below.

GI can also play an important role in regulating local microclimates (Forestry Commission, 2010). Broadmeadow and Freer-Smith (1996) report that daytime temperatures in a large urban park can be 2 to 3°C lower than in the surrounding streets, with cooling effects felt up to 100 metres from the site. Similarly both Whitford et al. (2001) and Liverpool City Council (2010) found that additional GI was likely to reduce the 'urban heat island' effect, especially where it incorporated a high density of trees. There are also some studies that estimate the cost saving due to this service:

- The cooling effect has been valued by the US Department of Energy, who found that placing three large trees around a house can save \$100 - \$250 per year in energy costs (McPherson, 1992).
- In the UK, Rawlings et al. (1999) similarly found that the sheltering effect of trees could save 3 to 9% of energy bills.
- A study by Liu and Harris (2007) on commercial buildings estimated cost savings at around 18% of heating bills.

A third area of potential benefit for which there is evidence on the value of cost savings is the role of GI in reducing flood risk. As well as conventional GI, this might include GI implemented specifically for drainage purposes, such as green roofs or sustainable urban drainage systems (SUDS). SUDS cover a range of different approaches to filter and/or retain water near where it lands (Duffy et al. 2008). Similarly, green roofs reduce the speed of water run-off, as do green permeable surfaces more generally. For example, Gill et al. (2007) found that increasing green cover by 10% in urban residential areas reduces run-off from a 28 mm rainfall event by 4.9%; and increasing tree cover by 10% results in a 5.7% reduction. There would also be additional savings from the prevention of erosion and the need for dredging as well as reduction in pollution entering aquatic systems.

To value the flood risk reduction service, The Trust for Public Land (2010a) compared actual storm run-off *with* parks against the theoretical run-off that would occur if there were *no* parks in Mecklenburg County. Annual figures were based on the amount and characteristics of rainfall from recorded weather data, with the reduced amount absorbed by parks estimated according to their additional perviousness. The cost of treating storm water was obtained by dividing spending on storm water facilities for 2009 by an estimate of the total amount of water falling on the developed areas of the county. This led to a calculation of storm water conveyance of US\$0.0344 per cubic foot, which, when applied to the amount of run-off absorbed by parks, came to an annual saving in the region of US\$19 million per year.

A more recent study in the US looked specifically at the economic benefits of a range of different green infrastructure stormwater solutions, including green roofs, rain gardens, bioswales, pervious pavements and capture and re-use of water on site (Odefey et al. 2012). In summary the main findings were as follows:

- Green infrastructure generally involves lower capital costs, smaller land acquisition requirements and reduced operational expenses, thus providing a less expensive and more cost-effective approach to managing runoff.
- Green infrastructure increases energy efficiency and reduces energy costs.
- Green infrastructure can reduce the economic impacts associated with flood events, such as the costs of repairing damage to property and the wider urban fabric.
- Green infrastructure protects public health and reduces illness-related costs by preventing contamination of drinking water supplies, recreational waters, and productive fish and shellfish areas.

The argument that not building and maintaining flood walls is justified on the basis of the savings generated has been used by organisations such as the Environment Agency for England and Wales to make a business case for investing in green infrastructure, along with the additional biodiversity and recreational benefits of these alternative approaches (e.g. managed realignment, constructing wetlands) (eftec, 2010). Similarly, many 'city greening' programmes are based as much on economic arguments as on the need to reduce ecological footprints. For example, in Canada the Vancouver *Greenest City 2020 Action Plan* states that achieving its goals "...will improve our quality of life and make us even more globally competitive, while helping us live in better balance with the Earth's natural systems" (City of Vancouver, 2012, p.5).

As noted above, while there is strong evidence on the environmental cost savings generated by green infrastructure, they are not explored further in terms of their actual impact on economic growth. It might be the case that the money saved from these reductions is diverted into investment in growing economic activities (e.g. directly via use of retained profits or through increased resources available through savings and investment vehicles; or indirectly via increased consumer spending). Cost reductions may also feed through into greater availability of public resources which could support an increase in expenditure on other activities; the emphasis here could be on those providing an economic stimulus, with associated impact on growth. Alternatively cost savings may enable reduced public spending, leading to lower taxation. For householders, such cost savings may mean reduced insurance premiums and building maintenance costs, and associated increases in other spending or saving.

All of the above are likely destinations for the money freed up in this way, so it is reasonable to assume that at least some of these resources will contribute to increased economic activity and hence economic growth. This is a reasonable assumption that can be used in support of green infrastructure investments, even if it would be extremely difficult to trace these flows through in detail, and virtually impossible to assess how they might feed through into specific aspects of economic growth and resultant increases in GVA or greater levels of employment.

2.5 Health benefits

Key linkages:

- Improvements in, and increased use of, green infrastructure can improve people's health, which in turn produces economic benefits.
- The improvements come from regulatory services that provide cleaner air and water, and outdoor recreational activities that generate physical and psychological benefits.
- The health improvements can lead to economic benefits through:
 - cost savings to the National Health Service (NHS);

- increased economic output due to a reduction in ill health, stress and absence from work; and
- increased economic output due to a reduction in the incidence of premature death.

This logic chain starts from the proposition that green infrastructure can contribute directly to improvements in people's health, and rests on the proposition that these improvements in turn produce downstream economic benefits. Triggers for the chain may be linked to several ecosystem services: regulatory, in the form of better air and water quality; health, in connection with physical and psychological benefits of exercise and exposure to the natural world; and aesthetic (or cultural) through the amenities and facilities that support such activities.

There is strong evidence from a large number of high-quality studies spanning several years that green space alleviates stress, fatigue and other mental health issues, with positive effects on mood, concentration, self-discipline, and physiological stress (see, for example, Health Council of the Netherlands, 2004; Kaplan and Kaplan, 1989; Halpern, 1995; Berman et al. 2008; Ulrich, 1984; Ulrich et al. 1991; Grahn and Stigsdottir, 2003). This effect was found to be especially marked for residents in large urban areas, and in particular for children and young people (Kaplan, 1995; Taylor et al., 2001). Similar effects can be found when people have contact with nature in work, as revealed by a study by Largo-Wright et al. (2011) of university staff in the south-eastern US.

Much of the research tracing the positive effects of urban green spaces on mental wellbeing has drawn on cross-sectional evidence, without taking into account the prior psychological health of the survey sample. A recent paper by White et al. (2013) sought to advance understanding beyond this by using British Household Panel Survey data from over 10,000 individuals living in English urban areas to explore the relationship between green space and wellbeing (indexed by ratings of life satisfaction) and between green space and mental distress (indexed by General Health Questionnaire scores) for the same people over an 18 year period. The amount of green space available to each person was assessed at the Lower Super Output Area (or neighbourhood) level, using data from the Generalised Land Use Database. Their analysis was based on a 'fixed effects' approach that allowed the influence of a range of changes in people's circumstances to be compared, including moving to areas with greater or lesser amounts of green space. The study found that individuals had both lower mental distress and higher wellbeing when living in urban areas with more green space. While the effect at the level of the individual was relatively small, the cumulative benefit for urban populations is likely to be significant, given that much of the green space is accessible to everyone.

The links between green space and physical health improvement are dependent on the amount of exercise that people take in that environment. A number of studies have noted that people living in areas close to accessible green space have a higher propensity to take moderate exercise that leads to enhanced physical health (see for example Jones et al. 2009; Mitchell and Popham, 2008; Kuo and Sullivan, 2001a; Nielsen and Hansen, 2007; Takano et al. 2002; Pretty et al. 2003).

However, other research that has specifically examined the relationship between exercise levels, health improvement and actual physical distance to nearest green spaces has produced mixed results. On the positive side, Coombes et al. (2009; 2010) found a positive relationship between levels of activity and proximity to a formal park, even when controlling for respondent and area characteristics. Those living further from green spaces were less likely to meet guidelines on physical activity levels and were more likely to be overweight or obese. Conversely, in an earlier study Hillsdon et al. (2006) found no

significant relationship between distance to and quality of parks on the one hand, and activity levels on the other; and Maas et al. (2008) could find no consistent relationship between the amount of green space in an urban environment and whether or not people living in the area met the Dutch public health recommendations for physical activity.

There is also an emerging body of literature that links improved health to economic impacts. Some of this is of a conceptual nature, mapping out the potential areas of impact. Thus Mourato et al. (2010) identified three main types of economic benefit flowing from better health:

- cost savings to the National Health Service (NHS);
- increased economic output due to a reduction in ill health (morbidity), stress and absence from work; and
- increased economic output due to a reduction in the incidence of premature death (mortality).

This study presented a hypothetical scenario which assumed a 1% reduction in the sedentary population in the UK (i.e. an increase in the number of people who are physically active on a regular basis). The resulting improvement in morbidity and mortality was estimated to lead to overall annual cost savings of £1.44 billion when those aged 75 and over are included in the analysis, or £450 million when they are excluded.

There is also a large literature on health benefits using the Quality Adjusted Life Years (QALYs) measure, which combines length of life with quality of life. Thus, one year of perfect health is equivalent to one QALY and any year with a decrease in health is given a value less than 1, but above 0 (which equates to death) (Drummond et al, 1997). There have been some attempts to estimate the monetary value of a QALY (e.g., Tilling et al. 2009; Jones-Lee et al. 2007; Mason et al. 2009). The latter study is based on UK figures and provides estimated monetary values of a QALY ranging from £6,414 to £21,519.

Because it is not directly linked to green infrastructure, this literature is not reviewed here. However, it offers helpful context and potential methods for future research, especially in the scope it might provide for linking changes in environmental and disease risk parameters and health outcomes. The improvements in these parameters due to GI investments would need to be quantified for QALYs to be used in this context.

In terms of health care and other cost savings, Bird (2004) estimated that a park in Portsmouth might provide potential savings of £4.4 million each year, including £910,000 to the NHS; and that a 3km footpath on the edge of Norwich could potentially save the economy £1 million, including £210,000 to the NHS.

Some studies have estimated the economic benefit flowing from 'green exercise':

- A UK Department of Health study estimated that a 10% increase in physical activity in adults would bring an overall economic benefit to England worth at least £500 million per year, of which 17 per cent (or £85 million) would be a direct saving to the NHS (Foster et al., 2009).
- In the US the various studies by the Trust for Public Land (see Table 2.2 above) also contained estimates for cost savings with respect to medical care and public health from green spaces. These were derived by applying a set of annual figures for over and under 65s to survey findings in terms of residents' use of local green space, with the results representing the difference in health care costs between active and inactive people.
- The World Health Organisation's (WHO) Health Economic Assessment Tool (HEAT) for cycling and walking allows estimation of the economic benefit of physical

exercise in terms either of health service cost savings or of 'willingness to pay' for additional years of life (Kahlmeier et al., 2011). This calculation takes into account reduction in premature death (mortality) but not susceptibility to illness (morbidity). There is an online calculation tool that allows users to vary the inputs according to scale of intervention, number of beneficiaries and national variations. As an example, if 100 people start walking one kilometre per day, this will produce a 10% reduction in mortality, with average annual benefits for this group of individuals assessed as being worth £31,000 (or £305k over a 10 year period).

Quantitative and monetary evidence on the incidence and scale of labour productivity gains and associated increases in economic output resulting from the physical and mental health benefits of green space is much harder to come by. It may be that establishment of the link to green infrastructure would be a step too far for studies of this nature. Alternatively, it could be argued that merely demonstrating the link between improved health and higher productivity would be sufficient.

Thus, there is strong evidence that increased use of GI promotes improvement in physical and mental health; and as is discussed below, there are studies which have established a connection between improved health and higher productivity. Therefore, it should be safe to assume that the health benefits accruing to people making use of GI feed through into improved attendance at the workplace, enhanced productivity and subsequent increases in economic output and performance.

Bloom et al. (2004) summarised the results of a dozen previous studies, most of which concluded that a 5-year increase in life expectancy would have a positive effect on economic growth. In their own calculations they apply an aggregate production function model to a panel of countries, using data at decennial intervals between 1960 and 1990. They conclude that on average a one-year improvement in a population's life expectancy contributes to an increase of 4% in economic output. As they state, "this is a relatively large effect, indicating that increased expenditures on improving health might be justified purely on the grounds of their impact on labour productivity, quite apart from the direct effect of improved health on welfare" (p.11).

A more UK-specific, individual-based study was undertaken by Layard et al. (2007). This involved a cost benefit analysis of the potential use of cognitive behavioural therapy (CBT) for people suffering from clinical depression or anxiety disorders. They estimated that people receiving CBT would be 4 percentage points more likely to be in work over the next two years; and that the extra output generated (plus improved performance of those already in work) over this period would be £1,100 per person. This was a conservative figure: the evidence suggests a relatively low relapse rate for those receiving such treatment, and hence a high persistence of the benefits over several years. In this case the use of an active intervention (CBT) may be a strong factor in producing the effect; but provision of GI and encouragement of its use for physical activity and quiet contemplation (through awareness campaigns, local advertising, special events and active leisure initiatives) may have similar effects on a larger number of people.

Combining physical activity in GI and psychological therapy may well bring high benefits. A study by the University of Essex (2008) sponsored by the mental health charity, Mind, found that 'green exercise' (or 'ecotherapy') helps to lower stress, to increase self-esteem, to improve physical health, to provide meaning and purpose and to develop skills. Indeed some ecotherapy projects offer specific qualifications and routes into employment. Unfortunately the research and evaluation evidence for such activity is currently at the development stage. However, it would appear that such approaches would offer a ready-

made context for more detailed exploration of the connection between GI, health improvement and economic outcomes.

2.6 Market sales

Key linkages:

- Green infrastructure, in particular private gardens, allotments, communal gardens and woodlands can produce goods that can generate economic returns either through being sold in the market or through reducing the need for purchasing food.
- There are not many studies that estimate this economic return as such green infrastructure is generally provided for its benefits in terms of physical activity and as places to get away from the urban environment.
- Thus, market sales data underestimate all such benefits provided by GI but they are worth presenting separately to make their existence explicit.

Ecosystem provisioning services encompass activities that lead to the production of goods for the human use and management of natural resources. Such products might include food (raw and processed), plants, seeds, timber, fuel, water, fibre, genetic resources, biochemicals, natural medicines, pharmaceuticals and other manufactures using this natural produce (e.g. wooden furniture). A distinguishing feature of most of these in economic terms is that they can be bought and sold in the market place, and in the process have a direct value assigned to them. Even where they are not traded, a market value can still be assigned: for example, crops from an allotment act as a substitute for shop-sourced alternatives, thus saving the consumer the retail cost of those purchases.

Extensive literature searches unearthed just a handful of studies that included an examination of the use of GI for such provisioning in economic terms. Academic interest in 'community gardens', for example, has tended to assess them in terms of alternative lifestyles and radical politics in cities such as New York, San Francisco and Toronto. One of the few UK studies in a purely urban setting and with an economic component is an assessment using the Green Infrastructure Valuation Toolkit of a 43 home ecohousing development (the Triangle) in Swindon (Jaluzot, 2011, for the Horticultural Trades Association). The development incorporated both kitchen gardens for each individual dwelling and areas for communal fruit trees (including polytunnels). The analysis calculated that the annual yield from these plots might be between 900 and 1,800kg, worth between £14,000 and £25,000 at present values. These are relatively small sums, and unlikely to be sufficient to stimulate much in the way of local economic growth. It remains to be seen whether such activity can be replicated in larger developments, or be scaled up across a larger number of similar schemes, as a means of releasing sums that would make a difference in wider economic terms.

There is growing importance being attached to the provenance of food supplies, and the increasing emphasis on sourcing local supplies as a means of combating carbon and greenhouse gas emissions. This has prompted the use of incidental open space within some towns and cities for the cultivation of fruit and vegetables (for example, in Todmorden, West Yorkshire). Such continued trends are likely to make further work on the economic consequences more feasible and interesting.

However, market values of such produce are not the main focus of providing GI for this purpose and the lack of attention to the economic benefit of produce from green spaces is likely to be an artefact of this. The main focus of such uses of GI is that they act as important escapes from the urban environment, to provide areas for leisure, recreation and relaxation. Even allotments may be seen primarily as fulfilling this role as well as

contributing to the nutritional value of diet through higher proportion of fresh produce. Thus, any analysis of allotments should include both health and market sales values.

In summary, while at first glance, market sales appear to be the most straightforward of the logic chains to quantify⁸, empirical evidence is lacking for various reasons. The key data on product volumes and employment levels, which are likely to be low, are extremely hard to come by, and there are no proxies or benchmarks available so that they could be simulated. Such market sales are not the focus of GI provision but with increasing importance of local food and other products, this link in the logic chain might warrant more detailed investigation and development in future. Where this involves self-provisioning on a family or community basis, the focus should be on what use the money saved from avoiding commercial sources is put.

2.7 Employment generation

Key linkages:

- Green infrastructure provides jobs: on site in construction, maintenance and operation, and off site in parts of the tourism sector that rely primarily on use of green spaces.
- The jobs created need to be additional to what already existed and to what might have arisen anyway: i.e. they would not have been created if GI investment did not take place, in order for the job creation to provide a net contribution to economic growth over regional and national scale.
- This contribution arises not through the jobs themselves but through the multiplier effects of the increased consumer spending associated with them.
- However, from a local decision-making perspective, such additionality analysis may not be needed as long as additional employment opportunities are given to the local population with the resulting regeneration impact of increased local incomes.

Provision, maintenance and management of green infrastructure inevitably entail various forms of paid employment. This can be divided into three types:

- on site development jobs in activities like construction, earth moving, landscape architecture and design;
- on site operational jobs concerned with management and upkeep, with posts including wardens, rangers, gardeners, foresters, managers and technicians, as well as staff looking after facilities and attractions, and
- off site ancillary jobs in suppliers and other supporting firms, including those in the tourism sector which rely primarily on use of green spaces (e.g. for events).

Any increase in current levels of these various types of employment will not only have an effect on the wider economy (e.g. through greater use of supply chains), but they will also give rise to a local economy multiplier effect through the higher aggregate disposable income available to local households that they provide via wages and salaries. Of course, existing jobs in GI provision and associated ecosystem services already make a contribution to the wider economy. Any impact on economic growth via multiplier effects

⁸ As the Green Infrastructure Valuation Toolkit (Green Infrastructure North West, 2010) points out, the calculation is simple: the quantity of produce multiplied with the unit market value over a given period of time. Employment effect can be estimated through actual employment in productive activities and the sectoral Gross Value Added figure for one full-time equivalent job (subject to appropriate 'gross to net' additionality calculations). It might then also be possible to undertake multiplier analysis to trace the further impact of these activities on the local economy.

can only occur where there is an increase in GI-related employment. The same can also be said of any increase in employment associated with the business growth emanating out of the 'Inward Investment' and 'Visitor Spending' logic chains (see Sections 2.2 and 2.3).

In terms of the current size of the GI sector, CABI (2010) estimated that the number of people directly employed in the 'green space sector' (including public parks departments, nature reserves, botanical/zoological gardens, landscape services and architectural services) at about 122,000 in England. This represents around 5% of all jobs in the country, and 7% of service sector employment. The figure is actually greater than for some industrial sectors such as electrical equipment, precision instruments, textiles and clothing, furniture and shipbuilding. Unfortunately the CABI study did not go further in assessing the occupational breakdown of these jobs, nor did it attempt to place an economic value on them in terms of their contribution to GVA. In view of the comment above on the wider economic benefits of jobs growth, it would also be helpful to know whether total employment in the sector has increased or decreased over recent years.

Two of the case studies examined in Section 3 below include estimates of employment effects, although these do not include the direct jobs of the type covered by CABI:

- The evaluation of the Glasgow Green improvements estimated that the actual works involved around 200 temporary jobs in construction and landscaping. The net increase in visitor spending following reopening then supported around 80 jobs in total, half of which were assessed to be additional to what had been there before. The wider business impact in the surrounding area as a result of the park's upgrade was estimated to generate an additional 230 jobs between 1998 and 2006. (GEN Consulting, 2006; see also Section 3.1).
- The study of the impact of canalside development in Birmingham city centre by GHK (2009a) also contains some employment estimates (see also Section 3.2). The waterways improvement plus the surrounding commercial and public developments were assessed as involving around 700 construction job-years (i.e. the equivalent number of posts assuming that all had a one-year duration). Between 2001 and 2007 the waterways element of the scheme was adjudged to have generated an additional 85 FTE jobs through visitor spending, and had contributed an additional 30 FTE jobs in commercial firms based in surrounding premises.

Other project assessments have included employment impact estimates. For example, Table 2.3 presents the results of a series of annual case studies for the Heritage Lottery Fund, GHK (2008; 2009b; 2010) which estimated employment effects from funded projects in terms of direct job creation in suppliers; and indirect and induced employment (via visitor spending and multiplier effects in the wider regional economy). These were expressed in 'job years', and also converted into GVA to illustrate their contribution to the economy. While only eight out of 30 projects related to green infrastructure, the results make interesting reading, as Table 2.3 illustrates. Those of a more rural nature have been retained in the analysis on the grounds that the majority of their users are likely to be from surrounding urban areas.

Another case study by Burton (2008) considered the effects of improving a rundown industrial estate in Wakefield, West Yorkshire. The scheme involved a mixture of site clean-up, design enhancements, security measures and environmental improvement. A management plan was also put in place to maintain the estate's appearance. The result was a more attractive business setting, leading within a year to 16 new businesses employing over 200 people relocating to the estate. While no assessment was made of

displacement or deadweight effects, the figures do bear out the potential pull that 'greened' areas have for both inward investment (see Section 2.2) and employment.

Table 2.3: Employment and GVA Impact of Selected HLF Projects

Project Name	Year of Study	Project Cost (£000)	Employment Effect (job years)	Contribution to GVA (£000)
Stoke Poges Gardens	2008	840	31.3	1,100
Wicken Fen		260	39.9	619
Croome Park	2009	4,900	177.4	5,000
Herts & Middlesex Wildlife Trust		820	32.4	1,100
Home Farm Marsh		367	0.9	42
Lincoln Arboretum		2,900	8.4	376
Greystones Farm	2010	469	2.4	111
Sherwood Initiative		5,500	25.2	7,400

Source: GHK (2008; 2009b; 2010)

While these various employment impact estimates are useful, it would be helpful if there was a more consistent basis to methods of assessment, and routine application of 'gross to net' additionality calculations as a means of indicating the likely extra impact of GI. As well as these basic principles in terms of the overall numbers, it would also be useful to produce breakdowns in terms of occupational structure, so that more accurate estimates of contribution to GVA and the likely scale of multiplier effects can be produced.

2.8 Applying the Logic Chain to Green Infrastructure in Integrated Schemes and City-wide Development

This section provides evidence from cases where green infrastructure development takes place alongside, or as a component part of, other forms of development aimed at generating economic growth. Evidence is presented as linked to some of the logic chains discussed in detail above. The cities covered are highlighted in bold for easier identification throughout the text.

The case study of **Birmingham** canalside presented in Section 3.2 below, for instance, involved not just waterways improvement but also a range of other large-scale public and private investments (GHK, 2009a). However, the canal works were integral to the overall success of the development as a whole. A number of similar examples of integrated development arise in the literature. Unfortunately this material tends to be more anecdotal than many of the studies examined so far, although figures are provided in some cases. None of the examples attempts to establish the specific role of GI within the developments discussed. Nonetheless these examples are worth including as they underline even more strongly the difficulties in disentangling the influence of GI in terms of economic growth.

Chattanooga, Tennessee provides a well-known example of such development. Here, initial investment in parkland and waterfront infrastructure was used as a setting for other investments in landmark developments such as a baseball stadium and aquarium, beginning in 1989. This investment totalled US\$410 million in investments from public and private sources, including the US\$45 million Tennessee Aquarium. In turn, investment in hotels, restaurants and other leisure facilities in the area took place. Outputs and outcomes of this development included the following (ConsultEcon, no date):

- More than US\$1.2 billion has gone into public and private building projects in and adjacent to downtown Chattanooga since 1990.

- 300 new housing units have been built, with an additional 250 units under construction.
- Tourism increased 73% between 1995 and 2000, with tourists spending 50% more in 2000 than 1991.
- New businesses in the vicinity of the Tennessee Aquarium increased from 33 to 128 since the development project began.
- The number of downtown workers has increased 33%.
- The city has experienced a 127% increase in property values and a 99% increase in property taxes.

It is clear that the heavy investment in the built environment was a key component in generating this growth, but the development and improvement of GI along and around the waterfront as a setting for these developments has been crucial to its success, including as a means to generate significant levels of buy-in from the public (*ibid.*)

In **Toronto**, significant investment has been made with respect to the Lake Ontario waterfront, beginning in 2001 and continuing to date. Canadian dollar (C\$) 750 million (£480 million) was invested in 'revitalisation' projects between 2001 and 2009. This has resulted in the following outputs and outcomes (UrbanMetrics, 2009):

- Around 8,400 full-time years of employment, of which almost 70% were in the City of Toronto. The majority of the jobs created were in the construction sector, the professional, finance, insurance, real estate and leasing sector, and the scientific and technical services sector.
- The scheme is estimated to have contributed C\$1.6 billion (£1 billion) in total economic output to the Canadian economy.
- To date the redevelopment has generated revenues of approximately C\$180 million (£115 million) to the Federal Government, approximately C\$124 million (£79 million) to the Provincial Government, and approximately C\$20 million (£13 million) to the City of Toronto.

However, there are claims from some resident groups that this scheme has created a 'sanitised' form of public realm, with GI being low in environmental quality, used only as a canvas for private investment in commercial development. This, they argue, has led a loss of a true 'sense of place' to the waterfront areas (Project for Public Spaces, no date).

Thinking more broadly, the prevalence of GI in successful cities has been marked as an important element in their competitiveness, in particular as a means for marketing them to high-value firms and workers. For instance, Konijnendijk (2010) contends that since the 19th Century, many European cities have developed green space in order to maintain attractiveness to skilled workers and business-owners.

Barcelona's successful re-branding of the city following the 1992 Olympics as 'the sustainable city' provides one such example, with the revitalisation of green spaces a central part of the plan to generate inward investment and employment in the city (Jonas and While, 2007). This approach has been criticised by some as being a process of managed 'gentrification' of urban space, with incumbent users and residents subsequently marginalised in the redeveloped areas (McDonagh, 2011), but the image of the city has undoubtedly been transformed by the large-scale regeneration programmes that took place. However, while there is a wealth of studies that reflect on these processes, and on the revitalisation of the Barcelona economy, these do not tend to focus on the impacts of GI within this process: as such it is difficult to say much more on this.

Singapore has taken a similar approach in focusing on the quality of life gains of city-wide GI networks, with an underlying rationale that the aesthetic benefits of GI improve the attractiveness of the city for 'high-value' workers. The city state's 'a city within a garden' slogan captures this, reflecting a long history of maintaining and developing green space alongside economic growth in the city. Singapore's 'Green Plan' (1992-present date) has been identified by the World Bank (Leitman, 2000) as a best practice example of integrating environmental concerns into economic growth, but also - importantly for this review - the emphasis on GI is seen as having played a complementary role in Singapore's economic growth. The constraints on land in Singapore and its relatively exposed position on the Malaysian peninsula means that, in order to maintain stable environmental conditions for economic growth, effective land use planning has been crucial to economic development, including effective use of green and blue space for managing flood risks. The government has also placed value on the aesthetic qualities of green infrastructure, both in terms its cultural ecosystem service provision and its value for attracting inward investment (Yuen, 1996).

Chicago provides another example. The city has been engaged in a process of 're-branding' itself in recent years as a 'green' city, in part through investment in green infrastructure. The city's 'GO 2040' plan (Cmap, 2010) focuses on improvements in quality of life as a means of generating sustainable economic growth. This includes improvement of GI as a priority, as does the city's Sustainable Chicago 2015 Action Plan (City of Chicago, 2012). The Plan quotes studies that suggest that, for example, Chicago's urban forests are worth \$64 million through the capture of pollution annually. It also suggests that residents can benefit from 20 to 50% savings in summer cooling costs and up to 10% increase in property value from enhanced presence of birds and wildlife. An example of this on-going work is the city's Green Alleys project which has transformed 100 miles of alleyways from hard to permeable surfaces in an effort to reduce flood risks. Hedonic modelling of the value of green space in Chicago proffered some interesting findings, however: "Proximity to large parks had significantly positive effects on sales prices, regardless of specification, but proximity to small parks, on the other hand, had a consistently negative effect on property values, regardless of specification" (Shaikh, 2011 p11). This tallies with findings discussed in Section 2.2 above which suggests that certain parks may be likely to be perceived as points for concentrations of crime, and thus have negative economic effects.

Yonkers, New York City, is a suburb that had high crime levels and low prospects following the departure of industry that had developed the area until the late 20th century. Proximity to New York City (a 20 minute train ride) was not sufficient to revive this suburb. Local government sought funding to make the area more attractive for new residents and businesses, and found support from a multitude of funders (including environmental charities) for unearthing the river in the centre of the suburb. The river became the focal point of the area's greening by improving the scenery and natural life, encouraging the construction of residential properties and establishment of associated service businesses. Apart from the Seoul example (see case study in section 3.4), unearthing rivers does not have many precedents, but here it had the support of many stakeholders (cultural heritage, environmental improvement, local government and business as well as the general community), and was seen as a risk well worth taking, especially given the lack of credible alternatives for a community like Yonkers (pers comm, Caroline Bacle, documentary film maker, *Lost Rivers*, 2013). It is too soon to judge the full effect of the investment (having finished in 2012), especially in terms of additional economic growth (which is likely to accrue over the longer term), but there is continued local government, funder and community support for the project.

A further study worth mentioning in the context of city-wide effects is the analysis undertaken by Keskin et al. (2011) involving input-output and local multiplier analysis to estimate the impact of selected GI schemes on the **Manchester** and **Sheffield** economies. The techniques enabled an assessment of the value of additional output, employment and income in the two cities as a result of investment in GI (accounting for displacement). In this case the analysis generated figures of £0.94 *additional* worth of economic activity for every £1 spent on GI in Sheffield, and £0.83 for every £1 spent in Manchester.

2.9 Conclusions

This section has reviewed the available evidence pertaining to the links between GI and economic growth, through six logic chains. These have been found to be a useful device for setting out the relationships in both conceptual and empirical terms, but at the same time there needs to be recognition of their limitations. The chief disadvantage is their suggestion that these linkage mechanisms operate independently, whereas in reality they are suffused with interrelationships and feedback loops.

The evidence presented indicates that each logic chain has varying degrees of empirical support. The strongest conclusions can be drawn about the first four logic chains (inward investment, visitor spending, environmental cost savings and health improvement), particularly in terms of the immediate effects of green infrastructure to the local economy. How these translate into wider impacts on economic growth are less frequently addressed in the literature.

As outlined in the summaries at the start of each section, the review has highlighted the following economic benefits of green infrastructure:

- Well designed and maintained green infrastructure helps to make an area more attractive, thus bringing in more residents, visitors and businesses, all of whom are likely to contribute to an increase in spending on local goods and services.
- Additional jobs may be created through this extra spending and the associated downstream multiplier effects.
- Green infrastructure can provide an appreciable contribution, at lower cost, to environmental management, such as alleviation of urban heat island effects, carbon sequestration, improved air quality and reduction of flood risks.
- This will in turn lead to a reduction in the expenditure required to repair any damage caused by extreme events, and the money freed up in this way can be spent on more productive economic activities.
- Improvements in, and increased use of, green infrastructure can improve people's health, which in turn produces economic benefits, including cost savings to the National Health Service, increased output from workers due to increased longevity and greater productivity due to better health and increased wellbeing.
- Market sales of produce from different types of green infrastructure may help support new businesses and additional jobs, although there has been little research undertaken on the actual or potential scale of such effects.
- An increase in employment associated with green infrastructure will bring downstream economic benefits via the multiplier effects of higher levels of spending in a local economy, although the scale that this might reach has not been assessed.

The review identified a number of areas where the evidence was too thin to draw any substantial lessons from it. Some of the gaps that could benefit from further research are explored further in section 4 below. The focus of this exercise has been particularly on

practical aspects that could potentially contribute to policy development, and also on topics where methods and approaches exist to enable definitive conclusions to be drawn.

The confounding effects of varying context, integration with other public and wider private investment and the intractable problem of disentangling displacement effects all indicate that establishing conclusive links between GI and economic growth is likely to be an elusive goal. However, the existing qualitative, quantitative and economic evidence on the benefits of GI can continue to be augmented and used for decision making at local, regional and national scales.

3 Green Infrastructure and Economic Growth Case Studies

This section presents five case studies where green infrastructure could have acted as a catalyst to economic growth. The case studies are:

- Glasgow Green, Glasgow, Scotland;
- Canalside Development in City Centre, Birmingham, England;
- Philadelphia Land Care Programme, Pennsylvania, USA;
- Cheonggyecheon Stream, Seoul, Korea, and
- The Highline Linear Park, New York City, USA.

Each case study is summarised, as far as the reported evidence allows, in the following way:

- Description of the local context;
- Description of the initial change;
- Description of intermediary changes;
- Transferability of the experience and evidence to the UK, and
- Summary.

3.1 Glasgow Green Renewal

3.1.1 Local context

Figure 3.1: Aerial photograph of Glasgow Green

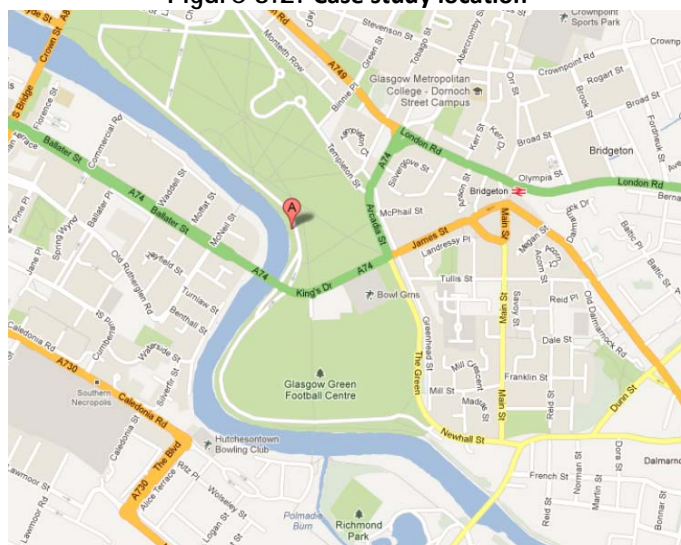


Source: Glasgow City Council

Glasgow Green is a 55 hectare area of parkland to the East of Glasgow city centre. It is the city's oldest park, having been donated to the city of Glasgow by Bishop Turnbull in 1450. The Green has played an important part in the history of Glasgow as - at times - its only piece of dedicated green space, and as the site for historic events including mass rallies, public meetings and the formation of Glasgow Rangers football club.

By the 1990s, however, the site had fallen into disrepair, and the Green had become a site reputed for vandalism and its use by drug-users and for prostitution. The Glasgow Green Renewal Project, led by Glasgow City Council, aimed to restore the Green and improve its image within the city. The Project, which took place between 1998 and 2006, received investment of £15.5 million, £10.3 million of which was leverage from other funding sources.

Figure 3.2: Case study location



Source: Google maps

3.1.2 Initial Change

The renewal project included the following developments:

- Restoration, enhancement and 'interpretation' of the key features in the park relating to Glasgow's history;
- Investment in physical fabric and infrastructure, including restoration of historic monuments; extensive boundary, carriageway and park furniture improvements; improved maintenance; appointment of Park Development officer & horticulturalist; improvements to safety and lighting, including installation of CCTV and help points; and
- Development of services and attractions, including the development of a 90,000 capacity external events space; investment in existing visitor attractions, such as the Winter Gardens; and a dedicated Park Ranger Service.

Figure 3.3: Glasgow Green



Source: Glasgow City Council

Figure 3.4: Photograph of Glasgow Green and Winter Gardens



Source: www.stv.tv

3.1.3 Intermediary changes

A study by GEN Consulting (2006) focused on an impact model that highlighted four areas of potential impact arising from the investment in Glasgow Green:

- Property investment, tracked through the following methods:
 - documentary evidence through planning consents, council tax records, housing register of Scotland, funding applications;
 - consultation with stakeholders and developers;
- Business investment, tracked through:
 - annual Business Inquiry statistics;
 - documentary evidence from funding applications;
 - consultation with local businesses;
- Increased visitors and use of the Green, measured through:
 - Glasgow City Council events information;
 - a visitor attraction monitor;
 - visitor survey;
 - consultation with visitors;
- Improved image and perceptions, measured through
 - visitor survey;
 - police records;
 - community council records;
 - consultation with visitors.

The study does not report any figures for absolute number of survey responses or numbers of interviews with stakeholders, developers, visitors and businesses. Without the size and representativeness of the sample for the surveys, it is difficult to judge the robustness and transferability of estimates.

3.1.4 Economic Growth

In terms of impacts on growth, the study looked at three geographic areas: 'in and around the Green'; 'the immediate surrounding area'; and Glasgow City (as a comparator). The findings are summarised under the four impact headings listed above.

Residential property investment

Table 3.1 presents the gross outcomes 'in and around the Green' between 1998 and 2006.

Table 3.1: Gross Benefits of Property Investment

Variable	1998	2006	% change
New residential units	1504 new units over the period (plus 3,666 in 'wider area')		
Council Tax receipts	£1,468,164	£2,164,679	47%
Average house price	£45,822	£68,640 (2005)	50% (compared to 111% across Glasgow)
Number of house transactions	30	134 (2005)	347%

Based on consultation with developers, the evaluation report estimated a 30-50% additionality ratio for the outcomes, i.e. 35% of the gross outcomes in the period studied can be attributed to the Glasgow Green development, giving net benefits as set out in Table 3.2.

Table 3.2: Net Benefits of Property Investment

Variable	Low	High
New residential units	500	750
Additional Council Tax revenue (per year)	£800,000	£2 million
Additional residential property transaction values	£3.0 million	£4.5 million
Construction jobs years created/supported	165	245

Business Investment

Gross outcomes 'in and around the Green' in terms of business investment are summarised in Table 3.3.

Table 3.3: Gross Business Investment Outcomes

Variable	1998	2006	% change
Number of businesses	192	222	16% (compared to 3% across Glasgow)
Number of employees	1800	2300	28% (Glasgow - 13%)
Rateable value of businesses	£1,298,900	£1,490,400	15%

Interviews with businesses in the area found that a location near the Green offered 'process benefits', including improved worker retention, satisfaction and morale. One business cited the regeneration of the Green as a key factor in their choice to locate in the area. Businesses that relied on visitors to the Green felt that they could see an impact on their turnover, although those without a direct need for passing trade could not cite such benefits. Nonetheless all businesses felt that the renewal project had impacted positively on their firm. While outcomes in the 'wider area' were difficult to ascertain, the role of the Green as a 'linking node' between the East End of Glasgow and the City Centre was seen as a factor in supporting the regeneration of the east of Glasgow.

Estimated net business investment benefits are summarised in Table 3.4. The authors of the evaluation report found it difficult to develop a robust estimate of additionality for business investment, despite consultation with local businesses. This is a common difficulty for many GI outcomes as mentioned in Section 2. Instead, the authors make the "modest" approximation that the Green Renewal Project was responsible for 10% of gross overall business indicators in and around the Green. For instance, the number of new businesses attracted is taken as 10% of the total number of businesses in and around the Green. This is different from a conventional additionality calculation, and arguably somewhat arbitrary.

Table 3.4: Net Business Investment Benefits (1998-2006)

Variable	Impact
New businesses attracted	20
Jobs supported	230
Additional business rates generated	£96,000

Visitors use and spending

The study was not able to track absolute user figures over time, owing to the use of ad hoc visitor surveys as opposed to monitoring over time. However, from a combination of surveys (which suggested that visitors are more likely to visit the Green on a more regular basis), use of data on the number of events held on the Green and monitoring the use of some of the Green's main attractions, the report does estimate visitor spend:

- £56.7 million gross sales in the wider economy;
- £15.5 million of gross wages and salaries, and
- 77 gross FTE jobs supported by the net expenditure each year.

The report applies a 40-60% additionality ratio to this spending based on the scale and range of events prior to investment, and the increase in visitor numbers over this time. This gives net figures as summarised in Table 3.5.

Table 3.5: Net Economic Benefits of Visitor Spending

Variable	Low	High
Sales in wider economy	£22.7 million	£34 million
Wages and salaries	£6.1 million	£9.2 million
Jobs supported	31	46

It is unclear whether there is overlap between figures for visitor spending and additional business rates, for example if businesses profit from additional spending by visitors. If there are, the two figures in Tables 3.4 and 3.5 should not be summed, as a portion of both figures will be counting the same spending and therefore summing these figures will lead to doublecounting.

Image and Perceptions

The research assumes a link between safety, image of the Green, health, 'civic pride' and community cohesion with setting the conditions for economic growth. The Green's renewal was found to have had a positive impact in each of these areas, including quantifiable reductions in crime (total number of reported crimes fell by 36% between 1998 and 2006) and improved perceptions of the Green: 45% of those surveyed felt more positively about the Green than five years prior to that, and only 2% felt less positive.

The research also showed that events held on the Green attracted a significant proportion of people from beyond the city boundary, around 29% for the Glasgow Show for example. Although there was no tracking of this over time, the increased number of events on the Green suggests that a greater number of people from outside the city than before would be coming in to Glasgow to attend events (and - the assumption is - spend money).

3.1.5 Summary

The Glasgow Green Renewal project was seen as providing an important link to the regeneration of a number of areas in the east of Glasgow, as well as providing economic benefits in its own right. GEN Consulting (2004) conclude that the renewal project has “played an important role in sustaining the regeneration of Glasgow” (p44).

Furthermore, in drawing key lessons from the study, they note that: “the most obvious lesson from the study is that investment in greenspace does have the potential to deliver significant economic, social and regeneration benefits” (p48).

It is worth noting however, the investment in the Green was comparatively high (capital investment of £15.5 million) and that the renewal project was part of a wider approach to regenerating the east of Glasgow, which meant that the benefits of the project were potentially amplified by changes in the surrounding area. The report suggests that timing green space investment to coincide with and reinforce wider investments would work to maximise the potential benefits.

Table 3.6 provides a summary of the key findings of this case study.

Table 3.6: Logic chains: Glasgow Green, Glasgow, Scotland

Location setting	Glasgow, UK
Reference	GEN Consulting (2006) Glasgow Green Renewal Benefits Analysis
GI definition	Park improvement
Inputs	Total investment = £15.5m (£10.3m leveraged). Involved improving physical infrastructure of the Green
Activities	
Theory	Investment in green infrastructure and its attractions to improve aesthetic desirability, alongside some health impacts
Evidence available	500 net new residential units in area; 16% increase in businesses in area; 22.7 million in sales from visitors
Outcomes	
Theory	Job creation; tax revenue; land values; visitor spending
Evidence available	47% increase in Council Tax receipts; 28% increase in number of employees in area; 230 jobs supported; and 15% increase in rateable value of businesses
Other factors that serve similar catalyst role	
Factors	Wider regeneration of East End of Glasgow, which may have reinforced / been reinforced by Glasgow Green regeneration
Evidence available	Not presented as part of the evaluation of the Glasgow Green
Methodology used	Comparison of outcome indicators before and after the Glasgow Green development and comparison to other parts of the city
Local context / transferability	Relevant to most UK cities

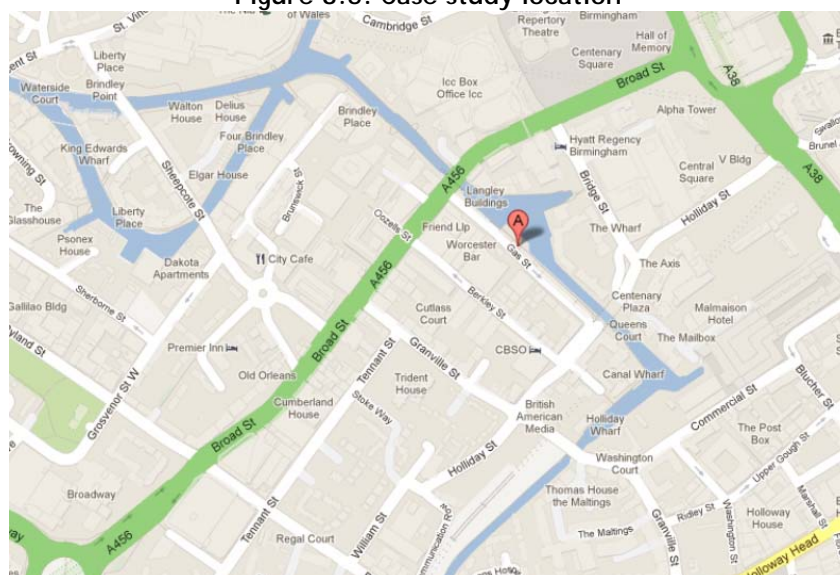
3.2 Canalside Development in Birmingham City Centre

3.2.1 Local Context

This case study looks at canalside development in Birmingham city centre based on a study by GHK (2009a), which also incorporates earlier studies by Ecotec (1996, 1998 and 2001) and focuses on tourism and leisure effects of development as well as property market effects.

The city centre is the point of confluence for three canals: the Birmingham New Main Line Canal, the Birmingham and Fazeley Canal and the Worcester and Birmingham Canal. The quality of the water and environment of these canals, particularly in the city centre, declined to a low point in the 1980s. The basin and canals sat on the city centre fringe, and became the site of dereliction as economic restructuring towards a service-led economy hit Birmingham particularly hard in the 1970s and 1980s. 149,000 manufacturing jobs were lost in the city between 1971 and 1987 (Champion and Townsend, 1990). This study looks at the redevelopment of this area, with a focus on a roughly one mile stretch of canal around the Gas Street Basin, as shown in Figure 3.5 below. This formed part of Birmingham City Council's strategy to encourage new service sector investment and promotion of a "dynamic image" for the city (Loftman and Nevin, 1994 p310).

Figure 3.5: Case study location



Source: Google maps

3.2.2 Initial Change

The development involved a mixture of investment in the quality of the canal infrastructure and initial investment in high profile economic regeneration projects such as the development of the International Convention Centre and National Indoor Arena (1988-1991). Therefore, it is not possible to fully separate the direct impact of the canal infrastructure improvement from the impact of the overall regeneration in the area. Net changes discussed below incorporate the whole regeneration and not just the physical realm improvements.

Initial changes to the area included development of the canal infrastructure, as follows:

- Improvements in water quality, navigability and moorings;
- Public realm works around Gas Street Basin and Brindleyplace; and
- Creation of pedestrian access to canals.

These were part of wider developments to construct office, residential and leisure related developments at both Gas Street and Brindleyplace, coming from a mixture of public and private investment.

3.2.3 Intermediary Changes

Figure 3.6: The improved canal waterfront



Source: www.urbed.coop

The set of changes set in motion were a host of further commercial developments between 1985 and 2001, totalling £555 million in investment. Outputs from this included 145,700 square metres of commercial space, 624 hotel bedrooms and 501 residential units. The GHK study, however, focuses on the period 2001-2007, giving a sense of what the long-term impacts of investment in Green and/or Blue Infrastructure might be.

Initial development of the Gas Street Basin led to commercial interest in developing along the canal corridor moving south from the basin. This included a four-star hotel development; three residential developments; and two mixed use developments. On the latter, GHK note that for the larger of the two, called *the Cube*, "although it is certain that *the Cube* would have been built regardless of the presence of the canal, the waterway clearly adds value to the scheme", and - based on other work (Ecotec, 2003) - quantify this added value at around 5% (further information on this figure is not available).

The total outputs from the 2001-2007 developments were:

- 2,440 residential units;
- 16,400 square metres of commercial space;
- 444 hotel bedrooms, and
- 13 moorings.

In addition, the improvement of the public realm was said to have led to an (unquantified) increase in the level of pedestrian flow into and around the city centre.

Figure 3.7: Canal Development



Source: Birmingham City Council

3.2.4 Economic Growth

Property-related impacts were measured through an inventory of all development since the regeneration of the canals commenced, and were included if they were connected to or influenced by the waterway (e.g. through a canal frontage), which were identified through study visits and stakeholder consultation. The impact of these developments was measured in terms of investment secured, jobs created and floorspace provided. Additionality was estimated on a case by case basis according to a mixture of established ratios and comparator valuations.

Evidence for the economic growth impacts in terms of tourism and leisure was generated through a range of different methods:

- time series data on boat movements along the canal at sites to estimate expenditure of boaters;
- data from pedestrian counters;
- visitor numbers at attractions, and
- a survey of tourism and leisure facility users.

These impacts are summarised in Table 3.7 and Table 3.8 below.

Table 3.7: Property Related Impacts of Canalside Development

Variable	Gross change (2001-7)	Net impact (2001-7)
Construction employment	8,100 temporary person years	715 temporary person years
Commercial employment	600 FTE jobs	30 FTE jobs
Property value 'uplift'	N/A	£25.7 - £57.1 million

Across the whole period of development (1985-2007), the canalside developments are calculated as having generated between 2,205 and 2,620 net FTE jobs within the immediate area.

Table 3.8: Economic Impact of Boaters

Variable	Net Expenditure	Net Jobs supported (FTE)
Boater expenditure	£115,000	2
Visitor expenditure	£2.28 million - £3.41 million	77-96

In addition, the survey of tourism and leisure businesses found that:

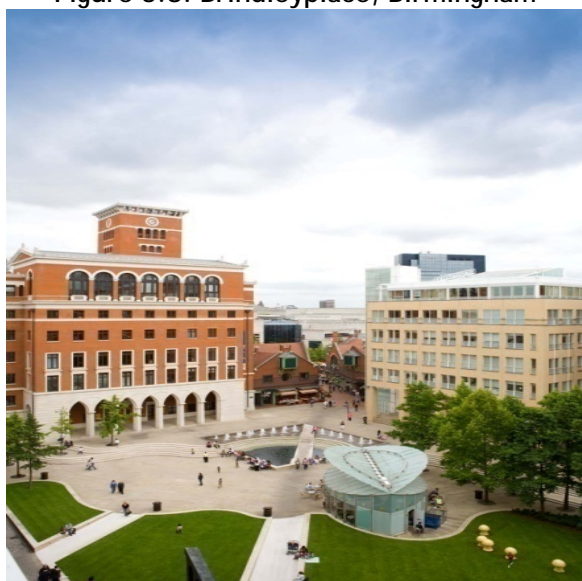
- 50% of respondents thought the canal to be an 'important' or 'very important' factor in determining their choice of business location;
- 39% per cent thought that the canal was either 'important' or 'very important' to their business revenue;
- 12% of survey respondents thought that the importance of the canal to their business had increased over the previous five years, and
- 33% felt that it would be increasingly important over the next five years.

These findings were, however, based on a small number of respondents (18 from a sample of 174) and so it is difficult to take any concrete conclusions from them.

A number of impacts on economic growth were also outlined but not quantified:

- improved image of Birmingham City Centre, with benefits to tourism and leisure industry as well as wider place-based competitiveness;
- a catalyst role in the regeneration of run-down and unsightly parts of the city centre with knock-on effects in adjacent areas, and
- a role in facilitating growth in city-centre living, which brings income to the city centre, in turn providing employment opportunities.

Figure 3.8: Brindleyplace, Birmingham

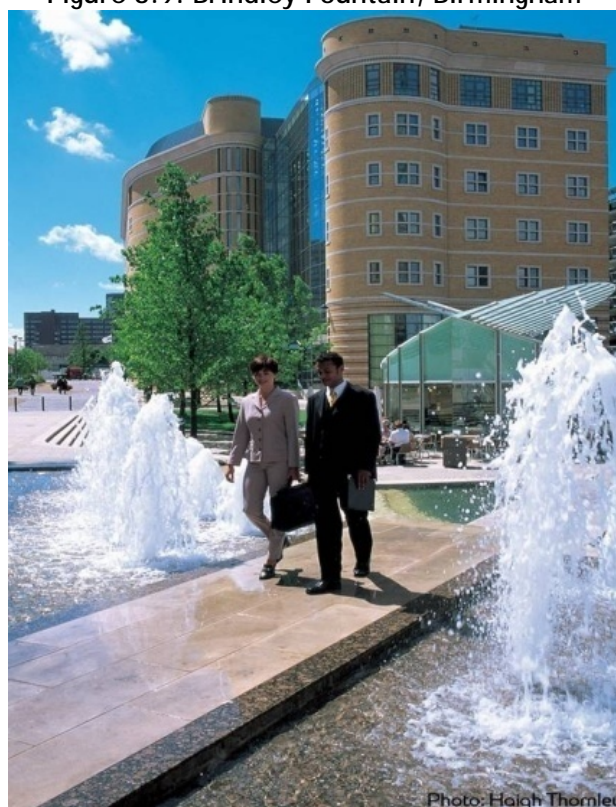


Source: Birmingham City Council

As noted above, in thinking about the impact of this development, the role of public investment in the wider regeneration of the city's canalsides also needs consideration. Developments such as the International Convention Centre and the National Indoor Arena were both publicly funded and other later additions involved at least some grant funding. This 'market intervention' will no doubt have impacted on the attractiveness of the area for investors. This issue is further complicated by the extended amount of time between initial canal development and outcomes/impacts measured in the report. Nonetheless, GHK conclude that, even for later additions that linked to earlier developments but are some distance from the canal, "the canal is undeniably an important feature within the success of the scheme[s] as a whole".

The figures arrived at for this development also need to be placed in the context of a period of relatively high economic growth in the UK compared to current conditions. As such, particularly in the case of property development, the levels of employment and property value uplift are likely to be greater than those achieved in a less benign economic environment.

Figure 3.9: Brindley Fountain, Birmingham



Source: Birmingham City Council

3.2.5 Summary

Birmingham canalside development offers a reasonably well evidenced example of the impact of 'blue' infrastructure improvements on economic growth. It has turned the canal from a liability to an asset that provides ecosystem services such as aesthetics, recreational opportunities and improved water quality.

The impacts are clearly tangled up with wider developments and broader patterns of economic growth, but there does appear to be evidence that the improvement of the canal and its environs had an impact on economic growth in the area. Although calculable

'positive' additionality may have been low for some elements of the canal development itself, there is also an argument that the alternative scenario - no public sector investment in the canal itself and continued decline of its public realm - would result in the loss of a potential focal point for development and a significant impact on the ability to develop in the area.

As with other case studies, a clear policy point to take from this case is the importance of tying green infrastructure investment with other regeneration/renewal initiatives where possible to generate mutual reinforcement of potential economic benefits.

Table 3.9 provides a summary of the key findings of this case study.

Table 3.9: Logic chains: Canalside Development in Birmingham City Centre

Location setting	Birmingham, UK
Reference	GHK (2007) The Economic Impact of Waterway Development Schemes: Volume 4
GI definition	Canal and canalside improvement
Inputs	Inputs not quantified, but total investment, including outputs = £555m. Involved improvements to canals and surrounding infrastructure
Activities	
Theory	Investment in physical developments in the area
Evidence available	2,440 residential units; 16,400 square metres of commercial space; 444 hotel bedrooms; 13 moorings
Outcomes	
Theory	Job creation; land values; visitor spending
Evidence available	30 FTE jobs created plus 77-96 jobs supported through visitor expenditure; 25.7 - 57.1 million property value uplift;
Other factors that serve similar catalyst role	
Factors	Macroeconomic conditions; regeneration of surrounding areas; public funding of some additional flagship developments
Evidence available	Not presented as part of this study
Methodology used	Visitor counts, resident and business surveys
Local context / transferability	Relevant to most UK cities

3.3 Philadelphia Land Care Programme, Pennsylvania, USA

3.3.1 Local Context

Philadelphia, Pennsylvania (USA) has experienced population decline since the 1950s, losing 500,000 people between 1950 and 2000. This had led to a city-wide problem with vacant land and dereliction as a result of suburbanisation and lack of investment in urban neighbourhoods. There were an estimated 27,000 abandoned residential buildings in 1992; and a more recent analysis estimated the number of vacant lots as being in the region of 40,000.

There is evidence to suggest that vacant land and derelict properties can create problems for surrounding neighbourhoods (Branas *et al*, 2011). Vacant lots may also work to increase vacancy as existing residents seek to leave increasingly unattractive neighbourhoods. Cities across the US 'rustbelt' are increasingly using greening programmes to address these issues (Schilling and Logan, 2008).

The Philadelphia Land Care (PLC) Programme was developed in response to these issues by a partnership of the Pennsylvania Horticultural Society and the New Kensington Community Development Corporation. New Kensington had been particularly hit by the city's economic decline and suffered from high vacancy levels. The programme began in 1996 and was expanded to encompass the whole city in 2003. A programme of demolition of unsafe empty properties began in 2003 and PLC was employed to manage the newly vacant lots.

Figure 3.10: An example of change through the Philadelphia Land Care Programme



Source: philadelphiagreen.wordpress.com

3.3.2 Initial Change

The programme involved removal of debris, and planting grass and trees in vacant lots. The idea was that lots may one day be redeveloped, so this was seen as only an interim treatment for land. The central theory behind the intervention was that improving the aesthetics of an area would have an impact on its desirability, in turn, uplifting property values. Potential secondary benefits included regulation services such as improved air quality, and services to health and society in terms of the recreational value of GI.

3.3.3 Intermediary Changes

The most significant (and studied) intermediary change has been the increase in the property values.

A parallel study by Branas et al. (2011) also found that the vacant lot greening programme had been associated with a reduction in certain types of crime (gun assaults, vandalism and criminal mischief) in some parts of the city. However there had also been an increase in group-based disorderly conduct. In health terms, local residents reported lower levels of stress and increased exercise, again in selected but not all parts of the city.

3.3.4 Economic Growth

The study by Heckert and Mennis (2012) estimates the impact of GI through statistical analysis of changes in property prices across the city of Philadelphia between 1999 and 2007 in areas containing vacant lots. This included a 747 PLC projects and a control group of 2241 lots that were vacant but had not received PLC treatment. The study's 'difference-in-differences' approach differs from the more commonly used hedonic modelling in its use of a control group to ascertain significance of land value change in PLC projects.

The results of the analysis found that property values had risen in all intervention areas, the increase in intervention areas was larger than in control areas (though this result was statistically significant in three of the six study areas). No figures are given in terms of percentage or actual changes in property values. The significant positive differences were all found in areas classified as 'distressed' housing markets, which, when broken down further was found to hold true for 'moderately distressed' but not 'highly distressed' areas. This chimes with broader literature on this form of GI: evidence from Baltimore suggests that in areas of high violent crime, parks can be associated with a decrease in property values (Troy and Grove, 2008). In other words, GI could not act as a salve for deep-seated issues of deprivation and community cohesion but works well as part of an overall development and regeneration programme.

The research attempts to account for a range of potential forms of 'interference', including distance of lots from the central business district, other amenities, and initial economic conditions, by testing for what is termed 'spatial non-stationarity' by observing differences in changes across different areas of the city and accounting for these in final calculations. The authors also account for differing neighbourhood retail market conditions.

They were not, however, able to control for other forms of regeneration taking place in the city, and some of the study areas had undergone housing regeneration programmes over the same period as the PLC programmes. The report reflects upon this issue and suggests that the PLC programme was likely to be most influential in disadvantaged neighbourhoods "where other dynamic influences on residential property values, such as very high concentrated poverty and/or gentrification, tend to be relatively moderate" (p3023).

A further issue relates to the fact that the interventions implemented by the PLC programme were chosen for particular reasons that were not available to the researchers and so it is not clear the extent to which the PLC lots were chosen for their perceived impact potential: if this did take place, then this reduces the significance of the findings.

3.3.5 Transferability to the UK

The issue of inner-city residential dereliction is not particular to the US, but is perhaps a more pronounced phenomenon in the US 'rustbelt' than in the UK. Nonetheless, such programmes are relatively popular in areas of urban decline in the UK, particular as part of regeneration programmes in 'social' housing estates (see, for example, Hickman et al. 2011), although the economic value has not been assessed. The approach used in this case study can also be used in the UK.

3.3.6 Summary

The research offers proxy evidence on the role of GI in regenerating disadvantaged areas and hence in being a catalyst of economic growth in the form of increasing property prices. The increase is likely to be delivered through making GI part of an overall regeneration initiative that will help counteract high crime rates, which improving GI alone cannot address.

Heckert and Mennis (2012) conclude that "such findings should certainly be encouraging to municipal governments of cities like Philadelphia, where the management of blight and vacant land presents serious challenges to the ongoing economic vitality and liveability of the city" (p3025).

Table 3.10 provides a summary of the key findings of this case study.

Table 3.10: Logic chains: Philadelphia Land Care Programme, Pennsylvania, USA

Location setting	Philadelphia, Pennsylvania (USA)
Reference	Heckert, M and Mennis, J (2012)
GI definition	Greening of vacant residential lots
Inputs	Not quantified, but includes remedial work to vacant/derelict land and planting of grass/trees
Activities	
Theory	<i>Improved aesthetic to neighbourhood as well as the associated physical and mental health benefits</i>
Evidence available	<i>Remedial work and planting of grass/trees on vacant/derelict land</i>
Outcomes	
Theory	<i>Property value increase, health benefits</i>
Evidence available	<i>Significant increase in property values in some intervention areas. Likely health impacts not quantified.</i>
Other factors that serve similar catalyst role	
Factors	<i>Other regeneration initiatives taking place in the intervention area</i>
Evidence available	<i>Other areas where other physical regeneration initiatives took place are outlined</i>
Methodology used	<i>'Difference-in-differences' modelling: analysing the property value changes in the area and comparing this change to that in other areas of the city</i>
Local context / transferability	<i>US context of inner-urban 'blight' is slightly more pronounced than in the UK but similar initiatives do already exist; the methodological approach can also be used in the UK</i>

3.4 Cheonggyecheon Stream Restoration Project, Seoul, South Korea

Figure 3.11: Photos of the area before and after stream restoration



Between 2003 and 2005 a large-scale river restoration project was completed that drastically changed the city of Seoul, South Korea in a variety of ways, including drastic physical changes (as seen in the before and after photographs above).

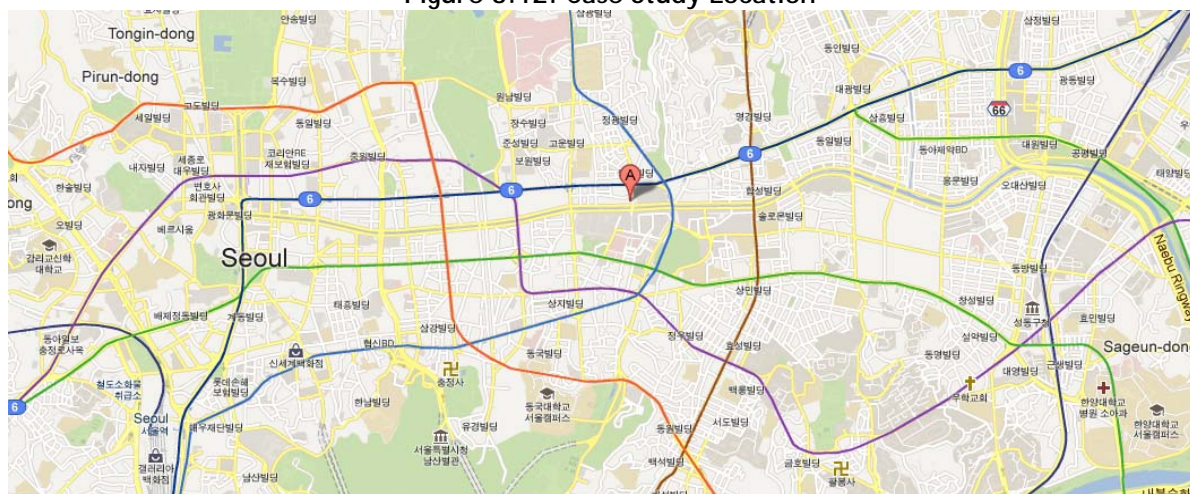
The Cheonggyecheon Stream, which runs through the centre of downtown Seoul in South Korea, carries a long history of maintenance and modifications. It served as a waste course to residents of Seoul from the 15th Century up to the middle of the 20th Century, when it became severely polluted due to the rise in the population at the end of the Korean War (1953). The smell and the sight of the polluted stream, coupled with the crowding of makeshift houses made more prevalent by the increasing population, became a symbol of poverty, negligence, and disorder. Being so, the stream was seen as a major obstacle to Seoul's redevelopment. To remedy this, huts were removed from the banks of the stream, the residents were relocated, and the stream was covered over with (first) concrete and (then) an elevated motorway which was completed in 1972. Modern buildings and shops were built by the motorway and the area surrounding the Cheonggyecheon soon became known as a symbol of the modernisation and industrialisation of South Korea (TPI, 2007; SMFMC, 2009).

However, industrial urban development had increased so much, that by the 1980s and 1990s the Cheonggye motorway and the area surrounding it became known as a shabby, industrial area, plagued by traffic and pollution, and the freeway and concrete cover over the stream were in need of maintenance or possible replacement (TPI, 2007; Hwang, 2004). The idea to remove the motorway and unearth the stream belonged to an environmental engineer at the Seoul government and was supported by a traffic engineer and championed by a famous poet and singer (pers comm, Caroline Bacle, documentary film maker, *Lost Rivers*, 2013).

In 2001, Lee Myung-Bak, ran for and won the election for mayor of Seoul promising to economically revitalise the area and made the removal the Cheonggye motorway and restoring the stream the focal point of this promise (TPI, 2007; SMFMC, 2009). And so, between 2003 and 2005 the motorway was torn down and the stream restored as a public park/green corridor for pedestrians, cyclists, and wildlife.

Local opponents of the Cheonggyecheon restoration feared gentrification of the area and negative impacts to the existing small businesses in the machines trades (Cho, 2010), but there is little information on whether these businesses have been displaced, or lost.

Figure 3.12: Case Study Location



Source: Google Maps

The Seoul Metropolitan Government also carried out a number of other works as part of its urban development programme, which aims to raise the competitiveness of Seoul through creating a “new urban brand for Seoul” by making the most use of its attractions and potentials. Other works were undertaken as an attempt to address the negative impacts of redeveloping the city centre (e.g. due to compulsory moving of businesses). The following are mentioned in the report “Urban Planning of Seoul” as representative projects amongst the many undertaken in Seoul between 2002 and 2010:

- improving underprivileged housing areas and promote the local economy through improving infrastructure;
- changes to downtown Seoul to reflect a 600 year old history with sustainable environment and landscape (Seoul’s Urban Renaissance project), including restoring historic sites, creating a pedestrian network connecting tourist attractions, creating a green walkway, increasing the use of digital media technology in park design and public art, preserving scenic views, and creating new cultural spaces around historic heritage sites; and
- plans to restore the Han River to its natural state and bring back its ecosystem, and restore the symbolic value of the Han River, to which the Cheonggyecheon is a tributary, to Seoul’s citizens (SMG, 2009).

3.4.1 Local Context

The Cheonggye motorway ran through downtown Seoul, the location of the historic capital city, where most palaces, government offices, corporate headquarters, hotels, and traditional markets are located. In 2000, the number of businesses in the central area had decreased by 24.1% to 77,000 compared to 1991. During the same period, the businesses in the central area made up 17.7% of all businesses in the city in 1991 which declined to 10.8% in 2000 (Hwang, 2004). Also, there were a few parks within a 1km radius of the motorway, including Namsan Park, a 3 km² park that features the 262 metre high Namsan Mountain (Google Maps).

The Cheonggye motorway is also within walking distance (about 1km) of some residential areas (SMG, 2009). In 2000, 49,510 people lived in downtown Seoul and 129,827 lived on

the Cheonggyecheon riverside, but population had decreased by 66% and 14.9% respectively over the last 20 years (Hwang, 2004).

3.4.2 Initial Change

The Cheonggye motorway was torn down and the Cheonggyecheon stream restored. The restoration included providing natural habitats to increase biodiversity, and the river banks were terraced for pedestrian access and to maintain interest in the stream through different seasons as the water levels changed. Together with these details, the restoration of the stream provided 5.3km of green corridor through downtown Seoul.

The stream was split into five zones, with a different emphasis for each zone:

- Zone 1: History
- Zone 2: Culture
- Zone 3: Nature
- Zone 4: Harmony
- Zone 5: Seoul Forest

Zone 5 of Cheonggyecheon Stream, "Seoul Forest" is situated on its east end. It was opened in June 2005, a few months before the stream restoration process was completed and extends over an area of approximately 1.1km². The forest consists of five themed parks: the Cultural Art Park, Ecological Forest, Nature Experiencing Study Field, Wetlands Ecological Field and Han River Waterside Park. The Ecological Forest and Wetlands Ecological field are man-made forest and wetlands to provide habitats for wild animals. Visitor facilities include walkways, bike paths, playgrounds and an outdoor theatre (visitkorea.or.kr).

To offset this loss of traffic capacity, the Seoul Government introduced traffic calming measures and increased public transport capacity, including introducing a new mode of public transport, the Bus Rapid Transit line (which introduced bus only lanes).

3.4.3 Intermediary Changes

Several intermediary changes have been reported as impacts from removing the motorway and restoring Cheonggyecheon Stream:

- inward Investment and Employment Generation;
- increased visitor spending;
- environmental cost savings; and
- health benefits.

3.4.4 Economic Growth

Inward Investment and Employment Generation

The number of businesses in the Cheonggyecheon area was increased by 3.5% during the planning period (2001 - 2003), which was double the rate of business growth in downtown Seoul. The number of workers in the Cheonggyecheon area was increased by 0.8%, versus a decrease in downtown Seoul of 2.6% (Kim, et. al. 2009). This might mean that companies are moving closer to Cheonggyecheon rather than that the area stimulated new businesses or brought in businesses from outside of Seoul (a displacement effect rather than a new business growth).

Visitor Spending

The stream attracts an average of 65,000 visitors daily. Of these 1,408 are foreign (external) tourists who contribute up to 2.1 billion won (£1.3 million) in visitor spending to the Seoul economy (Kim, et. al. 2009). It is unclear, however, how much spending is directly attributable to the Cheonggyecheon restoration; tourists may be visiting Seoul for other reasons, but it is possible that the Cheonggyecheon may play a part in their decision to visit Seoul or the number of days they have planned to stay there.

Environmental cost savings

In consideration of the increasing incidence of floods and the extraordinarily heavy volume of torrential showers during the summer months, achieving an increased quality of flood management was essential to the restoration of this stream. The restored stream can sustain a rain intensity of 118mm/hr, and embankments have been built along the river that can withstand a 200-year flood event. Additionally, to ease the threat of annual flooding during monsoon season, engineers constructed flood control tunnels beyond the embankment walls. In times of heavy rain or high stream levels, doors can be opened to release and carry excess water to the (much larger) Han River (Hwang, 2004).

The urban heat island effect is reduced along the stream, as temperatures are reduced by 3.3 to 5.9°C compared to those on a parallel road 4-7 blocks away (annual mean temperature in Seoul fluctuates between 17 and 8.9 °C - with the highest and lowest temperatures in the hottest month (August) between 29.6 and 22.4°C)⁹. This is a result of the removal of the paved motorway, cooling effect of the stream, increased vegetation, reduction in auto trips, and a 2.2 -7.8% increase in wind speeds moving along the corridor (Hwang, 2004), allowing for increased air quality as well as temperature reduction, mitigating the impacts of wind-blocking from the area's densely-built urban environment.

Overall biodiversity was increased by 639%, including increasing plant species from 62 to 308, fish species from 4 to 25, bird species from 6 to 36, aquatic invertebrate species from 5 to 53, insect species from 15 to 192, mammals from 2 to 4, and amphibians from 4 to 8 (Kim, et. al. 2009; Revkin, 2009). An increase in biodiversity raises interest in the natural environment and this may lead to higher interest in science, technology and environmental subjects in education and the increased positive mental health impacts that occur when humans observe and interact with other species (Fuller, et. al. 2007).

Health Benefits

According to a 2005 public survey, residents in the Cheonggyecheon area overwhelmingly noticed improvements in air and water quality, noise, and smells (nationalarchives.gov.uk), and rightfully so, as there has been a small-particle air pollution reduction of 35% from 74 to 48 micrograms per cubic metre (english.sisul.or.kr). Prior to stream restoration, residents were more than twice as likely to suffer from respiratory disease as those in other parts of the city (Hwang, 2004), and so this ecosystem service is of particular importance for this area. Pedestrian activity has also been said to have increased in the area (CABE, 2011), and, where this is not displacement from walking in other areas, this could be contributing to better health and social interaction and connectivity.

3.4.5 Transferability to the UK

A large draw for the newly restored Cheonggyecheon is the provision of access for the general population to clean running water, wildlife and culture in a public space that

⁹ Climate data in Seoul 1981 - 2010, Korea Meteorological Administration

generate benefits that are also relevant in the UK. Unearthing of urban rivers for public access and green space is increasingly becoming a more interesting approach to providing environmental and community benefits to cities and can be applicable to the UK.

3.4.6 Summary

The restoration of Cheonggyecheon stream was a large-scale, transformative project that has literally changed the face of Seoul and should serve as an example of how GI can be thought about in terms of redefining, as well as rejuvenating, a city.

While there is an abundance of information available on the environmental and economic impacts of the project, the analysis uses comparison of data before and after the project rather than comparing the data with and without the project. However, given the significant scale of the project, it is possible to argue that the changes in ecosystem services are directly attributable to the project. To identify whether the move of businesses to the area is a displacement effect (moving from elsewhere in the city) or new economic growth is not as straightforward, but the actual effect is likely to be a mixture of the two.

Table 3.11 provides a summary of the key findings of this case study.

Table 3.11: Logic chains: Cheonggyecheon Stream Restoration, Seoul, South Korea

Location setting	Cheonggyecheon, Seoul, Korea
Reference	Various web-based sources (see the references section)
GI definition	Stream/green corridor with man-made wetlands and woodland
Inputs	Restoration of stream with pedestrianisation and man-made wetlands and forest
Activities	
Theory	Businesses moving into the area; visitor numbers increase; urban heat island effect reduced; air pollution is reduced.
Evidence available	Number of businesses increased by 3.5% during planning period, double the rate of business growth in downtown Seoul; 65,000 daily visitors, of which 1,408 are foreign tourists; temperatures are 3.3 to 5.9°C less than those on a parallel road 4-7 blocks away (reduction in cooling bills may occur but not quantified; small particle air pollution reduced from 74 to 48 micrograms per cubic metre and associated decrease in respiratory diseases in the resident population
Outcomes	
Theory	Jobs created from businesses moving into area; increased spend from tourism / businesses profit
Evidence available	Number of workers increased by 0.8%, versus a decrease in downtown Seoul of 2.6%; 2.1 billion Won (Korean currency, around £1.3 million) contribute by foreign tourists to economy
Other factors that serve similar catalyst role	
Factors	Businesses may be relocating from other areas of Seoul (so not a net benefit across city, but benefit to Cheonggyecheon); tourists are likely to come to Seoul for other reasons (as well as or instead) of the area; and reduced traffic (which could be counted as part of the GI project)
Evidence available	No documented evidence
Methodology used	Comparison of data before and after the project; additionality (or displacement) is not accounted for; strong anecdotal experience and significant physical change; monitoring data and statistical analysis for environmental improvements and health benefits
Local context / transferability	Unearthing of urban rivers for public access and green space is increasingly becoming a more interesting approach to providing environmental and community benefits to cities and can be applicable to the UK

3.5 The Highline Linear Park, New York City, USA

Figure 3.13: High Line, New York



Photographs courtesy of <http://www.nycgovparks.org/parks/highline/photos>

In September 2010, New York City revealed the NYC Green Infrastructure Plan, which presents an alternative approach to improving water quality by combining green infrastructure (i.e. swales, vegetation, green roofs, porous pavement) with plans to optimise the existing system and to build targeted, cost-effective “grey” (traditional) infrastructure (NYCDEP, 2010). Thus, the key driver behind the NYC GI Plan is provision of ecosystem services.

In contrast, New York City’s High Line Park, which is the focus of this study, is a GI project that provides little in terms of quantifiable ecosystem services but is promoted as being a driver of huge economic growth. The High Line is a linear, one mile stretch of public urban greenspace running through Manhattan’s West Side, which was created by converting a portion of an unused, elevated freight-rail line from the 1930s into vegetated park land. The track was originally built as part of the West Side Improvement Project intended to alleviate traffic congestion from what was then the highly-industrialised meatpacking district. It had remained unused for the better part of 25 years (becoming a symbol of the steady decline of industrial activity and economic development in the area) before its refurbishing began in 2006.

The rail line itself was donated to the City of New York by CSX Transport, Inc. in 2005. The project, at a cost of \$153 million, was funded by both public and private backing; \$112.2 million was provided from the City of New York, \$20.7 million from the US Federal Government, \$700,000 from New York state, with the remaining balance being provided by a mixture of funds from Friends of the High Line (who operate and maintain the park) and real estate developers supporting the Special West Chelsea Zoning District that would be subsequent to the park’s creation (CoNY, 2011). Opened in two, half-mile stages in 2009 and 2011, the park is owned by the City of New York, is fully wheelchair accessible, and is

now the second most popular cultural tourist destination in the city. Plans to continue the park along the entire length of the rail line (a further 0.5 miles) are in progress.

3.5.1 Local Context

Running for one mile through Manhattan's West Side and connecting the Meatpacking District, West Chelsea, and Midtown West/Hell's Kitchen, the High Line is accessible by a large and very diverse population (datasearch.furmancenter.org)¹⁰. It lies 1.5 miles north of Hudson River Park, a 2.2km² public park on the Hudson River. When the original rail line was built in the 1930s, there were over 250 slaughterhouses and meatpacking plants in the area. The industrial decline of this district, and New York City in general, is denoted by the closing of the line in 1980. In decades since, the area has been transformed as its many warehouses have been turned into art galleries, design studios, restaurants, museums, and (more recently) residences, with West Chelsea now boasting the largest concentration of art galleries in the world (www.thehighline.org).

The early stages of High Line Park's construction were accompanied by a change in the use of the surrounding 15-block area from being restricted to light manufacturing and commercial use to allowing for new residential and commercial development, which together have contributed to making this area one of the fastest growing neighbourhoods in NYC (CoNY, 2011).

3.5.2 Initial Change

Construction work on the High Line started in 2006 and was broken into three phases: *Phase I* set out to remove existing surface materials from the structure, including rails (when not kept for design purposes), soil, debris, and a layer of concrete;

Phase II involved repairing and/or reinforcing the steel and concrete portions of the structure, installing new drainage and waterproofing, and removal of the original lead paint; and

Phase III consisted of the construction of the park landscape, including the spreading of subsoil, topsoil and specialised draining materials, the installation of the park's long concrete-slab walkways and special design features (i.e. water features, sculptures, lighting), and the planting of some 210 species of perennials, grasses, shrubs and trees. Visitor facilities include water fountains, restrooms, elevators, bike paths (and storage), and several picnic/lounging areas in addition to its walkways (thehighline.org).

3.5.3 Intermediary Changes

The anticipated intermediary changes included the following from the logic chain presented in Section 2:

- Inward Investment
- Place-making/Improved image
- Increased willingness to pay for proximity
- Increase in property development & building occupation
 - Occupation by growing/new businesses
 - New firms take up of premises vacated elsewhere by relocated firms

¹⁰ The Racial Diversity Index for this area has seen an increase from 0.47-0.55 in 2005 to 0.63-0.72 in 2009 (www.datasearch.furmancenter.org).

Figure 3.14: High Line, New York



Photo by: Nick White

3.5.4 Economic Growth

The purpose of the High Line's creation was that increasing the physical attractiveness of an area, through providing a unique open greenspace, would increase property values and boost local investment. The evidence provided is based on comparison of the relevant indicators before and after the opening of the High Line, and comparison of the area surrounding it to other areas in the city. Displacement effect (whether the inward investment to the area is new or coming from elsewhere) is not studied.

A study published by the New York City Economic Development Corporation in 2011 found that before the High Line was completed, residential properties in the surrounding area were valued 8% below the overall median for Manhattan, but from 2003-2011, property values near the park increased 103%, surpassing the NYC average (Moss, 2012; NYCEDC, 2011). The resulting value to the City in extra tax revenue generated by the increase in property values is estimated to be somewhere in the region of \$900 million over the next twenty years (CoNY, 2011).

After changing the use of the area from manufacturing to residential and commercial, and the start of the High Line's construction in 2006, new building permits in the immediate vicinity doubled accompanied by more than 29 major development projects accounting for more than \$2 billion in private investment, 12,000 jobs, 2,558 new residential units, 1,000 hotel rooms, more than 423,000 sq. ft. of new office space, and 85,000 sq. ft. of new art gallery space (CoNY, 2011).

In addition, since first opening to the public in June of 2009, the park has attracted more than 4 million visitors, of which half are estimated to be "out-of-town visitors", and a press release from the Mayor of NYC in July 2011 stated that the population within the

area surrounding the High Line park had grown more than 60% from 2000-2010 (CoNY, 2011).

Construction on the High Line park started during a period of near unheard-of building development in New York City, and continued through the housing crash of 2008 and its accompanying years of construction, investment, and development lulls (along with increased unemployment) throughout the entire nation. For instance, in 2009 building permits in the city, and thus future building activity, fell by 90% from 2008/2007 levels (Kershaw, 2010).

In addition, the uniqueness of the High Line park in being the only park of its kind (i.e. elevated, along a historic landmark) in NYC and the (relative) novelty in its design no doubt contribute to its popularity to visitors and locals alike. It has received a huge amount of media attention and awards, and was evaluated as one of "The Ten Most Positive Architectural Events of 2009 (USA) (thehighline.org)."

While it is not possible to identify how much of these benefits are due to the High Line, it is clear that all contribute to *initiating* the change. Thus, this case study highlights the multitude of potential impacts of timing the introduction of greenspace into plans for neighbourhood rejuvenation or increased economic investment.

3.5.5 Transferability to the UK

The success of the High Line has already inspired the investment in and refurbishment of other historical features within both urban and rural environments across the globe (such as Chicago, London, Melbourne and Philadelphia), preserving history and promoting ideas of re-use and contributing to concepts such as 'industrial heritage protection' (Banerji, 2012; Nobuo, et. al. 2011).

Located in one of the largest cities in the world, the estimated economic impacts of the High Line project are observably large (i.e. tens of thousands of jobs created, billions of dollars in investment attracted into the area, with a cost surpassing \$150 million).

Understandably, finding (estimated) impacts such as these corresponding to a project of similar design/size is likely to only be possible in a similarly large urban environment such as London. The two cities are similar in terms of size and diversity of their populations and similarities in culture, social norms, financial regulations, and the connection via various global institutions increase the likelihood of this project's transferability (Kuper, 2012).

However, the more general purpose of rejuvenation of derelict / industrial parts of a city is universally applicable and this case study shows that such an investment could initiate significant positive change.

3.5.6 Summary

While in the eyes of the Mayor of the City of New York and the NYC Department of Economics, the High Line project has been hailed as an economic success, there has been little attention given to the question of environmental success in the form of benefits provided (i.e. increase in biodiversity, increased air quality, reduced urban heat island effect, as well as psychological benefits from views, access, and exposure to greenspace). However, it is an example of how even a project with relatively small (in terms of total amount, size, type of vegetation) ecological scope can be a vehicle for the economic rejuvenation of an area.

Figure 3.15: High Line, New York



Photo by: Nick White

Table 3.12 provides a summary of the key findings of this case study.

Table 3.12: Logic chains: High Line, New York, USA

Location setting	West Manhattan, New York, USA
Reference	Various online sources as documented and interviews with NYC GI Plan office
GI definition	Elevated urban public park
Inputs	Restoration of unused freight rail with addition of vegetation and pedestrian access
Activities	
Theory	Increase property values and make area more attractive to investors
Evidence available	Property value data, new construction, development project investment
Outcomes	
Theory	Businesses moving into the area; jobs created; health benefits
Evidence available	Survey of businesses; additionality (displacement) not estimated; focus on communicating the likelihood of benefits arising
Other factors that serve similar catalyst role	
Factors	GI development as part of changing the plans for land use in the area from manufacturing to residential and commercial
Evidence available	Information on development projects initiated, (i.e. dates, scale, types)
Methodology used	Measurement of outcome indicators before and after the project
Local context / transferability	Rejuvenation of derelict industrial area is transferable to the UK

4 Conclusions and Recommendations

4.1 Introduction

The literature review and the case studies show clearly that investment in green infrastructure can contribute to local economic growth, following one or more of the logic chains identified as part of this study. However, at present there is little quantitative evidence, referenced against counterfactuals (what would have happened without green infrastructure), to corroborate this argument fully, in particular, at the level of the national economy. Where there is quantitative evidence, this tends to come from comparison of indicators before and after a green infrastructure investment, or from comparison between the area with the green infrastructure project and a similar area that had not benefited from the project.

While theoretically the best evidence would be comparing the outcomes with and without the green infrastructure investment, this is not possible in the real world. Indeed, across public policy generally the 'without' case (the counterfactual) is notoriously difficult to agree on, and to quantify. One key reason for this is that the economic impacts of green infrastructure are largely tied up with 'externalities', that is benefits (and costs) accruing in the wider economy to people and organisations not directly involved in the provision of green infrastructure. In this sense it is no different to 'hard' or 'grey' infrastructure (e.g. roads, railways, electronic communication networks, sewerage systems). It is commonly accepted by policy makers that investment in such installations is fundamental to economic growth; there are strong reasons to think that green infrastructure acts in the same way.

Indeed, the review of literature has illustrated a wide range of benefits emanating from the provision and improvement of green infrastructure, with many of these also traced through in terms of impacts on the wider economy. The evidence indicates that green infrastructure can potentially play a major role in the following economic outcomes:

- increased investment in the built environment in the surrounding area;
- increased building occupancy rates due to enhanced attractiveness of area;
- new developments contributing to increased local taxation revenue;
- business expansion or start-up on the back of increased visitor spending;
- increase in disposable household income or business surpluses due to cost savings or lower taxation as a result of environmental and health gains;
- increased productivity of employees as a result of physical and mental health improvement;
- growth in direct and indirect employment from provision, maintenance and associated services, and
- local multiplier effects of increased income and spending.

One key issue revealed by the review is that the existence of such economic benefits from green infrastructure is not in question: what is much harder to ascertain is their scale. The lack of quantitative evidence on these benefits suggests that a focused series of studies and evaluations would be in order, as a means of filling these gaps in knowledge - especially for the national scale policy making. This forms the subject of the following sub-section.

4.2 Gaps in the Evidence Base

This section summarises the gaps identified in the literature review and case studies. The gaps in the evidence base and the effort that should be spent to fill them depend on the purpose for which evidence is needed.

Appropriate evidence also depends on the scale of the GI investment. Large scale GI investments may require more detailed evidence to attract public funding from multiple sources. Alternatively, they may be large and prestigious enough and with benefits that are easy to identify and quantify in physical terms to be sufficient to secure support without detailed economic evidence. In any case, larger projects may well need analysis to be undertaken over a wide geographical area, such as a region or even the entire country, making additionality assessment even more difficult.

Suitable evidence is more likely to be forthcoming where stakeholders are committed to demonstrating that their investment in GI has actually achieved the anticipated impacts. This may focus primarily on overall benefits. For example, where the interest is in the regeneration of a neighbourhood or even a city, decision makers may just be interested in the changes in their area rather than whether or not the changes are net additions or mainly involve displacement.

One general issue here is the difficulty of comparing studies of similar types of green infrastructure because they make use of different sets of indicators, or use varying definitions for similar output or outcome measures. Therefore it would be useful if an agreed standard set of common indicators could be developed.

4.2.1 *Inward investment*

While there has been plenty of information on property price premiums from proximity to green infrastructure and firms moving into areas, there is little evidence on understanding what proportion of this premium is due to green infrastructure rather than other factors. In general, exactly what enhanced property values mean in economic development terms for different types of area is largely under-researched.

A few studies have addressed the question of businesses moving into an area as a result of environmental and property improvements, but none has examined the extent of business expansion or local labour recruitment that may be associated with such moves.

Where time and resources allow, it would also be helpful to undertake 'vacancy chain' surveys to ascertain the fate of premises vacated by firms who move to the area surrounding the green infrastructure installation.

4.2.2 *Visitor spending*

There is information on how visitor numbers (and spending) to an area increase following green infrastructure investment. However, it is not clear if these visits would have been made to another green infrastructure feature in the city or elsewhere (hence green infrastructure displacing activity from other places, rather than generating new trips). It is not possible to answer this question without visitor surveys specifically asking about the motivations behind visits and alternative uses of the visit time (including other locations for the same recreational activities). There is also little information on multiplier effects from visitor spending.

There is clearly a need for more UK-based evaluation studies in urban settings along the lines of the Glasgow Green example, or even the US Trust for Public Land approach if data availability will allow it. Some research to verify the basis of the assumptions used in the valuation methodologies used in such studies would be helpful. It would also be good if local additionality estimation formed a part of such work, thus enabling the demonstration of regeneration benefits to areas adjacent to green infrastructure schemes that have encouraged an increase in visitors from elsewhere. Even with an improved evidence base on visitor expenditure, however, one key question would remain: what scale of additional money flowing into the local economy would be required to stimulate business expansion (in the form of additional employees and/or extra outlets) on the one hand, and new start-ups on the other?

4.2.3 Environmental cost savings

Green infrastructure does the work of assimilation, protection and clean-up so that the public and private sector do not have to spend on alternative methods of reducing or alleviating the effects of emissions, flooding and wastewater treatment, or suffer the consequences of environmental decline. There is some data on quantitative changes from these services but it is not always clear what the financial savings are. There is also little information on what these savings are then spent on, and whether this involves business expansion and job creation, thus making a contribution to economic growth. However, unless there is a direct transfer of funds between different items, the standard methods of public resource allocation or reallocation are likely to make such assessments virtually impossible.

4.2.4 Health benefits

Very few studies currently exist that have moved from establishing the link between green spaces and health and wellbeing to estimating measurable health outcomes such as avoided excess morbidity and mortality, and what happens to the money saved from health improvements (e.g. less medical expenditures). However, it would be safe to assume that they would be spent elsewhere, indirectly contributing to economic growth. Health benefits in terms of reduced absenteeism can also lead to direct economic benefits in terms of promoting productivity gains.

Another possibility for establishing a direct link through from green infrastructure via health improvement to increased economic activity would be evaluation of the growing number of ecotherapy approaches to dealing with mental health issues. These would offer a ready-made context for more detailed exploration of the connection between use of green infrastructure, health improvements and economic outcomes.

4.2.5 Market sales

Data on urban food and forestry is limited. Existing data and research are mostly concentrated on rural areas. However, the Green Infrastructure Valuation Toolkit¹¹ includes methods that help to estimate the benefits of such activities. Application of these to a wide range of examples would help to establish whether the aggregate effects are of a scale and significance to make a difference in terms of the wider economy.

¹¹ <http://www.greeninfrastructurenw.co.uk/html/index.php?page=projects&GreenInfrastructureValuationToolkit=true>

4.2.6 *Employment generation*

It would be helpful to know whether total employment in the green infrastructure sector has increased or decreased over recent years, and to keep track of future trends.

It would also be useful to have an occupational breakdown of these jobs, so that placing a reasonably accurate economic value on them in terms of their contribution to GVA and local multipliers is facilitated.

4.2.7 *City-wide green infrastructure networks*

The role of green corridor networks and informal open spaces in providing wider accessibility - and hence benefits - to as many urban residents and workers as possible has received little attention. Studies could include the part they play in promoting active transport (walking/cycling) and environmental impact gains.

On a wider scale, there is also scope for investigation of the combined effects of the ensemble of formal and informal green infrastructure across a whole city for the urban economy.

4.3 Recommendations

The literature review concluded that in broad terms the presence and quality of green infrastructure do confer important economic benefits on an urban area, but there are limits to our knowledge of the quantity of these benefits. This implies that actions are required along three fronts:

- ensuring strong policy frameworks and project interventions to support maintenance and improvement of green infrastructure stock;
- research and evaluation designed to extend and enhance the evidence base, and
- how to make the most of the data that we do have.

4.3.1 *Policies and Projects*

- There is a strong case for investment in maintenance and improvement of green infrastructure networks to be sustained.
- In designing green infrastructure schemes a key strand will be incorporating elements that help to maximise direct economic impacts.
- Provision or improvement of green spaces and corridors can be supplemented by active leisure interventions among the local population, thus increasing the health benefits for a larger number of people.
- There is compelling evidence that further additions to sustainable green installations (Sustainable Urban Drainage Systems (SUDS), green roofs, etc.) will bring economic as well as environmental benefits.

4.3.2 *Research and Evaluation*

This area may be divided into four areas for attention:

- Core indicators
- Project and programme evaluations

- Policy-related studies
- In depth academic research.

Core indicators

A common set of core indicators to demonstrate the economic benefits of green infrastructure should be developed.

In an earlier review Saraev (2010) suggested a long list of such measures to enable monitoring and evaluation of net economic effect of green space interventions. However, many of these do not make a direct connection to green infrastructure. Therefore, we have adapted Saraev's approach in line with our review findings to produce a list of twelve measures that are of direct relevance to assessing the economic contribution of green infrastructure (see Table 4.1).

Table 4.1: Core economic indicators

Indicator	Description
Jobs growth	Increase in full-time equivalent jobs in project area
Local employment	Number of new jobs taken by residents of project area
Investment	Amount of inward investment in property and business in project area
Business expansion	Increase in turnover in firms within project area related to increase in businesses moving into the area and in visitor spend
Business start-up	Number of new businesses started in project area
Population growth	Increase in local residents of project area (depending on existing density, land availability, housing availability, allowable density)
Local tax revenue	Increase in Council Tax/Business Rate revenue in project area
Visitors	Increase in number of visitors from outside town/city to project area
Visitor spend	Increase in aggregate amount spend by new visitors
Health benefits	Increase in environmental quality that could improve general public health and also increase number of residents taking regular exercise
Water run-off	Amount of absorbed or abstracted from conventional stormwater drainage system, heavy metal, oil and fertiliser pollution reduction
Produce	Estimated value of produce from the site

These are all amenable to capturing the net economic benefit of green space interventions via additionality assessment along the lines of official guidance (HMT Green Book; BIS, 2009; English Partnerships, 2004; Scottish Enterprise, 2008). Most of them make reference to the 'project area': this is intended as a flexible concept, to be defined according to the scale of the green infrastructure covered by the study. Thus it could be a

local neighbourhood surrounding an improved park or containing newly greened vacant sites; or it could be a whole town or city and its network of formal and informal green infrastructure.

Project and programme evaluations

It is recommended that wherever resources allow, green infrastructure installation or improvement projects and programmes be the subject of economic evaluation, using the core indicators listed in Table 4.1 as appropriate.

The aim would be to build up a body of evaluation evidence that illustrated the different types of economic benefit according to project scale, type and context.

Policy-Related Studies

Where regional or national GI are concerned, research on individual economic benefits should pay more attention to additionality (and hence displacement) effect.

In-depth Academic Research

It is recommended that the Defra family of organisations offer support and assistance to longer-term research studies in further education institutions and related centres.

Here the goal would be to explore some of the more difficult issues associated with the economic impacts of green infrastructure. This might involve examples such as the take-up of premises vacated by firms moving to an area improved through green infrastructure investment. The detailed investigations required to disentangle such complex topics may well make this suitable for a doctoral research project; others may produce more robust results if undertaken by more experienced researchers.

4.3.3 Making the most of available evidence

As stated throughout this report, there is sufficient comparison data (before and after GI investment or between areas with and without GI) that shows GI contributing to local economic growth. Evidence on larger geographical and temporal scales and on additionality is harder to come by.

It is important that decision makers use the evidence that exists for the purposes it can help with, and communicate this evidence to the stakeholders as clearly as possible. Review of the literature and interviews with some of those involved in the case studies covered in this report recommend the following (Mikelle Adgate, a project director at NYC Office of Green Infrastructure):

- There will be a large and mixed group of stakeholders involved in any GI project. These may include beneficiaries, funders (public sector at local and national level, private sector, community groups) and those who stand to lose from projects. All will have different objectives and requirements in terms of what robust evidence means. This means balancing compliance with European, UK, devolved government and local laws and regulations in addition to communicating with, and enlisting support from, the diverse stakeholders involved.
- Focus on finding and communicating the benefit that will be most 'real' to the local population. For example, for the NYC GI Plan, initially they focused on storm water runoff and the facts and figures relating to problems associated with it and managing it. They wanted to keep it simple and explain that GI could do the job, be aesthetically pleasing, and cost less. Comparison between costs, market and non-

market (environmental and welfare) benefits of green and grey infrastructure also helps.

- It is crucial to tailor arguments to fit the different concerns of different stakeholder groups. Again, for NYC GI Plan, when speaking to policy makers they stressed the fact that GI is cheaper than alternatives and when talking to community members and local stakeholders they stressed water quality and aesthetics.

Glossary

Additionality: a net measurement of the impact of a project or policy after making allowances for what would have happened in the absence of the project or intervention. In other words, it is the additional benefit(s) gained from implementing an activity that is above the baseline conditions/what would have happened anyway.

Biodiversity: the variety of life in all its forms, including genetic, species, and ecosystem diversity.

Discounting: The process of expressing future values in present value terms. This allows for the comparison of flows of cost and benefit over time regardless to when they occur.

Economic Displacement: the degree to which a promoted activity will be offset by reductions in activity elsewhere.

Economic Growth: the increase in the amount of the goods and services produced by an economy over time. It is measured as the percent rate of increase in real GDP.

Economic Value: the value of all goods and services, whether traded in markets or not, that increase human welfare either through consumption or through making life on Earth possible and enjoyable. It is the value of what is 'given up' (or 'foregone' or 'exchanged') in order to obtain a good or service.

Ecosystem: defined at the most basic level as a natural unit of living things (animals, plants, and microorganisms) and their physical environment.

Ecosystem Services: the benefits to humankind from a multitude of resources and processes that are supplied by natural ecosystems. Some of these ecosystem services are well known including food, fibre, fuel, and the cultural services that provide benefits to people through recreation and cultural appreciation of nature. Other services, however, are not so well known, and can include climate regulation, air and water purification, flood mitigation, carbon capture and storage, soil formation, and nutrient cycling.

Green Infrastructure (GI): for the purposes of this report, GI is most broadly defined as living systems within the boundaries of an urban settlement, and/or living systems outside the boundaries of an urban settlement that can significantly affect the settlement. It can include a planned network of green spaces and other natural features including street trees, gardens, green roofs, community forests, parks, rivers, canals and wetlands. However, the definition can change slightly depending on country. For example, in the USA, GI has been extended to apply to the management of stormwater runoff through the use of natural systems and penetrable surfaces, but can also apply to "green" best management practices (i.e. management practices that prevent or reduce pollution). Although this use of the term is not central to the larger concept, it does contribute to the overall health of natural ecosystems.

Gross Domestic Product (GDP): the market value of all officially recognised goods and services produced within a country in a given period of time.

Gross National Product (GNP): a measure of a country's economic performance calculated by adding to GDP the income earned by residents from investments abroad, less the corresponding income sent home by foreigners who are living in the country.

Gross Value Added (GVA): A measure of the value of goods and services produced in an area, industry or sector of an economy. It is calculated by subtracting 'intermediate consumption' from gross output or turnover. In effect this 'corrects' the turnover (expenditure) estimates for the costs of goods and services consumed or used up as inputs in production: raw materials, services and various other operating expenses. This results in a 'net' figure that shows how much the turnover adds to the economy in the area.

Hedonic Property Pricing: A regression analysis of the data on property transactions, property and neighbourhood characteristics and socio-economic characteristics of the population in an area to estimate how much people are willing to pay for each aspect of a property, which includes environmental quality and visual amenity indicators.

Multiplier (also known as 'income multiplier'): every time there is an injection of extra income to an economy, it leads to more spending, which creates more income, and so on. The multiplier effect refers to the increase in final income arising from any new injection of spending. The size of this multiplier varies according to the pattern of expenditure, the nature of an area's economy, and the linkages between sectors in the economy.

Present value: A future value expressed in present terms by means of discounting.

Urban Heat Island: a metropolitan area that experiences increased temperatures, in comparison to surrounding rural areas, due to human impacts.

Willingness to Pay: the amount of money individuals are willing to pay either to secure an environmental (or other) gain or to avoid an environmental (or other) loss.

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