Making the case for investment in Green Infrastructure in Oxfordshire

- *Tackling sustainability challenges with natural solutions*
- *Generating social, economic and environmental benefits*
- *Evidence report with recommendations for further development and delivery*

A report commissioned by Oxfordshire County Council

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OXFORDSHIRE COUNTY COUNCIL

Photos

Front Page: wild flower strip included as part of tow-path improvements, River Thames, Oxford. 2019.

Back Page: mixed planting to support pollinators as part of a community-led planting project, Chipping Norton Health Centre. 2018.

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Executive Summary

Planning for, and enhancing, Oxfordshire's Green Infrastructure is an essential part of realising the county's long-term ambitions and economic aspirations, as expressed in the emerging Oxfordshire Plan 2050, the Oxfordshire Infrastructure Strategy and other policy documents.

This study provides evidence to demonstrate Green Infrastructure's contribution to economic development, sustainable housing provision and social wellbeing. It provides direct evidence to show how Green Infrastructure helps achieve Oxfordshire's strategic objectives for Local Authorities, businesses, organisations and communities in Oxfordshire.

The aim of this study is to establish the case for investment in Green Infrastructure within Oxfordshire. Only with such investment in Green Infrastructure will future growth be truly sustainable, achieving positive social, economic and environmental outcomes.

This study:

- Highlights key sustainability issues and considerations at county level.
- Promotes the contribution of Green Infrastructure to "place making" and urban development.
- Demonstrates that Green Infrastructure adds multiple benefits to the value of plans and projects.
- Sets out evidence that these benefits can be achieved in a cost-effective way.
- Makes the case for a significant, strategic and co-ordinated investment in Green Infrastructure.
- Facilitates a co-ordinated and consistent approach to Green Infrastructure strategy development and Implementation.

Our analysis highlights seven areas which are barriers to further growth of the county's economy. This is causing significant economic cost to Oxfordshire's Gross Value Added (GVA) each year:

Issue	Annual cost to Oxfordshire GVA
Mental Health	£1,300,000,000
Obesity	£427,000,000
Air pollution	£207,000,000
Transport – congestion	£170,000,000
Transport – accidents	£135,000,000
Inactive lifestyles	£120,000,000
Noise	£119,000,000
TOTAL	**£2,496,000,000**

Table 1: Top seven sustainability challenges in Oxfordshire and their annual cost to the economy

These seven "sustainability challenges" cost the Oxfordshire GVA £2.5bn every year. That is £3,790 per person living in Oxfordshire, over 10% of Oxfordshire GVA. It represents a 10% brake on Oxfordshire GVA.

There is a need for strategic, sustainable and cost-effective measures to tackle these barriers to growth.

The key principle in this study is to demonstrate the significant contribution that Green Infrastructure can make to addressing these challenges.

The study focusses on the role that Green Infrastructure can play in seven positive outcomes:

1. Supporting housing development.
2. Sustainable transport.
3. Better health & wellbeing.
4. Ensuring climate change adaptation and mitigation.
5. Reducing flood risk in Oxfordshire.
6. Improving air quality.
7. Thriving biodiversity.

Many detailed examples of the qualitative and financial benefits of Green Infrastructure investment are provided in Chapter 4 of this study. The presented evidence sets out the scale of both the challenge and the opportunities. The table below sets out headline figures on the benefits of investment in Green Infrastructure.

Headline benefits of investment in Green Infrastructure

- ✔ *A 1% increase in the amount of greenspace in a ward generates a 1% increase of the value of a residential property in England*
- ✔ *Vegetation may reduce noise by as much as 50%.*
- ✔ *A noise reduction of just 1 decibel for every property in the county would be worth £8m p.a. to the Oxfordshire Economy.*
- ✔ *Investment in cycling infrastructure could take one car off the road for as little as 80 pence per day.*
- ✔ *Reducing speed limits in residential areas could reduce traffic accidents by half.*
- ✔ *People with good access to green space are 24% more likely to be physically active.*
- ✔ *A 10% increase in physical activity in adults would be worth over £6m to the Oxfordshire Economy.*
- ✔ *Oxfordshire's woodlands remove 175,000 tonnes carbon dioxide (CO_2) per year from the atmosphere with an estimated value of £6 million each year.*
- ✔ *Green roof energy savings are 30 kwh/m^2 or 14 kg CO_2/m^2 or £5-6 m^2 per year for heating and air conditioning.*
- ✔ *River woodland is worth £6000 per year per hectare for its flood regulation benefits. Sustainable drainage systems (SUDS) are half the cost of traditional drainage over a 60-year life span.*
- ✔ *During an extreme rainfall event green roofs can retain up to 90% of rainfall.*
- ✔ *One square meter of green roof can offset the annual particulate matter emissions of one car.*
- ✔ *Planting of vegetation in streets can reduce street-level pollution concentrations by up to 60%.*
- ✔ *Oxfordshire's rural woodlands remove 400 tonnes of air pollutants and thereby save £6.5 million in healthcare cost per year.*
- ✔ *Converting intensive agriculture to a mixture of woodland and pasture near cities can generate benefits of £1,300 per hectare per year.*

Investment in Green Infrastructure will be most effective where it is spatially targeted and designed to deliver multiple benefits in the same location. Evidence from robust Benefit Cost Ratio (BCR) analyses suggests that BCR can be anywhere between 1.7: 1 and 65:1. **Many Green Infrastructure investment programs across the UK report average BCR of better than 10:1.**

Taking all of the above into account, this study proposes that all relevant stakeholders in Oxfordshire working in partnership:

Invest £50 million a year in Green Infrastructure over a period of 30 years (until 2050). The total economic benefits of this investment are estimated to be at least 6 billion.

To do this well and to spend the money effectively, the following need to be in place or developed:

- A comprehensive understanding of all Green Infrastructure assets, the quantity, quality and location.
- A spatial analysis of the needs of the people, businesses and organisations of Oxfordshire.
- A spatial analysis how assets can be matched with areas of greatest need.
- A fully costed business case following government 'Green Book' rules.
- An in-principle investment decision by the political leaders, e.g. the Oxfordshire Growth Board.
- An investment plan based on a stakeholder vision and consensus.
- Identification of funding mechanisms and funding sources across the public, private and voluntary sector.
- A dedicated management of the Green Infrastructure investment programme.
  The document identifies a broad range of funding mechanisms and funding sources, where this investment may come from (see Section 6.5).

Overall recommendations:

1. Develop a summary business case based on Government green book rules. It needs to include the cost and consequences of not taking any action.
2. Develop a vision for Oxfordshire's Green Infrastructure that inspires and co-ordinates action.
3. Build partnerships able to deal with the scale and complexity of the challenge.
4. Invest in filling data and other evidence gaps to ensure good decision making.
5. Invest in robust analysis of assets and data to ensure targeted and effective delivery.
6. The scale of proposed investment is £50m p.a. for 30 years.
7. Manage the Green Infrastructure investment programme in an appropriate way.
8. Build on previous work and existing strategies and fully embed Green Infrastructure in the Oxfordshire Plan 2050 and the assessment of its spatial options.
9. Apply good practice in Green Infrastructure delivery.
10. Identify funders, potential investors, funding mechanisms and specific funding sources.
11. Link at policy and delivery level in particular with the Oxfordshire Plan 2050.

The majority of original evidence and statistics for this document were collated in 2017. Since then this document has acted as an important internal evidence base for Oxfordshire County Council. A major policy review/update of the document took place in May 2018. Some key updates related to changes in local policy and available statistics were made in 2019. A final update in June 2020 updated the evidence base and brought the document in line with key policy documents, in particular the Oxfordshire Plan 2050.

1. Introduction

1.1 Background to this study

This report was commissioned by Oxfordshire County Council. It sets out evidence relating to Green Infrastructure in Oxfordshire, and the case for investment in Green Infrastructure.

The background evidence contained in this document and its annex can be used by a wide range of audiences to feed into policy and decision making.

Who is this document for and what does it aim to achieve?

This document is for all organisations, businesses and stakeholders in Oxfordshire who have an interest in the long-term sustainable development of the County, facilitated by investment in Green Infrastructure. Oxfordshire is currently the most rural county in the south east. Residents value the high-quality environment and high quality of life in Oxfordshire. Major natural assets include three internationally valued protected landscapes, the River Thames, Oxford Canal, productive farmland and a network of rivers, wetlands, grassland and woodland habitats. This report identifies 135,000ha of Green Infrastructure assets, and 5,500km of public rights of way.

Oxfordshire authorities have committed to building 100,000 new homes across Oxfordshire between 2011 and 2031 as part of the Oxfordshire Housing and Growth Deal funding from central government announced in autumn 2017. The Oxfordshire authorities have also committed to the preparation of a Joint Statutory Spatial Plan (The Oxfordshire Plan) to guide development in the county to 2050. The first topic papers were published in Feb 2019. A number of experts are currently preparing updated second versions of these topic papers[1].

The National Infrastructure Commission report into the Oxfordshire-Milton Keynes-Cambridgeshire Arc also recommended that there was a chronic undersupply of homes across the area, and that house building rates would need to double, building 1 million homes to 2050 across the Arc. High housebuilding rates in Oxfordshire could therefore continue.

This report was commissioned to bring together national and local evidence of the importance of Green Infrastructure to help build a case for investment in Green Infrastructure alongside growth.

This study:

- Highlights key sustainability issues at county level.
- Demonstrates how Green Infrastructure can contribute to improving outcomes.
- Promotes the contribution of Green Infrastructure to "place making" and urban development.
- Demonstrates that Green Infrastructure adds multiple benefits to the value of plans and projects.
- Sets out evidence that these benefits can be achieved in a cost-effective way.
- Makes the case for a significant, strategic and co-ordinated investment in Green Infrastructure.
- Makes recommendations for a co-ordinated and consistent approach to Green Infrastructure strategy development and implementation.

1.2 Definition of Green Infrastructure

This document uses the following definition of Green Infrastructure:

"Green Infrastructure is a network of multi-functional green space, urban and rural, which is capable of delivering a wide range of environmental and quality of life benefits for local communities."

National Planning Policy Framework, MHCLG, February 2019.

1.3 Key Green Infrastructure principles

The following important principles follow from the definition of Green Infrastructure:

More than Green Spaces

Green Infrastructure is often described as "a network of green spaces". The Green Infrastructure approach goes beyond the traditional "green space and open space" agenda. It includes non-accessible green spaces, public rights of way, access land. Also green roofs, green walls, sustainable urban drainage schemes and individual trees. The concept of the "Grey-Green Continuum" brings in footpaths and cycle paths. Many approaches also include some agricultural land, e.g. grassland and other environmental features. The concept of "Blue-Green Infrastructure" brings in lakes, ponds, rivers and canals.

Connectivity

As with any other infrastructure, it is important that Green Infrastructure assets connect with each other to form a network. This will look and feel different at various spatial scales from street level to regional level. Some nature conservation concepts contribute to connectivity. This includes wildlife corridors or biodiversity opportunity areas, known as Conservation Target Areas (CTA) in Oxfordshire.

Environment-led

Green infrastructure is not "just about the environment". But it has the environmental asset as a starting point. It aims to create a high Quality of Life standard and to achieve the best possible sustainable development.

Integration of Service Delivery

Green Infrastructure goes beyond the immediate environmental sector. It looks at environmental assets in an holistic and integrated way. Green Infrastructure assets have many functions or services that generate a broad range of benefits. These benefits will be relevant to aspects such as health, housing, tourism, transport and many others.

Organisations from different sectors and different local authority departments need to work together to plan the infrastructure of a place in order to reap the greatest benefits from Green Infrastructure for its communities.

Tailored approach to rural and urban areas

Green Infrastructure thinking has its roots in the habitat connectivity approach of the nature conservation sector. In the UK it was first and still is first applied in urban areas. Green Infrastructure knows no political nor town planning boundaries. It is important to tailor the approach to the situation. Green Infrastructure assets in rural areas will offer different services and functions than in urban areas. They will need a different approach to reap the maximum benefits.

Benefits orientated – multi-functional

The Green Infrastructure approach is positive. It looks at opportunities. It aims to optimise the planning, maintenance and development of green spaces. This helps to secure the greatest possible benefits from them and to meet the various needs of communities. In this context policy makers also use the term "Natural Capital". This means the environment is an asset that can be worked with to secure long-term economic and social benefits. Green Infrastructure has many different features and characteristics. These provide many functions or services. This will lead to benefit realisation through appropriate design, management and enhancement of Green Infrastructure assets.

Community led & community led solutions

The benefits of Green Infrastructure are directed at people. Oxfordshire will need significant resources to create a better Quality of Life and to create future resilience. Residents need to have a say in what, where and how we implement Green Infrastructure.

We need to place more emphasis on local residents providing local knowledge and expertise in the planning process, masterplanning and major environment-led investments.

This will support community ownership and community management of Green Infrastructure assets.

Resilience and climate change adaptation

Green Infrastructure can make a very significant contribution to climate change mitigation and adaptation. Ecosystems that are more healthy will be more resilient to climate change. Places with more Green Infrastructure will make people and essential infrastructure more resilient to climate change.

2. Vision, aims and benefits

2.1 Vision

Investment in Green Infrastructure will play a key role in transforming Oxfordshire into a county with a more sustainable and resilient future. Green Infrastructure will be well maintained and valued. It will provide the right social, economic and environmental benefits in the right locations. Benefits will include better air quality, noise reduction, safer and more encouraging environments for cycling and walking and creating conditions that encourage active lifestyles and promoting mental wellbeing.

2.2 Aims and Objectives

The aim of this study is to establish the case for investment in Green Infrastructure within Oxfordshire. Only with such investment in Green Infrastructure will future growth be truly sustainable, achieving positive social, economic and environmental outcomes.

The study focusses on the role that Green Infrastructure can play in seven positive outcomes:

1. Supporting housing development

Embedding Green Infrastructure in new and existing housing will ensure that Oxfordshire can retain its high levels of quality of life. This will help to maintain and attract a high-quality workforce. It will also help address many environmental issues and challenges, such as pollution, noise and flooding.

2. Sustainable transport

An integration of green and grey transport infrastructure will be an essential element to facilitate truly sustainable growth in Oxfordshire. This can become a positive force for a step change in our mobility agenda and overall sustainability.

3. Better health & wellbeing

The people of Oxfordshire will enjoy access to natural greenspaces for recreation, leisure, relaxation, inspiration and improved health and wellbeing.

4. Ensuring climate change adaptation and mitigation

Green Infrastructure will be part of Oxfordshire's contribution to global efforts to mitigate the effects of Climate Change. This will include capturing CO_2 in woodlands and other habitat. More attractive and safer Green Infrastructure corridors for walking and cycling will motivate people to switch their mode of transport. This will reduce emissions from transport. Green roofs will help save energy by better insulating buildings. These green roofs and other strategically placed Green Infrastructure will cool buildings and reduce the need for air conditioning.

There is a clear scientific consensus that climate change is occurring. Oxfordshire needs to prepare for this changing future. Green Infrastructure will help us to adapt to climate change. Green Infrastructure will enable transport infrastructure and especially urban areas to become more resilient to flooding and other extreme weather events. Green Infrastructure will also moderate temperatures, reducing "Urban Heat Island Effects" (UHIE) in the summer or providing shade for people walking or cycling. This will enhance physical health and quality of life.

5. Reducing flood risk in Oxfordshire

Green Infrastructure will help to reduce the risk from both river and surface water flooding.

6. Improving air quality

Green Infrastructure will provide a cost-effective, adaptable and small-scale solution to reducing air pollutants. This will contribute to improving people's health and overall quality of life. Any form of natural vegetation can contribute to this.

7. Thriving biodiversity

Networks of Green Infrastructure will provide great spaces for wildlife and will contribute to healthy ecosystems. This will give communities in Oxfordshire greater resilience against future challenges, such as climate change. Opportunities to engage with wildlife also benefit personal wellbeing.

3. Context & background

Local and National policy and strategy change all the time. This report is a snapshot of the policy and strategy situation as of June 2020. By the time of publication, there are likely to be further changes. For example, more information on statutory requirements for Biodiversity Net Gain and Nature Recovery Networks may emerge, as well as more information on a Future Green Infrastructure standard.

We trust that the following two sections give a good overview of which policies and strategies need to be considered in the context of multi-functional Green Infrastructure that seeks to integrate and find synergies with a broad range of other policy areas

3.1 National context

This section lists a number of national policy drivers for Green Infrastructure.

A Green Future: Our 25 Year Plan to Improve the Environment (25YP; HM Government, Jan 2018)

The first three policies are most relevant in the context of this study:

1. Using and managing land sustainably.
2. Recovering nature and enhancing the beauty of landscapes.
3. Connecting people with the environment to improve health and wellbeing.

The first policy includes a statement that "Used positively, the planning system can protect key natural and historic assets and encourage high-quality green infrastructure in urban areas."

The third policy includes a section on "Greening our towns and cities" with sub-headings on "Creating more Green Infrastructure" and "Planting more trees in and around our towns and cities". The Government commits to an action to "Supporting Local Authorities to assess green infrastructure provision against[...] new standards" (including an updated ANGSt standard by 2019). The Greater Urban Manchester Pioneer has a particular focus on Green Infrastructure.

Seven of the 10 goals of the plan are relevant to Green Infrastructure:

1. Clean air.
2. Clean and plentiful water.
3. Thriving plants and wildlife.
4. A reduced risk of harm from environmental hazards such as flooding and drought.
5. Using resources from nature more sustainably and efficiently.
6. Enhanced beauty, heritage and engagement with the natural environment. In addition, we will manage pressures on the environment by:
7. Mitigating and adapting to climate change.

The concept of "Natural Capital" features heavily in the document (see also below under Natural Capital Committee). Creating a national Nature Recovery Network is a major commitment in the UK Government's 25-Year Environment Plan. It may become a Government requirement to produce such a network at the local level (more detail about plans for Oxfordshire in sections 4.1.7, 4.2.8 and 4.7.7).

Natural Environment White Paper – The natural choice: securing the value of nature
(NEWP; HM Government; June 2011)

NEWP established the creation of Local Nature Partnerships (LNP). LNP build on the previous work of Local Biodiversity Partnerships. However, they have a wider remit to "improve the multiple benefits we receive from good management of the land." NEWP promotes a landscape-scale and Green Infrastructure approach to

achieve this. Green Infrastructure can be the "glue" that connects high-value biodiversity sites on a landscape scale and also connects them to urban areas.

NEWP recognises urban Green Infrastructure "as one of the most effective tools available to us in managing environmental risks such as flooding and heatwaves"(par. 2.78).

It acknowledges the existence of "strong evidence for the economic and social benefits of Green Infrastructure" (par 2.81). It states that "high-quality green infrastructure can also drive local economic growth and regeneration." (par 3.22). Under the heading of "Growing a green economy", it presents Green Infrastructure as part of the Natural Capital assets that underpin economic growth.

The Government committed to the establishment of a national Green Infrastructure Partnership.[2] Their aim is to "consider how green infrastructure can be enhanced to strengthen ecological networks and improve communities' health, quality of life and resilience to climate change. A whole chapter promotes "Reconnecting people and nature". This focusses on health and wellbeing, education, enhancing local neighbourhoods and giving people access to the countryside.

Housing and Planning Act 2016

The Act promotes the provision of sustainable urban drainage systems (SUDS).

The Secretary of State must carry out a review of planning legislation, government planning policy and local planning policies concerning sustainable drainage in relation to the development of land in England. (par. 171)

United Kingdom Air Quality Strategy (UK AQS) July 2007 Vol 1 Vol 2

This strategy requires councils to improve areas of poor air quality. They have to reduce any remaining significant risks to health and achieve the wider objectives of sustainable development about air quality in the UK.

UK Climate Change Act 2008 (UK CCA)

The Climate Change Act commits the UK government by law to reducing greenhouse gas emissions by at least 80% of 1990 levels by 2050. The Act establishes the framework to deliver on these requirements. The Act also created the Committee on Climate Change (CCC) to ensure that emissions targets are evidence based and independently assessed. The Act also requires the Government to assess the risks and opportunities from climate change for the UK, and to prepare for them. The CCC's Adaptation Sub-Committee advises on these climate change risks and assesses progress towards tackling them. Climate Change has gone up the political agenda very significantly in the last 18 months. The country has seen monthly 'climate strikes for the future'. The UK government declared an environment and climate emergency on 1 May 2019. On 27 June 2019 the UK government amended the Climate Change Act and set a legally binding target to achieve net zero greenhouse gas emissions from across the UK economy by 2050.[3] (more on the situation in Oxfordshire in section 4.4.6).

National Planning Policy Framework (NPPF; MHCLG, February 2019)

The NPPF brought Green Infrastructure into the statutory planning guidance for the first time in 2012. Some key paragraphs include (abridged text):

Strategic policies should set out an overall strategy for the pattern, scale and quality of development, and make sufficient provision for: conservation and enhancement of the natural, built and historic environment, including landscapes and ***green infrastructure****, and planning measures to address* ***climate change mitigation and adaptation****. (NPPF, par. 20)*

Planning policies and decisions should aim to achieve healthy, inclusive and safe places which:

a) *allow for easy pedestrian and cycle connections within and between neighbourhoods, and active street frontages;*

b) clear and legible pedestrian routes, and high-quality public space, which encourage the active and continual use of public areas; and

*c) enable and support healthy lifestyles, especially where this would address identified local health and well-being needs – for example through the provision of safe and accessible **green infrastructure**, sports facilities, local shops, access to healthier food, allotments and layouts that encourage **walking and cycling**. (NPPF, par 91)*

*Plans should take a proactive approach to **mitigating and adapting to climate change**, taking into account the long-term implications for flood risk, coastal change, water supply, biodiversity and landscapes, and the risk of overheating from rising temperatures. Policies should support appropriate measures to ensure the future **resilience** of communities and infrastructure to climate change impacts (NPPF par 149)*

*New development should be planned for in ways that: avoid increased vulnerability to the range of impacts arising from **climate change**. When new development is brought forward in areas which are vulnerable, care should be taken to ensure that risks can be managed through suitable adaptation measures, including through the planning of **green infrastructure** (NPPF par 150)*

*Plans should take a strategic approach to maintaining and enhancing networks of habitats and **green infrastructure**; and plan for the enhancement of natural capital at a catchment or landscape scale across local authority boundaries. (NPPF par 171)*

Biodiversity Net Gain

The UK government has increased its focus on achieving no net loss of biodiversity and the likely move towards mandatory net gain of biodiversity.[4] *There is an indication in the Environment White Paper that there will be a statutory requirement for 10% net gain in every new development. (The consultation concluded in July 2019).*

The government is also likely to set further tree planting and woodland creation targets and support this with appropriate funding mechanisms.

The new Environment Bill 2020 is likely to embed these concepts and aspirations.[5]

Industrial Strategy – Building a Britain fit for the future (BEIS, Nov 2017)

This white paper does not make any explicit references to Green Infrastructure, nature or the natural environment. It makes a few references to "Natural Capital" in the context of "Clean Growth", the circular economy and the 25-year Environment Plan. It has several foundational principles and policies Green Infrastructure can contribute to. These are:

- A major upgrade to UK infrastructure.
  - Green Infrastructure has the potential to make (transport) infrastructure more resilient to the challenges of climate change.
- Places – prosperous communities.
  - Green Infrastructure can provide renewable energy resources (biofuel, anaerobic digestion, woodfuel and green roofs in combination with solar panels).
  - Green Infrastructure can provide more sustainable transport solutions in the Grey-Green Infrastructure continuum.
- Agree Local Industrial Strategies that build on local strengths and deliver on economic opportunities:
  - Oxfordshire's version could have Green Infrastructure embedded in its approach.
- Create a new Transforming Cities fund:
  - Green Infrastructure can contribute to sustainable transport networks within cities.
- Innovation is another strong theme in the Industrial Strategy. The Green Infrastructure could provide a truly sustainable and highly innovative way to achieve clean growth.

Natural Capital Committee

The government created the Natural Capital Committee in 2012. The Natural Capital Committee provides advice to the government on the sustainable use of Natural Capital. It defines Natural Capital as "Our natural asset". This includes forests, rivers, land, minerals and oceans. The committee's remit covers the benefits we derive from natural assets, such as food, recreation, clean water, hazard protection and clean air. It has published a series of reports.[6]

Many activities currently deplete Natural Capital stocks. This reduces the amount of benefits or so called "ecosystem services" that can flow from Natural Capital. The main service groups are:

- Provisioning, such as the production of food and water;
- Regulating, such as the control of climate and disease;
- Supporting, such as nutrient cycles and crop pollination;
- Cultural, such as spiritual and recreational benefits.

Many studies have investigated Natural Capital. A few Natural Capital investment plans exist in the UK (e.g. Surrey Nature Partnership, 2015 and Greater Manchester, 2019).[7] The government tasked the Office for National Statistics to create Natural Capital Accounts (NCA) for key types of habitat.[8] Very few accounts exist at the local level. The Greater London Authority recently published a NCA for its green spaces (GLA, Nov 2017).[9] As this example shows, the boundaries between Natural Capital and Green Infrastructure can be somewhat fluid.

Natural Capital – Green Infrastructure – what is the difference?

Green Infrastructure is a concept enshrined in statutory guidance (the NPPF), Natural Capital was introduced as a concept to the NPPF refresh in 2018.

Green Infrastructure is more practitioner and solutions orientated. It often focusses on housing and planning in urban areas. Natural Capital is still more of an academic or theoretical approach, especially the associated concept of Ecosystem Services.

Natural Capital is more all-encompassing than Green Infrastructure. It can focus more on rural areas and habitats. For example, it includes soils, minerals, groundwater and the oceans. Green Infrastructure assets are a sub-set of Natural Capital.

Both share that they seek to put an (economic) value on the natural environment and to promote the natural environment as a solution to a problem. Both start with a detailed analysis of the assets.

Brexit

There are many uncertainties about the UK leaving the EU.

There is a likely increase in the formulation of new policy. Oxfordshire could be at the forefront of this by providing examples of truly innovative ways of urban and rural development. A change to UK farming subsidies may be a major opportunity. Many organisations have recently promoted the concept of "public money for public goods". This concept is actually much older than the referendum vote (e.g. ECIPE, 2009).[10] This could lead to financial incentives for farmers to provide benefits to people in the way they manage their land.

Covid-19 Pandemic

It is too early to say what social, financial, environmental and economic impact the Covid-19 pandemic will have. Some behaviour patterns are likely to change, e.g. more home working and greater awareness and use of local green spaces.

At the time of writing it is unclear, if there may be a 'green recovery' central stimulus package and how this may benefit Green Infrastructure investment.

The following table sets out how national policy and legislation is relevant to the seven key outcomes proposed in section 2.2.

OX Green Infrastructure outcome	Most relevant national policy/strategy/legislation
Sustainable Transport	♦ NPPF Section 9 is dedicated to promoting sustainable transport ♦ NPPF par 102 and 104 support walking and cycling
Air Quality	♦ NPPF par 103 – planning system to reduce congestion and emissions, and improve air quality and public health ♦ NPPF par 181 requirement of Air Quality Management Areas (AQMA)
Climate Change Mitigation & Adaptation	♦ NPPF section 14 is dedicated to Meeting the challenge of climate change ♦ NPPF par 20 and 150 promote measures to adapt to Climate change (par 150 explicitly through GI)
Housing	♦ NPPF par 67 and 70 make a requirement for a Strategic Housing Land Availability Assessment (SHLAA)
Flood Risk mitigation	♦ NPPF section 14 is dedicated to Meeting the challenge of climate change and flood risk ♦ NPPF par 118 refers to the importance of undeveloped land for flood risk mitigation ♦ NPPF par 157 makes reference to natural flood risk management
Biodiversity	♦ NPPF Section 15, par 170, 174 and 175 and par 141, 149 reference biodiversity in the context of nature conservation and climate change
Health/Access to green spaces	♦ NPPF Section 8 is dedicated to Promoting healthy and safe communities and par 91 refers specifically to safe and accessible Green Infrastructure

Table 2: Most relevant national legislation and policy and how it relates to the seven outcomes proposed for Oxfordshire.

To help policy makers and those wishing to embed and integrate Green Infrastructure into other policy areas, we recommend this tool developed by Northumbria University: Green Infrastructure Planning Policy Assessment Tool (2020). https://mainstreaminggreeninfrastructure.com/project-page.php?green-infrastructure-planning-policy-assessment-tool. It has been tried and tested by a number of Local Authorities.

3.2 County Context

Basic statistics

Land area: 260,492 ha (c1% of UK). Land Cover statistics below[11]

Local Authority	Built on	Green urban	Farmland	Natural
Oxford	53%	14%	31%	1%
Cherwell	8%	3%	88%	1%
South Oxfordshire	6%	4%	81%	9%
West Oxfordshire	5%	3%	87%	4%
Vale of White Horse	7%	3%	86%	4%
Oxfordshire	**7%**	**3%**	**84%**	**5%**

Table 3: Basic land use statistics for Oxfordshire.

Population: 653,798 (155,348 children and 498,450 adults, *c*. 1% of UK population)

Gross Value Added (GVA): £20.5 bn (c1.3% of UK)

Unemployment rate: 4%
In the last 10 years the rate has been between 1 and 5% points lower than the average in England.

People between 16 and 64 in employment: 81%

Oxfordshire is asset rich and a global brand. 1,500 high tech firms employ around 43,000 people. Oxfordshire's visitor and cultural economy contributes *c*. £3.1 bn to the local economy (Oxfordshire LEP).[12]

The table below gives a quick summary of the most relevant Oxfordshire strategies and plans. It lists specific objectives or targets that Green Infrastructure can contribute to.

In conclusion: Green Infrastructure has potential to deliver on objectives across many different policy priorities.

Title	Specific targets/objectives Green Infrastructure can contribute to
Oxfordshire Local Transport Plan (LTP, 2016 update), OCC	Support **jobs and housing growth** and economic vitality
	Enhance air quality and support the transition to a **low carbon economy**
	Protect and **enhance Oxfordshire's environment** and improve **quality of life** (including **public health**, safety and individual **wellbeing**)
Oxfordshire Infrastructure strategy – stage 2 report, Sep 2017, Oxfordshire Growth Board	Prioritise strategic infrastructure investment needed to support jobs and housing growth in Oxfordshire
	Shape & influence investment strategies and plans
	Prioritise the delivery of different types of strategic infrastructure
	Maximise the use of available and planned infrastructure capacity
	Make better informed choices about the location of future growth
	Better position Oxfordshire in funding and investment discussions with government. Green Infrastructure was specifically identified as an area needing additional work.
Oxfordshire Local Industrial Strategy, adopted July 2019 [https://www.oxfordshirelep.com/sites/default/files/uploads/Oxfordshire-SINGLE-PAGE_1.pdf]	Improve Oxfordshire's quality of life for residents and its attractiveness as a location, to attract top talent and encourage talent to stay.
	Places - Establish a Health & Wellbeing Lab.
Minerals & Waste Core Strategy (adopted Sep 2017, OCC)	**Minimise the flood risk** associated with minerals development and contribute to **climate change mitigation and adaptation**, including through restoration schemes which **provide habitat** creation as a mechanism for addressing climate change adaptation and additional flood storage capacity
	Protect Oxfordshire's communities and natural and historic environments (including important landscapes and ecological, geological and archaeological and other heritage assets) from the harmful impacts of mineral development (including traffic)
	Provide benefits to Oxfordshire's natural environment and local communities through the restoration and aftercare of mineral workings, in particular by contributing to nature conservation, enhancing the quality and extent of **Conservation Target Areas**, contributing to landscape character, improving access to the countryside, safeguarding local amenity, providing opportunities for local **recreation** and providing benefit to the local economy
	Implement a **biodiversity-led restoration strategy** that delivers a net gain in biodiversity, and contributes to establishing a coherent and resilient ecological network, through the landscape-scale creation of priority habitat

Title	Specific targets/objectives Green Infrastructure can contribute to
Oxfordshire's Joint Health & Wellbeing Strategy 2018-2023, March 2019, OCC	**Strategic Objective:** Be Happy and Healthy - Children have easy ways to get active.
	Strategic Objective: Prevent the development of long-term conditions by helping people to live healthy lives, live in healthy places and avoid the need to go to hospital.
	Strategic Objective: Value mental health equally with physical health.
	Strategic Objective: Nurture healthy communities that enable people to participate and be active.
	Strategic Objective: Deliver preventative services in the community to reduce or delay the need for health and care services.
	Strategic Objective: Healthy Place Making - ensuring the physical environment, housing and social networks can nurture and encourage health and wellbeing.
Oxfordshire Local Flood Risk Management Strategy, 2014, OCC	Take a collaborative approach to **reducing flood risks**, using all available resources and funds in an integrated way and in so doing derive enhanced overall benefit
	Prevent an increase in **flood risk** from development where possible, by preventing additional flow entering existing drainage systems and watercourses
	Take a sustainable and holistic approach to flood risk management, seeking to deliver wider **environmental and social benefits**, **climate change mitigation** and improvements under the Water Framework Directive
Partnering for Prosperity – a new deal for the CB-MK-Oxford Arc (National Infrastructure Commission, 2017)	Link homes and jobs, connecting the places where people live and work
	Co-ordinate patterns of new development, creating focused opportunities to build new **communities around transport hubs** and interchanges
	Create **inclusive liveable places**, connecting people and communities with opportunities for work and leisure
	Create up to **1 million new homes** across the corridor by 2050
	Help reduce congestion in and around Oxford

Title	Specific targets/objectives Green Infrastructure can contribute to
Housing and Growth Deal (Sep 2018) [https://www.gov.uk/government/publications/oxfordshire-housing-deal]	Ambition to plan and support the delivery of circa 100,000 new homes across Oxfordshire between 2011 and 2031
	Commitment to ensure new housing and employment development are of high quality design and meet environmental standards in order to create attractive, sustainable places that offer a good quality of life for existing and new communities.
	Housing and Growth Deal (outline agreement, 2017)
Oxfordshire Plan 2050 (draft objectives 2019) **[http://oxfordshireplan.org / https://oxfordshireplan.org/wp-content/uploads/2019/02/Introducing_the_Oxfordshire_Plan_Feb_2019.pdf]**	**Obj.1:** To maintain and enhance the historic built and **natural environment** of the county through strategic investment and high-quality design.
	Obj.2: To protect and enhance the County's distinctive landscape character, recreational and **biodiversity** value by considering the benefits these assets bring, by improving connectivity between environmental assets and securing a net gain for **biodiversity**.
	Obj.3: To improve **health and wellbeing** by enabling independence, encouraging healthy lifestyles.
	Obj.4: To create sustainable communities by providing good access to open space to meet identified needs and that respond to the challenges of **climate change**.
	Obj.5: To establish the right conditions to sustain and strengthen the role of Oxfordshire in the UK economy by building on our key strengths and assets.

Table 4: Green Infrastructure's contribution to targets and objectives to key Oxfordshire policy and strategy documents

This Green Infrastructure study is intended to positively inform documents currently under development and any future policy documents.

Annex 1 lists more detail on the above and other strategic documents in the County.

Annex 1 also lists an example of how preparatory work for this document influenced and informed the Oxfordshire Infrastructure Strategy (OXIS). It also explores how Green Infrastructure and other essential infrastructure needs to be considered relative to each other.

4. Green Infrastructure – contribution to sustainability challenges

This chapter examines how Green Infrastructure can contribute to the aim and outcomes set out in this document and the aims and targets of other key policy documents, such as the Oxfordshire Infrastructure Strategy or the new Oxfordshire Plan 2050 (see section 3.2). The evidence in this chapter draws upon reliable sources of research and data. These include statistics and publications from local governments and other public sector bodies and peer-reviewed science papers. Evidence, case studies and reports from the voluntary sector and a selected number of international studies complement the above.

The evidence shows that Green Infrastructure can make a significant contribution to tackling the sustainability challenges we face.

This chapter has seven sections, one for each aim set out in section 2.2.

All sections have the same structure:

1. A brief description of UK situation and context.
2. Key strategic issues.
3. Baseline evidence on challenges and existing assets, Including a quantification and financial scale of a problem where possible.
4. Opportunities.
5. Evidence on the value of investing in the Green Infrastructure asset.
6. Examples of good practice in policy and implementation, both within and outside the county.
7. Implications for Strategy and Policy.
8. Practical actions in Oxfordshire to achieve the aims set out in this study.

Changes in policy and strategy as well as practical actions on the ground (i.e. subsections 7. and 8) will facilitate achieving the aims and outcomes set out in this study.

Each sub-section on the **evidence on the value of investing in the Green Infrastructure asset** covers aspects such as:

- Green Infrastructure contribution to providing a solution to the problem (how?)
- A quantitative description of benefits (how much?)
- An economic value of the benefits (value in ££?)
- Benefit Cost Ratios (how effective in economic terms?)
- Comparative cost analysis with traditional or technical solutions (how competitive in economic terms?)

4.1 Supporting sustainable housing development

Key Outcome

Embedding Green Infrastructure in new and existing housing will ensure that Oxfordshire can retain its high levels of quality of life. This will help to maintain and attract a high-quality workforce. It will also help address many environmental issues and challenges, such as pollution, noise and flooding.

4.1.1 UK situation

There were 24.4 million dwellings in England in March 2019. This is an increase of 241,000 dwellings (1%) on the previous year.[13] 2010 saw the lowest post-war house building levels, at just over 100,000 new dwellings built.

Programmes such as Eco-towns (since 2009)[14] and Garden Villages Towns and Cities (since 2016)[15] are seeking to increase the sustainability of UK house building. They are promoting Green Infrastructure or green spaces respectively.

- The County Council is currently working on the Oxfordshire Plan 2050 identifying spatial locations. Considerations on Green Infrastructure and evidence and methods presented in this document can feed into the process.
- Consider exploring the Urban Greenspace Factor (UGF) - as now adopted by the Greater London Authority. This is seeking to increase the proportion of quality, multi-functional Green Infrastructure in all new development.[16]

Without urgent action, a chronic undersupply of homes could jeopardise growth, limit access to labour and put prosperity at risk.

4.1.2 Strategic issues

- Oxfordshire's 2014 Strategic Housing Market Assessment (SHMA) identified that 100,000 homes are needed across the county by 2031 to meet its trend-based economic and demographic growth and to ensure that people can live in affordable homes close to where the economic potential will be delivered.
- OXIS and the Oxfordshire Housing and Growth Deal confirms this aspiration, with detail being developed via the *Oxfordshire Plan 2050* (Oxfordshire's joint statutory spatial plan). The Oxfordshire Plan 2050 will include the 100,000 homes by 2031 identified in the SHMA.

  The Oxfordshire Plan will provide a long-term spatial planning framework for Oxfordshire to the year 2050.
- It can be challenging to identify the most sustainable locations for housing development.
- Housing affordability is a pressing issue in Oxfordshire.
- Developers need to consider many factors for Economic Viability Assessment. Green Infrastructure provision affects viability and can get squeezed out. There is a tension with the concept that a Green Infrastructure development is "better value for money for society". This is because there is a discrepancy between who invests in Green Infrastructure and who the indirect and ultimate beneficiaries are (e.g. insurance companies, NHS, the general population)
- This can become a barrier to creating housing development with more Green Infrastructure. However, Bicester Eco-town is an example where the target was 40% Green Infrastructure.
- Funding for Green Infrastructure within development (S106, Community Infrastructure Levy) has to be balanced with other infrastructure needs. Historically, other infrastructure needs have often been regarded as of higher priority.

4.1.3 Baseline Evidence

As of 1 April 2019, there are 295,517 dwellings in Oxfordshire. Net additions to dwelling stock have grown steadily since 2012/13 and reached 5000 in 2018/19. (MHCLG, June 2020).[17]

4.1.4 Opportunities

- Have a more bespoke/tailored/strategic approach in Local Development Management policy. For example, identify one housing site requiring 20% Green Infrastructure for a specific purpose. Identify another site as already having good Green Infrastructure in neighbourhood, so it only needs 10%.
- Didcot Garden Town and Bicester Eco-town, as well as the three garden villages – Salt Cross Garden Village (formerly known as Oxfordshire Cotswolds GV), Dalton Barracks and Berinsfield, may bring opportunities for exemplary, more sustainable housing development.
- Using SUDS where sewers are at or close to maximum capacity. This will help to avoid significant capital investment for upgraded sewers to support additional housing development.

4.1.5 Evidence on value of investing in assets

Green Infrastructure enhances property values

- A 1% increase in the amount of greenspace in a ward generates a 1% increase of the value (*c.* £2,000) of a residential property in England (LSE, 2010).[18]
- Each hectare of park space within 1km of housing increases house prices by 0.08% in London. The presence of a regional or metropolitan park within 600 metres adds 2-3% to total house value (GLA, 2010).[19]
- Houses and flats within 100 metres of public green spaces are an average of £2,500 more expensive than they would be if they were more than 500 metres away – an average premium of 1.1% in 2016 (ONS, 2019)[20]
- Section 4.5.5 covers evidence on the (economic) benefits of SUDS.

4.1.6 Good practice in policy and implementation

- The Vale of White Horse, Oxford City Council and South Oxfordshire District Council's adopted Community Infrastructure Levy Regulation 123 lists include provision for Green Infrastructure (West Oxfordshire and Cherwell Districts have yet to decide their CIL provision).
- Oxfordshire County Council has now adopted and published guidance on SUDS.[21]
- Strategic documents from elsewhere have given pointers what this could mean in practice:
  - *Green Infrastructure by design – adding value to development* (Natural England *et al.*, 2010). This guide for sustainable communities in Milton Keynes and areas in the South Midlands gives very practical design recommendations. It shows how developers can secure multiple benefits from embedding Green Infrastructure. This includes access and recreation, flood attenuation, landscape setting, access to nature and countering the urban heat island effect.
  - The *St Edmundsbury Green Infrastructure strategy* includes an "information pack" of *guidelines for developers and planners* (Sep 2009). It makes recommendations both at local and development scale.
  - In the Tees Valley, Stockton Borough Council has done some excellent work with their *Stockton Green Infrastructure Strategy* (2011) and action plan. This seeks to connect as many residents as possible from their doorstep via tertiary and secondary Green Infrastructure corridors to the main Green Infrastructure corridors in the Tees Valley.
  - Wales has now put legislation in place to enact Schedule 3 to the Flood and Water Management Act 2010, making SUDS a requirement for all new development of a certain type and size.[22]

- As part of the national pilot on healthy new towns, Oxfordshire had two demonstrator sites in Bicester and Barton. Work there resulted in the development of the 'Healthy Place Shaping' policy, that also influenced national NHS guidance.[23]
- A recent policy approach by the Greater London Authority led to the introduction of the Urban Green Space Factor (UGF), seeking to increase the proportion of quality, multi-functional Green Infrastructure in all new development.[24]

The 2019 amendments to the CIL regulations removed the requirement for authorities to publish a CIL Regulation 123 List. By 31 December 2020 an Infrastructure Funding Statement will replace this list. In the meantime the list remains a useful indication of infrastructure that may be CIL funded and what is likely to be required as part of Section 106 agreements, to be negotiated on a site-specific basis.

4.1.7 Implications for strategy and policy

- Housing development has the potential to contribute significantly to Green Infrastructure creation. This requires strong policies and the political will to enforce it to the full extent it is intended.
- Housing and Growth deal.
- There is an important role for Local Plans, Green Infrastructure Strategies and subsequent Planning Development Management. New housing development needs to be much closer aligned with a strategic implementation of targeted and well designed, multifunctional Green Infrastructure for new and existing housing developments.
- Develop spatially explicit Green Infrastructure policies in Local Plans. Ensure that policies feed through to implementation. This will ensure that new Green Infrastructure provision as part of new housing development meets the strategic needs of the county. These needs include buffering and enhancing Conservation Target Areas and other high biodiversity value sites, creating networks and corridors (rather than a collection of sites) and/or tackling the most pressing current or project future challenges.
- Develop a county-wide Green Infrastructure strategy that sets high level principles. It also needs to provide a high-level spatial analysis what kind of Green Infrastructure is most needed in which locations. Build on this document. (e.g. *Green Infrastructure principles*, the evidence presented here and proposed methods for spatial analysis in Annex 5). This spatial analysis only needs to inform the spatial options of the Oxfordshire Plan 2050.
- There is a joint working group developing a Health Impact Assessment to be used as part of the OP2050 evidence base/ scenario assessment. A Topic Paper on Healthy Place Shaping is being developed to support the inclusion of a Healthy Place Shaping Policy in the OP2050.
- Alternatively or to complement this, develop Green Infrastructure strategies at the local level and build on existing ones.
- Have a dedicated Green Infrastructure section in local CIL and regulation123 list with specific Green Infrastructure projects (where this does not yet exist).
- Build on the 2015 Strategic Environmental and Economic Investment Plan (SEEIP) and any subsequent reviews to look at the "Big Picture" and identify geographic gaps. Any future updated SEEIP needs to assess proposed projects on what a place needs (based on spatial analysis and other evidence).
- A joint approach by the county and districts to create a network of Green Infrastructure corridors. Seek planning policy provision that gives residents better provision of multi-functional Green Infrastructure assets, e.g. access to (natural) greenspace. Secondary and tertiary green corridors would connect residents from their doorstep to the main Green Infrastructure Corridors in the County (e.g. River Thames). A joint approach could be set out in the Oxfordshire Plan. TVERC led on a proposal to develop an Oxfordshire-wide nature recovery network in 2019.[25] This could build on good national practice emerging.[26]

- Link Conservation Target Areas to accessible green corridors via planning policy (except for sites sensitive to human disturbance). Where housing development happens immediately adjacent to CTA, design Green Infrastructure provision on site to buffer or enlarge them.
- The emerging concept of a Nature Recovery Network for Oxfordshire will build on the CTAs.[27] It will also build on good national practice as developed and proposed by The Wildlife Trusts.[28]
- Where CTA are sensitive to access and disturbance (e.g. by dog walkers), use policy to create Sites of Alternative Natural Greenspace (SANG) (see more on CTA in section 4.7 on biodiversity).
- Include or extend inclusion of Green Infrastructure provision in the Districts' Community Infrastructure Levies, Regulation 123 lists and Infrastructure Development Plans.
- Consider Annex 2, i.e. the requirements for evidence on assets and further need for analysis of assets.
- A 2020 report looked into how the Oxford-Cambridge Corridor can be made sustainable. This report uses a Green Infrastructure Matrix to show the benefits (ecosystem services) of different habitat types. Further analysis will aim to explore a 'Green Vision' scenario that aims to reduce impacts on natural capital through more compact developments that protect existing natural capital assets and build in new Green Infrastructure.[29]

4.1.8 Practical actions to deliver outcomes

- Work with political leaders. Increase the actual delivery of enhancing and creating Green Infrastructure through the planning system (planning conditions and planning obligations) based on existing good policy on Green Infrastructure.
- Work in partnership with developers. Provide real local examples of SUDS, renewable energy, green roofs and green walls and promote these. This will raise awareness and inspire potential buyers about what sustainable places may look like. Bicester Eco-town and Didcot Garden Town may be good places to do this.
- Organise events for developers to showcase innovative and sustainable housing developments (within and outside the County)
- Establish and then periodically review residents' provision of accessible natural greenspaces (ANGSt) baseline in local areas. Set targets for creating new or enhancing existing green spaces in local areas. Consider the improvement of accessible natural greenspace (ANGSt) provision for existing residents via new housing development. Explore how large developments may contribute to the provision of new accessible green spaces in the size category 20-100 ha. (e.g. new Country Parks)
- Use Geographical Information Systems (GIS) analysis to establish the scope of ANGSt provision for /from new housing development. More on ANGSt in section 4.3 related to access, health and wellbeing.

4.2 Sustainable transport solutions

Key outcome

An integration of green and grey transport infrastructure will be an essential element to facilitate truly sustainable growth in Oxfordshire. This can become a force for change for a step change in our mobility agenda and overall sustainability.

Introduction – What is the link between Transport Infrastructure and Green Infrastructure?

Green Infrastructure is as much **essential infrastructure** as waste, energy, transport, information and social infrastructure. It needs similar levels of maintenance and upgrading as transport infrastructure to work

effectively. As with transport infrastructure, it needs to be universally available, it needs to start where you live, be continuous and allow you to get where you want to go.

Green Infrastructure can make a positive contribution to the transport challenges we face. Within the **Grey-Green Infrastructure continuum,** the provision of Green Infrastructure is particularly important. This will encourage changes to the mode of transport (walking & cycling) and keeps cyclists and walkers safe and healthy.

Figure 1: Grey-Green Infrastructure Continuum. Adopted from Green Infrastructure Planning Guide.[30]

Examples where Grey and Green Infrastructure (transport) interface are:

- Cycling routes to public transport hubs.
- Park & Ride hubs.
- Cycling or walking routes acting as commuter routes.
- Footpaths and cycle paths along roads, railway corridors and canals.

Investing in Transport Infrastructure towards the "Green" end will:

- Reduce CO_2 emissions pollution and noise and exposure to these.
- Promote physical activity and people's physical health.
- Promote the uptake of public transport in combination with walking and cycling.
- Enable people's access to the natural environment. This will promote mental wellbeing, recreation and inspiration.
- Reduce costs for creation, maintenance and upgrading of infrastructure. (The modal shift will reduce demand for more expensive and increase demand for lower cost infrastructure.)
- Increases the ability of infrastructure and surrounding area to store and filtrate water (acting as SUDS and for water purification).
- Enhance overall sustainability of a place.

In summary, replacing Grey Infrastructure with Green Infrastructure and the accumulated benefits of many people making a modal shift will reduce many problems associated with grey transport infrastructure. The same will happen, when existing Grey Infrastructure is greened through vegetation and moved along the gliding scale towards the green end of infrastructure. For example, vegetation along transport corridors can reduce noise pollution (detail below) and air pollution (see section 4.2.5) and reduce the risk of erosion/earth slides.

Many local authorities now create green active travel routes, green corridors or cycle highways. Green active travel routes combine active travel (such as cycling and walking) with linked "Green Infrastructure" places to create attractive places and journeys for people and improve the environment. These Green Infrastructure places can be parks, playing fields, and waterways.[31]

4.2.1 UK situation

- One quarter of a 2004 DfT survey respondents stated that the impact of traffic on their quality of life was serious. 55% of all respondents thought that traffic in their area was dangerous to pedestrians and other road users. Of those that thought traffic was dangerous in their area, half thought that traffic calming would be a solution. Parking for residents (46%), children playing (43%) and walking (42%) were the top three priorities for street redesign.[32]
- In the same survey, respondents were also asked which physical quality they looked for when choosing a place to live. 80% stated feeling safe when walking around, 75% thought that a good general environment was important.
- The UK has the fifth lowest level in the EU of people cycling at least once a week (14%). In contrast, approximately four in ten respondents in the Netherlands (43%) cycle daily. Roughly three in ten respondents in Denmark (30%) and Finland (28%) also cycle daily.[33]
- In the UK, only about 1-3% of children cycle to school. In the Netherlands, around 49% of primary school children cycle to and from school, 37% walk and only 14% are brought and collected by car.[34]
- In 2018, 555 people in the UK were killed and 10,442 "seriously injured" (Adjusted figures) during cycling or as pedestrians (DFT, 2019). The cost of people being killed or seriously injured whilst cycling according to figures used by the DfT[35] is over £1.1bn and £2.3bn respectively in 2018 in the UK.
- In the UK, the risk of being killed is 14 times higher for cyclists than for motorists per mile travelled. The risk of being seriously injured is 42 times higher. The risk for pedestrians is 16 and 17 times higher respectively.[36]
- Bus fares in England outside London have gone up by 35% in the 10 years between 2005 and 2015 and nearly doubled since 1995 (RPI adjusted).[37]
- The use of public buses is on a steady decline in England (outside London). Figures are down from 68 journeys per person/year in 1991 to 50 journeys/person/year in 2014/15.[38] This increases the pressure on traditional road infrastructure.
- The number of miles travelled by bike in Great Britain has dropped from 14 bn miles in 1949 to just over 2 bn miles. Since 2008 there has been a small increase in cycling.[39]
- A study for England confirmed the "Safety in Numbers"" effect of cycling: More people cycling makes cycling safer. However, the absolute number of injured cyclists increases unless significant measures are put in place at the same times as prevalence of cycling increases (Road Safety Analysis, 2016).[40]

4.2.2 Strategic issues

- Public transport in Oxfordshire is currently crowded in many areas. Major roads are congested, especially in the peak hours. The quality of cycling and walking networks is variable. Some towns had very little investment in pedestrian and cycling infrastructure.[41]
- It is too early to say what the long term impact of the COVID pandemic will be on public transport use.

4.2.3 Baseline Evidence

- In 2018, in **Oxfordshire**, there were 31 fatal casualties, 242 serious accidents and 1240 minor accidents. Of these there were 7 fatal casualties and 74 serious accidents amongst pedestrians and cyclists. There hasn't been a clear trend since 2004, but numbers are lower than in 2000. Casualty rates/1000 population are worse in Oxfordshire than GB average. They are worse than in all but three of the 13 surrounding counties.[42]
- Using DfT costs for casualties,[43] the cost of all fatal casualties and serious and minor road accidents in **Oxfordshire** in 2018 was £135m. The cost of pedestrian/cyclist casualties and accidents was £25m.

Headline figure for the case for investment:

Fatal and serious traffic casualties cost the Oxfordshire Economy £135 million every year.

- 35% of people in **Oxfordshire** access the natural environment by car, 61% by walking or cycling and 3% by public transport. For comparison England figures: 37% by car and 56% by walking and cycling.[44]
- 3.3% of people in **Oxfordshire** who work full time usually cycle to work (England 1.3%, Cambridge 12%, and York 4.4%). For walking it is 4.2% (England 3.1%, Cambridge 5.6%, and York 6.2%).[45] While this is 2.5 times better than the England average, Oxfordshire could learn from cities such as Cambridge or York how to increase this further.
- Data based on the 2011 census shows the mode of transport for commuting as follows: (please note the figures for walking & cycling are much higher and seem to contradict the previous figures).[46]

% of journeys by	Inbound traffic	Outbound traffic	Within Oxfordshire	All Journeys
Car	85%	76%	66%	70%
Public transport	9%	19%	10%	11%
Walking or cycling	6%	5%	24%	18%
Total number of journeys	**57,447**	**48,170**	**246,022**	**351,639**

Table 5: Journeys in Oxfordshire by different modes of transport

- 18.4% of adults in **Oxfordshire** cycle at least once a week. That is higher than the England average, but lower than "cycle friendly" cities (England 9.5%, York 27%, and Cambridge 52%).[47]
- Statistics for Local Authorities in England for adults cycling at least three times a week sees Oxford City Council third and Oxfordshire seventeenth in the top 20 list.[48]

Noise

- Two agreed indicators for measuring noise impact on health are listed below (Public Health England, 2011)[49]. It is worth noting that Oxfordshire is better than the regional and England average.

Noise Indicator	England	South East	Oxfordshire
The percentage of the population exposed to road, rail and air transport noise of ≥65dB(A) [daytime]	5.2%	4.6%	3.4%
The percentage of the population exposed to road, rail and air transport noise of ≥55 dB(A) [night-time]	8%	8.1%	5.4%

Table 6: Noise Indicators in Oxfordshire compared to England and the South East

- The annual social cost of urban road noise in England is an estimated £7 to 10 billion. This estimate includes between £3-£5bn in annoyance costs. The adverse health costs are about £2-£3 billion. Productivity losses account for another £2 billion.[50] Oxfordshire has 1.4% of the English urban road network. Taking the proportion into account, the cost to Oxfordshire is an estimated £98m-£140m p.a.
- Headline Figure for the case for investment: Noise costs the Oxfordshire Economy £98-£140 million every year.

Congestion

- Cars move close to 12 million miles in Oxfordshire every year. Congestion has further deteriorated since 2011. In 2015, 11% of Oxfordshire roads were congested during morning peak. At that time of day, 9800 cars travel into Oxford at average speeds of under 10 mph.[51]
- Traffic consultancy CEBR estimates the 2013 cost of traffic congestion in the UK at $20bn (approx. £16 bn). CEBR is projecting this value will go up to $33bn (approx. £27bn[52]) by 2030. These figures include fuel and time wasted and increased cost of doing business.[53]
- Extrapolating this value to Oxfordshire on a population basis results in costs of *c.*$207m (c.£170m) p.a. rising to *c.*$341m (*c.*£280m) in 2030.

Headline figure for the case for investment:

Traffic congestion currently costs the Oxfordshire Economy £170 million per year. It is projected to rise to £280 million by 2030.

- For comparison, the congestion in and around Oxford alone will cost an estimated £150m to the Oxford economy by 2031(Oxfordshire LTP, Sep 2015).[54]
- The DfT estimates that traffic in England will grow by 19-55%. The proportion of all traffic in congested conditions will be between 8 and 17% in 2040. (In 2010, this figure was approx. 7% of all traffic in congested conditions.)[55]

4.2.4 Opportunities

- Create green corridors for walking and cycling (e.g. towards public transport hubs). This will encourage a change in transport mode – more cycling and walking.
- Continue to invest in cycling infrastructure and targeted promotion and encouragement of shifting the mode of transport – to reduce congestion.
- Physically screen transport infrastructure with vegetation to reduce and mitigate noise, pollution and visual intrusion and enhance landscape quality.
- Create shade for footpaths, cycling routes, car parks, bus stops, roads and pedestrian routes to e.g. schools, to adapt to the impacts of climate change.
- Continue to make transport infrastructure more resilient to climate change and flooding.
- Use existing Park & Ride schemes to enable greater access of the countryside surrounding urban areas ("pushing out" rather than just enabling coming into urban centres).
- Oxfordshire has great aspirations regarding digital infrastructure, as set out for example in the Oxfordshire Local Industrial Strategy.[56]
- Together with increased homeworking - catalysed by the Covid-19 pandemic - this may reduce the need for commuting and may increase those cycling and walking to work.

- The ongoing Covid-19 pandemic has caused significant changes in people's behaviour, such as increased levels of home-working and video-conferencing. More people have been walking and cycling for leisure or to commute. This trend may continue beyond the pandemic.

Figure 2: Walking and cycling are two of the most sustainable forms of transport. © Brillianto

4.2.5 Evidence on value of investing in asset

Headline Figures

Vegetation may reduce noise by as much as 50%. A one decibel noise reduction at every property in the county would be worth £8m p.a. to the Oxfordshire Economy. Investment in cycling infrastructure could take one car off the road for as little as 80 pence per day. Reducing speed limits in residential areas could reduce traffic accidents by half.

Information about the current assets to support sustainable transport solutions is set out in Annex 3.

- A 7km cycleway in Glasgow delivered a social return of £7 for every £1 invested. The benefits included increased exercise and a safer, greener community.[57]
- See more evidence under "Health and Wellbeing".

Noise Abatement

- A dense belt of trees 30m wide can reduce noise levels by as much as 6-8 decibels. [10 dB reduction = half the loudness] (Leonard & Parr, 1970).[58]
- Noise affects house prices. Over the lifetime of a property, a decrease in noise levels from 56-55 decibels would be worth £31 per household per year (Day *et al,* 2007)[59]. Were this noise level reduction to be achieved for all *c.*260,500 households in Oxfordshire it would be worth *c.*£8.3 m p.a.
- A 10m wide green roof can reduce noise levels from a 70mph car 15m away by 5db on the 2nd floor of a building (van Renterghem *et al.*, 2009).[60]

- Vertical Greenery Systems in Singapore can reduce noise levels by as much as 10db (halving the loudness, a difference noticeable to the human ear) (Wong *et al.*, 2010).[61]
- Noise level reduction along roads by belts of vegetation can be as high as 17dB when compared to an open area (Islam *et al.*, 2012).[62]
- Residents are willing to pay £13.70 more council tax per person per month to have noise level reduced from the current state to the desired ideal. They would also pay £23.30 to increase tree cover (Defra, 2011).[63]

Reducing traffic congestion

- The 100 km "Radschnellweg" (aka "cycle highway") between Duisburg and Hamm in the German Ruhr area will cost an estimated € 180 million. It is expected to take 50,000 cars off the road every day. (RS1 Ruhr, 2016)[64] That is about 18 million journeys a year. For a period of 10 years, that would be just € 1 to get one car off the road for one day.

Reducing road accidents

- Home zones in Manchester introduced "green streets" with particular features such as small gardens and wall mounted pots outside the houses and planting trees in the area. It reduced speeds from 18- 23 mph to 9 -13 mph. 72% of residents thought it was "very safe" or "quite safe" for adults walking or cycling in the Home Zone. The number of accidents per year reduced from 1.0 before to 0.5 accidents per year after.[65]
- 67% of respondents to a streetscape survey said it was important for their streets to have more "soft landscaping" such as trees and green areas.(DfT, 2005).[66]

4.2.6 Good Practice in transport policy and implementation

- Dutch schemes from the 1970s introduced the concept of shared space between vehicle and pedestrian. The schemes reconstructed streets to tip the balance in favour of the residential function of the street and to reduce the domination of motor vehicles. The schemes introduced speed humps, chicanes, road narrowing, planting and other measures. This reinforced the message that the motorist is only a guest in the area and that the residential function takes priority in a physical and visual way. Many Schemes in e.g. Germany use tree planting in combination with other measures. (University of Leeds).[67]
- **Cherwell** and **West Oxfordshire** have a dedicated chapter to Open Space and Green Infrastructure respectively in their Infrastructure Delivery Plan.
- **Oxford City** and **West Oxfordshire** refer to the importance of walking and cycling in their Air Quality strategies/plan. Cherwell does so in their Low Carbon Environmental Strategy.
- The **Oxfordshire Local Transport Plan** (2016) is a good starting point. It makes good references to Green Infrastructure and the Rights of Way Investment Plan (ROWIP). It commits to enhancing natural environment through transport. It has regular references to access, walking & cycling, health, air quality and climate change. It also includes an Active Healthy Travel Strategy (AHTS), incorporating a cycling strategy.
- The Oxfordshire LTP is currently being updated into the Local Transport & Connectivity Plan A. Consultation is currently underway on a range of topic papers including **Climate Emergency and Air Quality: Green Infrastructure**.[68]
- Oxfordshire has developed a Local Walking and Cycling Infrastructure Plans for Oxford.[69] It is in the process of developing equivalent plans for Abingdon, Bicester, Didcot and Kidlington. These include a prioritised programme of infrastructure improvements for future investment.

- The Oxfordshire *Cycling Design Standards* and *Walking Design Standards* (both Summer 2017) provide a guide to developers, planners and engineers.
- Further national guidance on how to encourage cycling complements this:
  - e.g. *Making Space for Cycling* A guide for new Developments and street renewals (Cyclenation, 2014). https://www.makingspaceforcycling.org/
  - *Cycling Revolution London* (Transport for London, 2010). https://www.london.gov.uk/sites/default/files/cycling-revolution-london.pdf
  - *Greenway management handbook* (Sustrans, June 2016) provides excellent guidance and example of good practice. It covers design of greenways and topics such as access, walking, cycling, biodiversity, architecture, trees and woodlands. https://www.sustrans.org.uk/media/2752/sustrans_greenway_management_handbook_2016.pdf

Greenway definition

"Greenways are traffic-free routes which are attractive, generally well separated from traffic and continuous over obstacles and through road junctions. Quite typically greenways may run along old railways, canal towpaths, riverbanks, forest roads and tongues of open space leading into urban areas. Although greenways are often rural, many of the most popular and important ones thread their way through the urban fabric." (Sustrans, 2016)[70]

- Sustrans provides many positive **case studies** on cycling's contribution to sustainable transport in the context of Green Infrastructure.[71] For example:
  - A £380k Connect2 project saw the removal of a one-way system in West Green, North London. This created a shared cycle and pedestrian space. It improved crossing points for pedestrians and cyclists in the form of zebra crossings. It also reduced traffic speed, gave better access to green space and a park and provided much safer access to schools.
  - The £4.3m Bath Two Tunnels scheme combines two tunnels, a viaduct and two new bridges along 5.3km of disused railway line. This created a well-loved route through hilly Bath. The scheme is attracting an average of 520 daily cycle journeys.
- There are a number of local authorities, commercial and voluntary sector websites showing and promoting cycle routes in the UK/England/**Oxfordshire**.[72]
- Cycling UK Oxfordshire proposed a Strategic Cycle Network for Oxfordshire in March 2017.[73]
- The city of Groningen, NL, recently decided to invest €85/head (*c.* £73/head[74]) on cycling.[75] The equivalent for Oxfordshire would be *c.* £48m p.a. invested in Cycling.
- Renewable Energy company Ecotricity announced in Nov 2016, they will build their first plant producing bio methane from grass in 2018 in Hampshire.[76] This approach may be applicable to the management of some of Oxfordshire's road verges.

4.2.7 Implications for strategy and policy

- Strengthen future versions of the Oxfordshire Local Transport Plan (2015) and its implementation and policy influence in respect of Green Infrastructure. (The new Local Transport & Connectivity Plan will conclude its consultation in Jan/Feb 2021). This needs to happen in terms of realising biodiversity opportunities through transport infrastructure projects. For example, consider green bridges, biomass production or creation of linear wildlife corridors and habitats and the contribution Green Infrastructure can make to climate change resilience and adaptation.

- Local Infrastructure Delivery Plans benefit from separate chapters on Green Infrastructure. Acknowledge the importance of Green Infrastructure comparable to transport and other infrastructure opportunities. Make strong links between transport and Green Infrastructure (e.g. cycle tracks grey-green continuum), reflecting national and local good practice (as referred to on Oxfordshire LTP above) where possible.
- Continue to seek opportunities to integrate cycle paths as part of redevelopments or new developments across the county.
- Consider Annex 2, i.e. the requirements for evidence on Green Infrastructure assets and further need for analysis of assets.

4.2.8 Practical actions to deliver outcomes

- Development Management – continue to use planning conditions and obligations to secure the provision of cycle tracks associated with Green Infrastructure for any redevelopment or new development, as part of the Grey-Green Infrastructure continuum. Seek to contribute to town-level and A to B cycling. Detailed Geographical Information Systems (GIS) analysis can help establish where such investment has the greatest benefits.
- Community engagement activity to promote walking and cycling for commuting, to get from A to B and for leisure. Geographical Information Systems (GIS) analysis, for example looking at levels of deprivation relative to the location of suitable assets indicates where this investment has the greatest benefit.
- Invest in new off-road cycle tracks, convert key rights-of-way into multi-user routes.
- Continue to seek to close key gaps in the network relevant for commuting, A to B cycling and major points of interest (e.g. Didcot – Wittenham Clumps). Further GIS analysis will identify the best locations for this
- Clearly mark cycle paths or seek to separate them from the road, enhancing road safety and reduce risk of accidents.
- Pilot projects on key transport Green Infrastructure opportunities, based on thorough needs analysis, followed by large-scale implementation:
  - Road verge management for biodiversity.
  - Road verge management for biomass.
  - Transport infrastructure corridor land management with a view to increasing resilience and climate change adaptation (e.g. in partnership with Network Rail or Highways Agency).
  - Noise and pollution mitigation through greening, green walls, facades and street trees in noise and pollution hot spots. Focus on areas close to noise sources and high concentrations of human receptors.
  - Up-stream and catchment-based changes in land use and land management to help protect major transport infrastructure assets from flooding.
- All these pilots need robust monitoring and evaluation with the aim of identifying Benefit : Cost Ratios, ensuring lessons are learned and results are transferable and scalable.
- Assessment of the Conservation Target Area network, habitat fragmentation and climate change resilience. This needs to include Green Infrastructure spatial analysis, but also on-site assessment. Develop proposals for positive interventions to reconnect habitats and allow species movement (e.g. green bridges).
- The emerging work on an Oxfordshire Nature Recovery Network is likely to build on the CTA work.[77]
- Learn from existing national case studies and develop local case studies for:
  - Green corridors for walking and cycling (e.g. towards public transport hubs).
  - Shading to footpaths, cycling routes, car parks, roads and pedestrian routes to e.g. schools.

4.3 Health and Wellbeing

Key Outcome

The people of Oxfordshire will enjoy access to natural greenspaces for recreation, leisure, relaxation, inspiration and improved health and wellbeing.

4.3.1 UK situation

What is public health?

"Public health is about helping people to stay healthy, and protecting them from threats to their health. The government wants everyone to be able to make healthier choices, regardless of their circumstances, and to minimise the risk and impact of illness." (Department for Health, 2017) [78]

The British Medical Association stated that the next government must tackle the public health "ticking time bomb". It called on "politicians who form the next government to make tackling the crisis in public health a priority" (BMJ, May 2017).[79]

Failure to help people stay healthy has significant personal and national economic consequences:

- **Obesity:** The total annual cost to the NHS of overweight and obesity is an estimated £6.1 billion. This figure includes treatment and its consequences. The total economic impact is an estimated £27 billion.[80] By 2030 the NHS cost is projected to be £10bn - £12bn[81] to the NHS, with wider societal cost estimated at £50bn by 2050 (Scarborough *et al.,* 2011, figures from 2002).[82]
- **Physical inactivity:** Over a third of British adults fail to achieve the recommended levels of physical activity (37%). For children and adolescents, the proportion is much higher. The figure reaches 85% for 15-year olds. The total annual economic cost is an estimated € 14 billion. This is equivalent to 8% of UK health spending (ISCA & CEBR, 2015).[83]
- **Mental Health:** Mental health conditions cost approximately £105bn a year in England. This is due to loss of earnings and associated treatment and welfare costs (Centre for Mental Health, 2010).[84]
- There is compelling evidence that we as a nation, and especially our children, are exhibiting the symptoms of a modern phenomenon known as "Nature Deficit Disorder" (National Trust, 2012).[85]
- Nature Deficit Disorder describes the human costs of alienation from nature, among them: diminished use of the senses, attention difficulties, and higher rates of physical and emotional illnesses.[86]
- **Access to greenspace and greenspace funding:** Local authorities' expenditure on open spaces in England, Scotland and Wales is approximately £1.2bn per year, or 0.15% of total public expenditure (The National Federation of Parks and Green Spaces, 2017).[87]
- In Scotland, annual expenditure by local authorities on parks and greenspace has fallen steadily from £190 million in 2010/11 to £167 million in 2014/15.[88] There is strong anecdotal evidence that in some Local Authorities in England, funding for parks and greenspaces has fallen much more dramatically.
- Again in Scotland, there has been a significant decrease in those saying that greenspace meets their needs (from 82% in 2011 to 76% in 2017). A similar reduction occurred in those saying they are very satisfied with the quality of their local greenspace (from 40% in 2011 to 23% in 2017). 40% of people think the quality of their local greenspace has reduced in the last 5 years (up from 33% in 2011). This figure rises to 50% for people living in the 15% most deprived areas (up from 35% in 2011).[89]
- The recent Public Parks Enquiry describe parks as being at a "tipping point" (HM Government, Feb 2017).[90]

4.3.2 Strategic issues

- UK health spending is largely for treating illnesses and diseases. Some of these are caused by unhealthy lifestyle choices or environmental conditions. The proportion of funding invested in Public Health, i.e. preventing illnesses and diseases is very small (*c.*2%; £2.5 bn of a total NHS budget of £125bn; The Kings Fund, 2017).[91]
- There is a lack of funding and consequently little delivery of Green Infrastructure to support public health outcomes. Maintenance mechanisms for green space are challenging to fund.
- The published Oxfordshire Plan 2050 topic paper 'Strong and healthy communities' will be updated to strengthen the new policy concept of 'Healthy Place Making'.[92]

4.3.3 Baseline Evidence

Obesity

- The proportion of residents in Oxfordshire considered inactive (neither walking nor cycling at least once a month) is 10.2% (South East 11.8%, England 12.9%).[93]
- 20% of adults in Oxfordshire are obese (compared to 22% in the South East and 24% in England). An additional 40% are overweight (41% in South East and England). That is approx. 200,000 overweight adults and 100,000 obese adults in Oxfordshire. 1,085 or 17% of 10-11 year olds are obese. That is 3% lower than the UK average.
- 16% of Oxfordshire Year 6 schoolchildren are obese (South East 16%, England 19%).[94]
- The Oxfordshire Health and Wellbeing Joint Strategic Needs Assessment sets out further challenges: An estimated 55% of people aged 16 or over in Oxfordshire are classified as overweight or obese. 55,000 patients in Oxfordshire are registered with their GP with obesity as their (main) health condition.[95]

The estimated cost to the Oxfordshire NHS is £96m p.a. and the total cost to the Oxfordshire Economy is estimated to be £427m p.a. (using the above national figures[96] and taking the proportion of obese and overweight people into account).

Headline figure for the case for investment:

Obesity costs the Oxfordshire Economy £88 million every year.

Physical Inactivity

94,342 residents of Oxfordshire are registered with their GP with high blood pressure as their (main) health problem.[97] Many factors contribute to high blood pressure, including being overweight and a lack of exercise. A summary of indicators on people's physical activity are listed in table below (Public Health England)[98]

Green = statistically better than England average

Amber = no significant difference to England average

Red = statistically worse than England average

Indicator	Year	England	South East	Oxfordshire
Utilisation of outdoor space for exercise/health reasons	2015/16	18%	18%	24%
Percentage of adults who do any walking, at least once per week	2014/15	81%	82%	84%
Percentage of adults who do any walking, at least five times per week	2014/15	51%	50%	52%
Percentage of adults who do any cycling, at least three times per week.	2014/15	4%	5%	9%
Percentage of adults who do any cycling, at least once per month	2014/15	15%	17%	26%

Table 7: Indicators of physical activity in Oxfordshire compared to England and the South East.

Levels of walking and cycling are higher than England/UK averages, but lower when compared with some UK cities (evidence is already covered in section 4.2.3).

Researchers have calculated the cost of physical inactivity as a separate and additional figure to those of obesity. For example, not everyone who is obese is physically inactive. Not everyone who is physically inactive is obese. For example, many normal weight elderly, anorexic, but also children and adolescents are not physically active. Being physically inactive and obese has some overlap in symptoms. However, there are also illnesses and diseases caused by one, but not by the other. For example, worn out knees and hips are common in highly physically active people and the obese, but not in physically inactive people.

- The cost of inactivity in **Oxfordshire** is an estimated **€138m** (**c.£120m**[99]) **p.a.** (using the level of inactivity of the **Oxfordshire** population relative to the national average – see above),

Headline figure for the case for investment:

People's lack of physical activity costs the Oxfordshire Economy £120 million per year.

Mental Health

67,557 residents in Oxfordshire are registered with their GP with depression being their (main) health problem.[100] There are many indicators for public health and mental wellbeing. A selection is presented in the following table (Public Health England):[101]

Green = statistically better than England average

Amber = no significant difference to England average

Red = statistically worse than England average

Indicator	Year	England	South East	Oxfordshire
Hospital admissions for mental health conditions (0-17 years) (per 100,000)	2015/16	86	81	75
Hospital admissions as a result of self-harm (10-14 years) (per 100,000)	2014/15	225	182	221
Hospital admissions as a result of self-harm (15-19 years) (per 100,000)	2014/15	949	727	709
Hospital admissions as a result of self-harm (20-24 years) (per 100,000)	2014/15	410	497	357
people with a low happiness score (Self-reported wellbeing)	2014/15	9%	8%	7%
people with a high anxiety score (Self-reported wellbeing)	2015/16	19%	19%	16%
Parents in drug treatment: rate per 100,000 children aged 0-15 years	2014/15	110	79	100
Parents in alcohol treatment: rate per 100,000 children aged 0-15 years	2014/15	147	120	136
Percentage reporting low life satisfaction	2014/15	14%	14%	14%
Self-reported well-being – high satisfaction score: % of respondents	2014/15	81%	84%	85%
Self-reported well-being – high happiness score: % of respondents	2014/15	75%	76%	77%

Table 8: Mental Health Indicators in Oxfordshire compared to England and the South East

- There were 42 suicides in Oxfordshire in 2018. This is lowest number since 2003, but there are fears the numbers will increase again during Covid-19 and the following economic downturn. The suicide rate is 1% point under the England average.[102]
- Mental health costs Oxfordshire are an estimated £1.3 bn p.a. (extrapolating above UK figures on a population pro rata basis).

Headline figure for the case for investment

Mental health costs the Oxfordshire Economy £1.3bn every year.

Access to green spaces

A summary of health indicators

Access to nature, for example green spaces, facilitates significant health benefits to people (see below in *Evidence on value of investing in assets*).

We have a good understanding of people's access to the natural environment (Natural England's Monitor of Engagement with the Natural Environment survey 2014/15; data for Oxfordshire):[103]

- 54% of all respondents had no visit to the natural environment in the last week (up from 37% in 2009) and a further 14% just one visit.
- Of those who visited a place with natural environment, the average was 3.5 visits per week. Of all respondents the average number of visits was 1.6 visits per week.
- The following are some key factors why people access the natural environment more or less frequently than the average person:
  - People not exercising at least 3 days/week have a lower value of 1.1 visits.
  - People not owning a car, only visit natural places half as often (0.8 visits/week).
  - People owning a dog, visit natural places three times as often as average (5 visits/week).
  - People who walk or cycle to visit the natural environment had the highest number of 5 and 4.2 visits/week respectively.
  - People who can access the natural environment nearby (1 mile or less), had the highest number of visits (4.9/week).
- The number of visits per week are down 27% since 2009.
- 42% of respondents had taken exercise on 3 or more days in the last week (down from 58% in 2009), 58% on 2 days or less (up from 42% in 2009). This is a reduction from reasonable levels to insufficient levels of exercise of 16% in total, over 3% p.a.
- 35% accessed the natural environment by car, 61% by walking or cycling and 3% by public transport (Oxfordshire little change since 2009). For comparison England figures: 37% by car and 56% by walking and cycling.
- The following are the top three reasons why people in Oxfordshire do not visit the natural environment more often (England for comparison):
  - Too busy at work (35%) (England: 24%)
  - Poor health (26%) (England: 16%)
  - Poor weather (18%) (England: too busy at home 15%)
- 93% agreed to statement "Having open green spaces close to where I live is important" (England 93%).
- 86% agreed "I am concerned about damage to the natural environment" (England 87%).
- 86% agreed "Spending time out of doors (including my own garden) is an important part of my life" (England 87%).
- 69% agreed to Outcomes of visit – "It made me feel calm and relaxed" (England 85%).

4.3.4 Opportunities

- Green Infrastructure investment targeted in the right locations can help address health inequalities. This will start breaking vicious circles some communities may have fallen into and start creating virtuous circles.
- Strengthen links between health and Green Infrastructure and Biodiversity policy areas. This could make a very large and significant positive difference, both at county and district level.

- Ensure that agendas are fully aligned between Green Infrastructure, Health benefits and other policy priorities when refreshing the Oxfordshire Infrastructure Strategy, Local Transport & Connectivity Plan and the Oxfordshire Plan 2050.
- Local greenspace and Green Infrastructure strategies and the county LTP & ROWIP already have positive references to health benefits. Future work and implementation could build on this.
- Green Infrastructure can separate people from traffic. It can make walking and cycling safer, more enjoyable and thereby a more attractive alternative.
- Green Infrastructure can improve air quality and reduce noise.
- Health friendly design of greenspaces (e.g. sensory gardens, tranquillity, gym equipment).
- Green Infrastructure provides many benefits for mental and physical health. This will help address the obesity endemic, anxiety and depression and high levels of inactivity.
- The use of "social prescribing", i.e. GPs referring suitable patients to green exercise groups has proven to be an appropriate intervention. It could be used more widely in Oxfordshire.
- Local food initiatives and an increase in access to and use of allotment areas will contribute to several aspects of health: mental health, encouraging physical activity and providing healthy food.
- Intergenerational and/or volunteering activities in the natural environment have the potential to enhance social cohesion and mental wellbeing.
- The ongoing Covid-19 pandemic has highlighted the essential importance of more local green spaces for people's mental and physical health. More local residents seem to be aware of their nearest local green spaces. More residents, policy and decision makers seem to appreciate the value of local green spaces for mental and physical health. More people have been walking and cycling for leisure or to commute. This trend may continue beyond the pandemic.

4.3.5 Evidence on value of investing in asset

Headline Figures

People with good access to green space are 24% more likely to be physically active. A 10% increase in physical activity in adults would be worth over £6m to the Oxfordshire Economy. Benefit Cost Ratios for investment in green spaces (targeting health benefits) range between 12:1 and 30:1.

Greenspace promotes physical activity and health

- People with good access to green space are 24% more likely to be physically active (Natural England, 2009).[104]
- 100 people starting to walk one kilometre per day is worth £31,000 per year (or £305,000 over a 10 year period). This benefit is due to reduced risk of premature death due to exercise (WHO).[105]
- A 10% increase in physical activity in adults would bring an economic benefit to England worth at least £500 million per year. Of this17 per cent (or £85 million) would be a direct saving to the NHS (DfT, 2009).[106]
- Using the Oxfordshire adult population, that would be equivalent to £6.2m overall savings. This includes £1m direct savings to the Oxfordshire NHS.
- A 1% reduction in the sedentary population in the UK would result in improvement in morbidity and mortality. This would lead to an estimated annual cost savings of £1.4bn (LSE, 2010).[107]
- 1 year improvement in a population's life expectancy contributes to an increase of 4% in economic output (Bloom *et al.*, 2004).[108]

- A park in Portsmouth provides health costs savings of £4.4 million each year. This includes £910,000 directly to the NHS. A 3km footpath on the edge of Norwich could save the economy £1 million, including £210,000 to the NHS (RSPB, 2004).[109]
- If 20% of the Inner London population within 2km of green space are physically active 30 mins for 5 days a week, it will bring many benefits. It would generate £8.7m savings to the national economy and £1.8m directly to NHS (RSPB, 2004).[110]

Older people living in the greenest neighbourhood quartile have a 19% lower relative hazard of developing diabetes. The hazard ratio remains similar after adjusting for age, sex, BMI, parents' diabetes diagnosis and socio-economic status. The incidence of diabetes in the least green neighbourhoods would fall by 10.7% if they were as green as the average neighbourhood (Dalton *et al*, 2016).[111]

The Benefits: Cost Ratio (BCR) for investment in London's public parks is 27:1. 19% of the asset value is due to economic benefits for mental and physical health (Mayor of London, 2017).[112]

Figure 3: Parks are a vital asset for children's and adults' health and wellbeing © Brillianto

Mental Health & Wellbeing

- Housing association tenants with high nearby tree cover had a significantly higher reported mental wellbeing than those with negligible levels (Winston, 2012).[113]
- Forest environments promote wellbeing. They cause lower concentrations of cortisol, lower pulse rate, lower blood pressure, greater parasympathetic nerve activity and lower sympathetic nerve activity than city environments. The Higher Frequency (HF) of the Heart Rate Variability (HRV) was significantly enhanced in the forest settings (56% enhancement after viewing; 102% enhancement after walking) (Park *et al*, 2010).[114]
- The tree canopy cover in Oxford City is 21%. (for comparison: Birmingham 23%, Torbay 12%). The tree canopy cover varies in specific wards from 11-30% (Forestry Commission, 2015).[115]
- Viewing tree canopy can aid stress recovery. Every tree matters. There is a positive, linear association between the density of urban street trees and self-reported stress recovery (Jiang *et al*., 2016).[116]

Green health schemes are cost-effective

- The Land Trust state their BCR for money invested by the Trust to secure health benefits as 30:1.[117]
- The Land Trust state their BCR for money invested by the Trust towards crime and anti-social behaviour reduction as 23:1.[118]
- Just 2-10% of inactive people in the local community taking up exercise by providing a new accessible and attractive green space resulted in a cost-effective solution. It reduced loss in Disability Adjusted Life Year (DALY) ranging from £4,500 /DALY to £18,000/DALY. (UK healthcare sector considers any intervention less than £20,000-£30,000/DALY to be cost-effective.) (Dallat *et al*, 2013).[119]
- Introducing a Physical Activity Loyalty Card (PAL) scheme led to a gain in workplace productivity and Quality Adjusted Life Years (QALYs) compared to a No-incentive group. The cost-effectiveness ratio for the health sector was £2,900/QALY. This is well below the UK cost-effectiveness threshold of £20,000/QALY. It is considered very cost effective (Dallat *et al.*, 2013).[120]
- An investment of £9.6 million in parks and greenspace in Edinburgh generates benefits worth £114 million. This is a Benefit Cost Ratio of 12:1. Benefits include £41 million for health & wellbeing, £36 million for social equality and £51 million for local businesses (City of Edinburgh Council, 2015).[121]

4.3.6 Good practice in policy and implementation

- Recent national publications focus on the importance of the planning system in providing favourable conditions to encourage walking and cycling, such as The Planning for Walking Toolkit (TfL, 2020).[122]
- As part of the national pilot on healthy new towns, Oxfordshire had two demonstrator sites in Bicester and Barton. Work there resulted in the development of the 'Healthy Place Shaping' policy, that also influenced national NHS guidance.[123]
- A new Oxfordshire Joint Health and Wellbeing Strategy is seeking to have a county-wide strategic approach to improve people's health and wellbeing.[124]
- As part of this Oxfordshire has adopted the 'Healthy Place Shaping approach'. Many other partnerships and parts of the council now use this concept, e.g. Active Oxfordshire.[125]
- Likewise, the Oxfordshire Mental Health Prevention Framework 2020-2023 promotes access to high quality open spaces and opportunities for sport and recreation. this is to make an important contribution to the health and well-being of communities and to tackle poverty and inequality.[126]
- The **Oxfordshire** LTP, Minerals and Waste Core Strategy and ROWIP make good connections to topics of health (and air quality) facilitated by Green Infrastructure. LTP4 also includes ***Active Healthy Travel Strategy*** (AHTS, updated 2016).
- Likewise the **Cherwell** Recreation Strategy and Corporate Biodiversity Action plan and most of the district level Greenspace/Green Infrastructure strategies.
- The National Charity Centre for Sustainable Healthcare has its headquarters in Oxford. It runs the ***NHS Forest*** project in the county, e.g. the ***Marston Green Health Route*** scheme. It also recently published the Green Walking in Mental Health Recovery guide.[127]
- There is a ***Green Gym*** network in Oxfordshire, created by the Conservation Volunteers (TCV)
- Bicester has a ***Healthy New Town initiative***.
- There is a wealth of documents and toolkits published linking Green Infrastructure and Health (see ***Green Infrastructure Resource Library*** "health" section; too many to list them here).

- There are hundreds of "*Incredible Edible*" groups in the UK (27 in Oxfordshire to date). This local food initiative network has three main aims:
  - The Community Plate – growing produce and working together.
  - The Learning Plate – providing training from field to classroom to kitchen.
  - The Business Plate – supporting local commerce.
- The *Forest School* is an inspirational education program. It offers all learners regular opportunities to achieve and develop confidence and self-esteem. This happens through hands-on learning experiences in a woodland or natural environment with trees. It generates multiple benefits for participating learners, including health and wellbeing. Oxfordshire has been a leading authority in this initiative which is currently led by the Oxfordshire Forest Schools Service.
- CASE Study: *Rainbow Garden* is part of the *Food4Hull* campaign. This is just one of many examples of how community gardens can generate many benefits such as mental wellbeing.
- A "social prescribing" pilot for Green Exercise took place in Barton, Oxford (NHS England & Oxford City Council, 2017).[128]
- Bridewell Gardens in West Oxfordshire is a well-established facility providing mental health support and recovery services within a walled garden and vineyard.

4.3.7 Implications for strategy and policy

- Integrate further Green Infrastructure and Health Policy at County and local level.
- Make more explicit and stronger references to the benefits that a healthy natural environment has for people's health in local Biodiversity strategies and action plans. Suggest appropriate actions to facilitate nature delivering health benefits for people. Similarly ensure links are made in future plans and strategies including the Oxfordshire Climate Change Adaptation Plan, Joint Health and Wellbeing Strategy, any studies on the Green Belt, district level Air Quality Action Plans, climate change/Sustainability strategies. It applies to most Biodiversity Action Plans and Health/Recreation/wellbeing strategies and even some Greenspace/Green Infrastructure strategies.
- There is a joint working group developing a Health Impact Assessment to be used as part of the OP2050 evidence base/scenario assessment. A Topic Paper on Healthy Place Shaping is being developed to support the inclusion of a Healthy Place Shaping Policy in the OP2050.
- Reinforce the connection to nature in County and local strategies on recreation, health and wellbeing. Make clear and positive links to green spaces, green Infrastructure, biodiversity, access to nature, walking and cycling.
- Periodically review the engagement between health, Green Infrastructure, transport and biodiversity policy areas to ensure they remain relevant and effective at both at County and local level.
- Consider Annex 2, i.e. further evidence needs on assets and need for analysis of assets.

4.3.8 Practical actions to achieve outcomes

- Continue to invest in the physical structure and promotion of the Rights of Way network. This will encourage greater levels of use and associated benefits.
- Continue to support investment in the "welcome" and access to large Green Infrastructure resources in the county such as woodlands and water where this is compatible with land ownership, owner motivations and site management. Build on examples such as Otmoor, Farmoor and a number of BBOWT nature reserves.

- Increase the variety of functions and services provided by Green Infrastructure assets. This applies to larger scale greenspaces. It also applies to unreached/unconverted audiences, children and other groups currently not using green space often. In practice this means adding features to greenspaces that attract and benefit more people, e.g. sculptures, play equipment, cafes, giant chess boards etc.
- Seek opportunities to enhance existing Green Infrastructure assets in their functionality and features (e.g. benches, way markers, interpretation, fitness equipment; healthy walking groups). This will provide better for those seeking health benefits.
- Support the creation of new Green Gym initiatives in areas lacking provision and of highest need.
- Improve the provision of lower tier ANGSt sites prioritising areas with high level of (health) deprivation.
- Also consider other standards. This includes the **Greenflag Award** (for green space quality) and **Building with Nature** and await the new national GI standard (Natural England 2021).
- Provide green roofs/walls, trees and other vegetation in areas of highest noise and air pollution and around sensitive receptors (hospitals, old people's homes, primary schools, nurseries).
- Increase the tree canopy cover in Oxford City from its current baseline (21%) to the level of Birmingham (23%). This would increase tree canopy cover by nearly 10%. That is the equivalent of 91 ha more covered by trees. That would be an additional 30,000 trees to plant in Oxford alone.
- Provide more suitable Green Infrastructure assets within or in the vicinity of (primary) schools. This will benefit environmental education and growing food.
- Enhance the safety and naturalness of green corridors to (primary) schools to encourage more walking and cycling.
- Help to make sensitive buildings (hospitals, old people's homes, primary schools, nurseries) more resilient to climate change by providing more shading and evaporative cooling.
- Seek to improve skills in masterplanning and greenspace management.
- Explore how to promote and enhance access to parks and greenspaces in market towns.
- Extend the 2017 "social prescribing" for green exercise pilot from Barton, Oxford.

4.4 Climate Change Adaptation and Mitigation

Key Outcome

Mitigation

Green Infrastructure will be part of Oxfordshire's contribution to global efforts to mitigate the effects of Climate Change. This will include capturing CO_2 in woodlands and other habitats.
More attractive and safer Green Infrastructure corridors for walking and cycling will motivate people to switch their mode of transport. This will reduce emissions from transport. Green roofs will help save energy by better insulating buildings. Green roofs and other strategically placed Green Infrastructure will cool buildings and reduce the need for air conditioning.

Adaptation

There is a clear scientific consensus that climate change is occurring. Oxfordshire needs to prepare for this changing future. Green Infrastructure will help us to adapt to Climate Change. Transport infrastructure and especially urban areas will become more resilient to flooding and other extreme weather events. Green Infrastructure will also moderate temperatures, reducing "Urban Heat Island Effects" in the summer or providing shade for people walking or cycling. This will enhance physical health and quality of life.

4.4.1 UK situation

- The global annual cost of achieving stabilisation of CO_2 between 500 and 550ppm CO_2e are estimated 1% of global GDP, if we start to take strong action now. If we don't act, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year. This will be now and ongoing. For the UK, the 1% is equivalent to £15.6bn investment p.a. to avoid a cost of £78bn p.a. (Lord Stern, 2006).[129]
- Cars in congested areas across the UK waste 72 litres of fuel per vehicle while idling, producing 1,931 kilotons of CO_2 every year (CEBR, 2014).[130]
- Conversion of farmland from grassland to arable land can produce additional emissions of between 3.5 to 6.2 tonnes of CO_2 equivalent per hectare per year (Natural England, 2012).[131] Using 2016 DECC carbon trading figures (*c.*£6/tCO_2e), that CO_2 emission costs £20-£37 p.a. per ha. However, using 2030 EU figures (*c.*£78/tCO_2e) that value rises to £271-£486 p.a. per ha.
- UK road and railway infrastructure need an additional investment of £70 million between 2013/14 to 2018/19 to accommodate climate change (Defra, 2012).[132]

Urban Heat Island Effect (UHIE)

- In the summer of 2019 the South East experienced an estimated 275 excess heat deaths[133]. In the 2018 heat wave there were an estimated 1200 excess deaths in England[134] (this compares to up to 10,000 cold related deaths in the winter).
- The UHIE in London can add 5-6°C to the night time temperatures experienced. During the summer heatwave of 2003, differences of up to 10°C between city and rural temperatures were measured in London.[135]
- In summer 2003, anthropogenic climate change increased the risk of heat-related deaths by ~20% in London. Out of the estimated ~315 deaths attributed to the heatwave event in Greater London, 64 (±3) deaths were attributable to anthropogenic climate (Mitchell *et al*., 2016).[136]

4.4.2 Strategic issues

- Climate Change is a complex issue. It requires co-operation across a large number of organisations and across local government departments.

4.4.3 Baseline Evidence

- Oxfordshire needs to invest £205m p.a. to achieve climate stabilisation. The financial damage to Oxfordshire would rise to £1bn p.a., if we do not take action (based on % figures used in Stern, 2006).[137]
- An estimated 20,000 tons of CO_2 p.a. or £120,000 p.a. are wasted on idling cars in **Oxfordshire** (extrapolation of UK figure, based on a population basis, CEBR, 2014).[138]
- In 2015, cars moved close to 12 million miles in **Oxfordshire** every year.[139] Reducing this amount by just 10% would save 1.2m miles of travel. Using a figure of 120g CO_2/mile, this would save approximately 144t of CO_2 p.a.
- Evidence on Urban Heat Island temperature measurements in Oxford or on excess urban heat deaths in Oxfordshire do not seem to exist.

4.4.4 Opportunities

Green Infrastructure provides the following **opportunities** to mitigate and adapt to climate change:

- Reduction in CO_2 emissions through increasing modal change to walking and cycling.
- Carbon storage through biomass (e.g. tree planting) and renewable energy production (e.g. wood fuel, road verge biomass).
- Energy cost and carbon savings through installation of green roofs, green walls and tree planting (summer and winter).
- Shading and evaporative cooling from green roofs, facades and trees can enhance climate change resilience.
- The flood management section (below) covers more opportunities.
- The ongoing Covid-19 pandemic has dramatically reduced CO_2 emissions (and air pollution) during the most restrictive period of the lockdown in March and April 2020. More people have been home-working and walking and cycling for leisure or to commute. This trend may continue beyond the pandemic, encouraged by the provision of suitable incentives in the form of attractive and safe Green Infrastructure corridors.

Figure 4: Industrial and retail units may provide opportunities for green roofs *© UK Pers 2009*

4.4.5 Evidence on value of investing in assets

Headline figures

Oxfordshire's woodlands remove 175,000 tonnes carbon dioxide (CO_2) per year from the atmosphere with an estimated value of £6 million each year.

Green roof energy savings are 30 kwh/m^2 or 14 kg CO_2/m^2 or £5-6 m^2 per year for heating and air conditioning.

Strategic placement of trees and Green Infrastructure can reduce the UHI and cool the air by up to 8°C. This reduces heat-related stress and premature human deaths during high-temperature events.

Renewable energy and carbon sequestration

- There are about 4.2-4.7 ha road verge per km of highway in the Netherlands available for biomass production. This is based on an estimated average width of just over 2 m on each side of the road. 0.8-2.7 ha/km are available along local roads. The net energy gain (after energy input costs) could be between 625 and 2215 GJ /ha (Voinov *et al.*, 2015).[140]
- Oxfordshire has approx. 2200 miles (3500 km) of dual carriageways and minor rural roads. Using the above values they would have *c.* 15.000 ha to 16,500 ha of road verge. This represents a substantial potential for habitat creation, noise and pollution filtration and biomass production. That area is more than three times the size of all sites with nature conservation designations in Oxfordshire. That is 40 times the size of Wytham Woods.
- The economic value of London's urban forest for carbon sequestration and storage is £151m (per annum). It stores 2.4m t of Carbon p.a. and sequestering 77,000t of Carbon p.a. (Forestry Commission, 2015).[141]
- Environmental stewardship schemes in England reduce emissions by just under 0.5% of the 1990 Kyoto baseline over a 100-year time frame. This amounts to net savings of 5.1 million tonnes of CO_2 (worth £264 million p.a.) (FERA, 2010).[142]
- An enhanced UK woodland creation programme involving planting 23,200 hectares p.a. could capture 15 megatons of CO_2 per year by the 2050s. Mixed woodlands for multiple objectives can capture carbon at less than £25 per tonne of CO_2. This is a lot less than the £100 per tonne cost-effectiveness threshold set by the Committee on Climate Change (Forestry Commission, 2009).[143] For Oxfordshire, this equates to 255 ha woodland creation (area based pro rata amount). It would capture *c.* 160,000t CO_2 p.a.
- Grassland restoration can remove between 4 and 12 tonnes of CO_2 per hectare per year (Natural England, 2012).[144]
- The value of carbon sequestered by UK woodlands is £680 million p.a. Woodlands sequester an estimated 5.2 tonnes of CO_2 per hectare, per year. This is worth £276 per hectare per year (UNEP, 2009).[145] Based on these values, the 23,200ha* of woodland in Oxfordshire sequester approximately 121,000 tons of CO_2 to a value of £6.4 m per year.
  [*note: it is a coincidence that the national figure above proposed by the Forestry Commission is identical with the amount of woodland in Oxfordshire.]
- Oxfordshire's woodlands remove 175,000 tonnes carbon dioxide (CO_2) per year from the atmosphere with an estimated value of £6 million (TOE2, 2015).[146]

Figure 5: A roadside "living fence" in Milton Keynes provides local air quality and noise level improvements.
© Oxfordshire County Council

Energy savings from Green Infrastructure

- A single large tree can transpire 450 litres of water in a day. This uses 1000 mega joules of heat energy, making urban trees an effective way to reduce urban temperature (Natural England, 2012).[147]
- The direct energy savings in Toronto from whole-scale greening would be *c.*$22 million (*c.*£18m[148]). This comes from reduced energy for cooling. This is equivalent to 4.2 kWh/m^2 per year [CO_2 emission saving of 1.7kg/m^2]. Peak energy demand would reduce by an estimated 115 MW. This would lead to fossil fuel reductions in the region of 56,300 metric tonnes per year (City of Toronto).[149]
- The sheltering effect of trees could save 3 to 9% of energy bills (Defra, 1999).[150]
- One m^2 of green roof saves 2 litres of fuel oil per year. Domestic buildings with flat roofs save 3-10 % on winter fuel bills. There is a maximum saving of 7 kWh/m^2 [1.5kg/m2 CO_2 e tonnes] and a minimum saving of 2 kWh/m^2 [0.44kg/m^2 CO_2e] (GLA, 2001).[151]
- Green areas within London may cool the city by as much as 2 or 3°C (Walker Institute, 2010).[152]
- Strategic placement of trees and Green Infrastructure can reduce the UHI and cool the air by between 2°C and 8°C. This reduces heat-related stress and premature human deaths during high-temperature events (Forestry Commission, 2013).[153]
- 3.2 million m^2 of the 10 million m^2 roof area in London have the potential to be greened. This is a potential energy saving of 19,200 MWh per year or the equivalent of *c.*8,300 CO_2 e tonnes (GLA, 2001).[154]
- Green roof energy savings are 30 kwh/m^2 or 13.5 kg CO_2/m^2 or £4.70-5.90/m^2 per year for heating and air conditioning in London (GLA, 2008).[155]

Temperature mediation – avoiding Urban Heat Islands

- A green roof can reduce summer temperature fluctuations under a roof from 45°to 6°C (GLA, 2001, quoting work from Ottawa, Canada).[156]
- 50% green roof cover within the metropolitan area of New York would lead to a reduction in surface temperatures of 0.1-0.8°C. For every degree reduction in the UHIE this saves roughly 495 million KWh (GLA, 2008).[157]
- Placing three large trees around a house can save $100-$250 (*c.*£80-£200[158]) per year in energy costs through the cooling effect (McPherson, 1993).[159]

4.4.6 Good practice in policy and implementation

- **CASE STUDY:** Lincolnshire County Council launched a project in 2016. This explored more sustainable ways of managing nearly 4,000 miles of rural roadside verges. The authority is running a pilot project where they collect grass cuttings from verges for use in a local anaerobic digestion (AD) plant. They will cut stretches around the Scrivelsby AD plant using new machinery. The biomass they collect will generate electricity and biogas.[160] Various organisations have compiled the learning and good practice from this pilot.[161]
- **CASE STUDY:** Dorset County Council developed guidance in 2012 how to manage roadside verges. This includes the production of biomass, traffic calming, climate change adaptation and biodiversity gain.[162]
- **CASE STUDY:** City of London *Green roof case studies*.
- **CASE STUDY:** 400m^2 *green roof on Florence Park Family Centre*, Oxford, officially opened in June 2008 by former local MP Andrew Smith. Client: Oxfordshire County Council. This is the only documented and published green roof case study for Oxfordshire that we could find.
- Oxfordshire County Council has acknowledged the Climate Emergency. Oxford City Council and the District Councils have declared a Climate Emergency. South Oxfordshire set a target to be carbon neutral by 2025, the other authorities by 2030. All have All have established or are in the process of establishing a Climate Emergency Advisory Committee (CEAC).[163]

- A lot of excellent guidance documents on climate change mitigation and adaptation have been published over recent years. This includes:
  - Emergency Tree Plan for the UK - How to increase tree cover and address the nature and climate emergency, Woodland Trust, 2020[164]
  - Advice on using nature-based interventions to reach net zero greenhouse gas emissions by 2050, Natural Capital Committee, 2020[165]
  - Climate Change Adaptation Manual, RSPB & Natural England, 2020[166]
  - green infrastructure and climate change factsheet, TCPA, 2019[167]

4.4.7 Implications for strategy and policy

- With district council and other partners, develop and adopt a county-wide climate change adaptation strategy and action plan, building on existing proposals.
- Where appropriate in both the county level and local strategies and plans on sustainability and climate refer more to:
  - Resilience, climate change adaptation and the role that Green Infrastructure has to play in it.
  - Renewable energy opportunities from biomass (trees, road verges and agriculture).
  - The need to help biodiversity to increase resilience to climate change.
  - Contribution of Green Infrastructure and greenspace to secure modal shifts in transport (walking and cycling).
- Make a positive reference to the role of the natural environment in climate change mitigation and adaptation in local greenspace/Green Infrastructure and biodiversity strategies.
- Consider Annex 2, i.e. further need for evidence on assets and their analysis.

4.4.8 Practical actions to achieve outcomes

- The transport section above already covers modal change to walking and cycling and road verge biomass.
- Pilot and then apply to large-scale project to:
  - Achieve carbon storage & carbon emission reductions through biomass (e.g. tree planting).
  - Renewable energy production (e.g. wood fuel, road verge biomass). The amount of carbon savings will be virtually identical regardless of location. It will be important to understand where these activities may be inappropriate (due to adverse effect on biodiversity and operational concerns) and where these activities are most likely to achieve additional multiple benefits (recreation and health, climate change adaptation, noise and pollution mitigation etc.). GIS analysis will identify the most suitable locations. A partnership including TOE2, the Woodland Trust, Low Carbon Oxford and other suitable organisations may be one mechanism to deliver this.
  - Secure cost and carbon savings through installation of green roofs, green walls and tree planting (summer and winter). Better policies requiring green roofs (see London policies) for certain types of development and specific locations can achieve this. GIS-analysis would identify the most suitable locations.
  - Creating climate-change resilience by providing shading and evaporative cooling from green roofs, facades and trees. This needs to happen in areas where UHI is most likely. Target areas include those where the most vulnerable people are likely to be active or wanting to be active (as part of an active lifestyle) or where a modal change is most desirable. GIS-analysis will identify the most suitable locations.
  - The Oxfordshire Energy Strategy acknowledges the importance of biomass, such as wood fuel and biofuel in their contribution to climate change mitigation. It also sets out key investment priorities.[168]
  - Oxfordshire can also learn from the excellent ParkPower project launched in Scotland in 2018 and providing its initial findings in 2020. This project proposes a strategic approach to establishing a broad range of renewable energy schemes in parks and other green spaces. This includes heat pumps, solar, wind and hydro turbines.[169]

4.5 Reducing flood risk

Key outcome

Green Infrastructure will help to reduce the risk from both river and surface water flooding.

4.5.1 UK situation

- The costs of urban flooding in the UK could rise to between £1-10bn a year by the 2080s if no action were taken to reduce the risks (Foresight, 2004).[170]
- Agricultural practices make flooding worse by £234m p.a. in the UK (Defra *et al.*, 2008).[171]
- Government will spend more than £700 million p.a. on managing flood and coastal erosion risk in England. Around 5.2 million properties in England, or one in six properties, are at risk of flooding (EA, 2009).[172]
- Insurers paid out £1.2bn for flood and storm damage across the UK during 2012 (ABI, 2013).[173]
- The insured losses from extreme events in the UK cost an average of £1.5bn per annum (Defra, 2013).[174]
- Economic damages of the 2007 floods were an estimated £3.9bn. 38% was damage to residential property owners and 23% to businesses. The best estimate of total economic damages is £1,300 million in England and Wales for the winter 2013 to 2014 floods. 38% of damage was to residential property owners and 23% to businesses EA, 2016).[175]
- The 2015/16 winter floods cost an estimated *c.*£5bn to the UK economy (*The Guardian*, 2015).[176]
- The economic impact of rainfall overwhelming the drainage system and causing urban flooding is an estimated £270 million a year in England and Wales (POST, 2007).[177]
- UK flooding events seem to increase in frequency and severity. The last flooding event hit the UK between November 2019 and February 2020. Estimates have put expected insurance payouts as a result of the flooding in the hundreds of millions of pounds. Reliable figures on the overall cost to the economy were not yet available at the time of preparing for publication of this document.[178]

4.5.2 Strategic issues

- Flooding studies to date have mostly focused on big infrastructure solutions.

4.5.3 Baseline Evidence

- The natural flow from an undeveloped site is called "greenfield rate" of runoff. It is usually between 3-8 litres/second/hectare. In urban areas most existing development generates much higher uncontrolled flow rates, often between 200-350l/sec/ha.[179]
- In Oxfordshire 32 residents needed to be evacuated in January and February 2014 compared with 600 in the summer of 2007. High groundwater levels brought historic plumes of solvent to the surface (for example, at Harwell in Oxfordshire). This mobilised banned pesticides from the unsaturated zone.[180]
- The repair costs for all roads following flooding damage in 2007 were an estimated £40–60 million in England (Highways Agency, 2011).[181]
- During the 2013/14 winter floods, 40 roads had to be closed in Oxfordshire, causing major travel disruptions.[182]
- Oxford City Council has paid out almost £200,000 to people affected by the floods that hit the city in winter 2013/14.[183]

- During the 2013/14 winter flooding over 44,400 hectares of land was flooded in England. This included 16,000 ha arable and 28,000 ha grassland; affecting 40,000 cattle, 11,000 pigs and 50,000 sheep. The total economic cost to agriculture was *c.* £19m or £425 per hectare flooded. For the Thames Valley an estimated 6,400 ha of arable and 6,600 ha of grassland were flooded. Of arable winter crops, 10% were considered unviable. 90% were considered viable but flooding was expected to have some yield impact (ADAS, 2014).[184]
- An extreme weather event hit parts of South Oxfordshire on 16/09/2016. Didcot Train Station was flooded due to 49.3mm of rainfall in four hours, closing the station for over eight hours. The station was flooded again on 1 June 2018.[185]

4.5.4 Opportunities

- Identify the most effective places for investment in changes to land use and land management solutions. This is likely to include forestry, measures to reduce runoff, water storage and SUDS. This will deliver small scale solutions tailored to the location that can be replicated across the county.
- Work on perceptions around water and flooding and the perceived benefit of quick solutions ("Get water away from where I live" e.g. ditch clearance).
- Promote the value of trees in natural flood management with decision makers, local authority officers and the general public.
- The Oxford Flood Alleviation Scheme has the potential to be a positive example how we can align flood risk and Green Infrastructure provision.
- New development can integrate SUDS in urban areas. We can also retrofit SUDS into existing development.
- In rural areas, changes to land use and land management, could reduce peak flood flows.

Figure 6: SUDS schemes are now common in best-practice housing development. © Oxfordshire County Council

4.5.5 Evidence on value of investing in asset

Highlight figures

- ✔ *River woodland is worth £6000 per year per hectare for its flood regulation benefits.*
- ✔ *Sustainable Urban Drainage Systems (SUDS) are half the cost of traditional drainage over a 60-year life span.*
- ✔ *During an extreme rainfall event green roofs can retain up to 90% of rainfall.*
- ✔ *Increasing green cover in the urban core of Oxford by 10% would keep 4.2 million litres of water off the roads/out of sewers during an extreme rainfall event*

Role of woodland and trees in flood alleviation

- ❖ River woodland is worth £6000 per year per hectare for its flood regulation benefits (Defra, 2011).[186]
- ❖ In Northumberland, woodlands provide £1,200 per hectare p.a. in flood alleviation savings versus the cost of engineering a solution (National Urban Forestry Unit, 2010).[187]
- ❖ Conifer forests retain 25-45% of annual rainfall. This compares to 10-25% for broadleaved woodland (Forestry Commission, 2005).[188]
- ❖ The economic value of London's urban forest for stormwater alleviation is £2.8m (per annum) reducing floodwater by 3.4m m^3 p.a. (Forestry Commission, 2015).[189]

Role of green roofs in flood alleviation

- ❖ During an extreme rainfall event (of 300l/s/ha), green roofs can retain 30-90% of rainfall. How much, depends on the depth of substrate (Lösken *et al.*, 2002).[190]
- ❖ In areas with rainfall between 650 and 800mm p.a. annual average water retention of green roofs can be between 40% and over 90% depending on substrate depth (FLL, 2002).[191]
- ❖ In central London, 3.2 million m^2 of 10 million m^2 roof area have the potential to be greened. The potential capacity to store rainwater is in the region of 80,000m^2 at roof level (Design for London, 2008).[192]
- ❖ A rain garden with a 0.49 hectare catchment can remove 973 m^3 of water run-off per year (Flynn *et al.*, 2013).[193]
- ❖ Adding green roofs to all retail and high-density residential buildings in Manchester could reduce run-off by 17-20%. Increasing green cover by 10% in urban residential areas reduces run-off during a high rainfall event by 5% (28 mm precipitation event = 2.8l/m^2 – expected in the 2080s High Emissions Scenario). Increasing tree cover by 10% reduces the run-off by 6% (Gill *et al.*, 2007).[194]
  [28 mm = 28l/m^2 which can add up to very significant volumes over a larger area.]
- ❖ Taking just the urban core of Oxford City (30 km^2), a 28mm rainfall event delivers 84 million litres of water. Reducing this by just 5% would keep 4.2 million litres of water away from Oxford's roads and houses. For illustration purposes only: 4.2 million litres of water would cover Oxford station forecourt/square (4800m^2) in 88cm (nearly 3 feet) of water.

Sustainable Urban Drainage Systems (SUDS)

- ❖ Capital costs of traditional drainage are more than double the capital costs of SUDS. Annual maintenance capital costs are 20-25% cheaper for SUDS. SUDS is around half the cost over a 60 year life span (Duffy *et al.*, 2008).[195]
- ❖ SUDS for new small to medium housing development of moderate density are £500-£2000 (8-33%) cheaper per property than traditional drainage systems (Committee for Climate Change, 2012).[196]

- 20-year costs for drainage to New York City using a more sustainable combination of Grey and Green Infrastructure are an estimated 12% lower compared to a Grey Infrastructure only. The costs are $5.3 bn *vs* $6.8bn – a saving of $1.5bn. This is expected to reduce combined sewer overflows and provide multiple additional benefits for the community (New York City, 2011).[197]

4.5.6 Good practice in policy and implementation

- There are a few documented examples of SUDS schemes in Oxfordshire, e.g. Great Western Park in Didcot[198] or in Witney[199]. There is some good practice within the County.[200]
- The Oxfordshire **district level** Strategic Flood Risk Assessments/Plan all refer to climate change adaptation, SUDS, green roofs and the role of green space. All but one make the connection to enhancing biodiversity with SUDS.
- **South Oxfordshire's** Strategic Flood Risk Assessment has a particularly strong link to Green Infrastructure. It embraces the concept of multi-functionality.
- There is an excellent ***SUDS manual*** (CIRIA, Nov 2015). Other local examples of manuals exist. https://www.ciria.org/Memberships/The_SuDS_Manual_C753_Chapters.asp
- The best documented pilot on retrofitting Suds is in ***Paying for Ecosystem Services pilot: Flood regulation in Hull*** (Defra, May 2013). https://www.cbd.int/financial/pes/unitedkingdom-hull.pdf
- The best documented monitoring of a SUDS scheme is the ***Lamb Drove SuDS final Monitoring report***. This monitored performance and cost of a specific SuDS site in Cambridgeshire over 3 years. http://www.icfr2013.ex.ac.uk/papers/C2_Stevens.pdf
- The best documented pilot or case study on changing land management to reduce peak flood flows is ***Slowing the Flow*** at Pickering. (Forestry Commission 2010). https://www.forestresearch.gov.uk/research/slowing-the-flow-at-pickering/
- A first trial on Natural Flood Management in the Thames River Basin started in 2016 in the Evenlode Catchment.[201]

4.5.7 Implications for strategy and policy

- In line with NPPF "Inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere" (par 155).
- Strategic county-level documents can refer more to SUDS (urban) and natural flood risk management (rural), e.g. in the Climate Change Adaptation Plan and Local Transport Plan.
- Inclusion of further positive references to multi-functional Green Infrastructure and its role in flood risk management, in the Oxfordshire Local Flood Risk Management Strategy, building on the district level Strategic Flood Risk Assessments (SFRA).
- Improve the understanding of SUDS in local SFRA. SUDS is more than a green roof and a pond. It contains many features at many scales. For example, the role of urban trees, green facades, rain gardens, swales and many other features needs promoting.
- Fully embrace the concept of multi-functional Green Infrastructure in SFRA. Green spaces are not just beneficial to tackle the flooding issue. Good practice design of SUDS schemes achieves multiple social, economic and environmental benefits.
- Future studies on the Oxford green belt could usefully consider the potential of land in the green belt in mitigating the impact of flooding on Oxford.
- Improve local biodiversity, greenspace and Green Infrastructure strategies by making a positive reference on the role of these in flood risk mitigation.
- Consider Annex 2, i.e. the need for further evidence on assets and their analysis.

4.5.8 Practical actions to achieve outcomes

- Oxfordshire can repeat national pilots on retrofitting SUDS into existing development. As a second phase a programme can then replicate this at a much larger scale. Target areas are in Flood Zone 1,2,3 (based on GIS Analysis).
- Collaborate with the Forestry Commission and the Environment Agency to identify areas for woodland creation that enhance natural flood management. Prioritise areas that generate multiple benefits (soil protection, water quality and flood mitigation). This requires detailed data modelling to ensure that peak flows are reduced in areas most at risk of flooding.
- Consider an incentive scheme for woodland creation in rural areas, following the Payment for Ecosystem Services pilot approach. Liaise with Natural England, the Environment Agency and Forestry Commission to determine the best way forward.
- Collaborate with Natural England and WFD catchment co-ordinators. Target land managers for changes in land management, e.g. greater targeting of grass margins along waterbodies. This would also address water quality issues and thereby aquatic biodiversity.

4.6 Better air quality through natural vegetation

Key Outcome

Green Infrastructure will provide a cost-effective, adaptable and small-scale solution to reducing air pollutants. This will contribute to improving people's health and overall quality of life. Any form of natural vegetation can contribute to this.

4.6.1 UK situation

UK Local Authorities have to meet the following air quality standard targets[202] since 1 Jan 2016:

Pollutant	Concentration	Averaging period
Fine particles (PM2.5)	25 µg/m^3	1 year
Sulphur dioxide (SO_2)	350 µg/m^3	1 hour
	125 µg/m^3	24 hours
Nitrogen dioxide (NO_2)	200 µg/m^3	1 hour
	40 µg/m^3	1 year
PM10	50 µg/m^3	24 hours
	40 µg/m^3	1 year
Lead (Pb)	0.5 µg/m^3	1 year
Carbon monoxide (CO)	10 mg/m^3	Max. daily 8 hour mean
Benzene	5 µg/m^3	1 year
Ozone	120 µg/m^3	Max. daily 8 hour mean
Arsenic (As)	6 ng/m^3	1 year
Cadmium (Cd)	5 ng/m^3	1 year
Nickel (Ni)	20 ng/m^3	1 year
Polycyclic Aromatic Hydrocarbons	1 ng/m^3	1 year

Table 9: Air Quality standards for UK Local Authorities.

- In the UK, Urban background pollution with PM10 has been declining since the early 1990s. Levels dropped from about 35 µg/m^3 to 16.4 µg/m^3. However, the rate of change has reduced recently. Both PM10 and PM2.5 triggering moderate or higher air pollution in urban locations has been declining since 2012. Ozone background pollution has been increasing in urban areas from the early 1990s onwards. It has remained relatively stable in rural areas. It stands at 61 µg/m^3 in urban and 72 µg/m^3 in rural areas in 2015.[203]
- 1.1m children and 4.3m adults are currently receiving treatment for Asthma in Britain. In the South East it is 8.6% of children (128,851) and 8.1% of the population (687,892).[204]
- Around 40,000 deaths per year in the UK are attributable to exposure to outdoor air pollution. Exposure to indoor pollution causes further deaths.[205]
- Air pollution reduces productivity, which together costs the UK economy at least £20bn per annum.[206]
- Air pollution (specifically PM) reduces the average life expectancy in the UK by an estimated 6 months. This equates to a value of £8.6 to £18.6 million per year.[207]
- In all UK cities and 99% of cities globally, the benefits to mental and physical wellbeing from being active by cycling or walking are greater than air pollution damage to your health (Tainio *et al.*, 2016).[208] However, highly polluted environments are not attractive for walking and cycling. There may be a vicious circle between air pollution and the number of people willing to cycle. Also, more people are less active and drive more to avoid exercise during ozone warnings. Avoiding activity during certain days or times of the day is supported by ongoing government advice (e.g. Defra, June 2017).[209]
- In the UK, wheat crop losses due to ozone pollution cost an estimated £90 million in 2000 (7% of national wheat production). For potatoes, the loss was an estimated £12 million (2% of national potato production) in 2012.[210]

4.6.2 Strategic issues

- Air Quality Management Areas (AQMA) in Oxfordshire prioritise actions on a small proportion of the county. High air pollution levels also apply to a significant proportion of the county.
- High levels of congestion contribute to air pollution.
- With the aspirations for growth, more investment in road infrastructure is proposed. Studies project an increase in traffic. Air quality models predicting future air pollution levels across the county are not available at this point.

4.6.3 Baseline Evidence

- 43,906 residents in Oxfordshire are registered with their GP with Asthma as their (main) health problem.[211]
- Oxfordshire has an air quality monitoring network. These stations provide evidence on current air pollution levels, focussing on NOx. Live data is available online.[212]
- In **Oxfordshire**, there are 13 Air Quality Management Areas.[213] They have set targets for NO_x, but not for other air pollutants:
  - 4 in Cherwell (declared 2013-2015).
  - 1 in Oxford City (city-wide, 2010).
  - 3 South Oxfordshire (2008-2013).
  - 3 in Vale of White Horse (2006-2015).
  - 2 in West Oxfordshire (2005).
- The Oxfordshire Minerals and Waste Strategy HRA states that some Special Areas of Conservation (SAC) – particularly the woodland habitats – are above the nitrogen deposition limits. Other sites are quite close to their limits.[214]

- Using the South East value quoted above, there are an estimated *c.* 53,000 people receiving asthma treatment in Oxfordshire.
- Other sources using a different methodology, criteria and definition quote the "percentage of patients with a recorded diagnosis of asthma in a GP registered population" as 5.7% in 2015/16. This would put that number at "only" 38, 332.[215]
- Deaths from particulate matter air pollution alone in Oxfordshire are estimated to be 276 p.a. . That is 5.6% of all deaths, the same proportion as England (Inner London 7.2-8.3%, Northumberland 3.9%).[216]

Headline figure for the case for investment

Air pollution causes 414 deaths and costs the Oxfordshire Economy £207 million every year.

4.6.4 Opportunities

Green Infrastructure offers the following opportunities regarding air quality:

- Air quality improvement by reducing traffic (Green Infrastructure enhanced routes get more people walking and cycling).
- Air quality improvement through green roofs, facades, green spaces and trees.
- Introduce maps, real time measurements and smart technology to encourage cyclists to use routes with much lower air pollution exposure.
- Green Infrastructure, through the planting of vegetation, will have the desired effect of reducing exposure to air pollution, especially Particulate Matter, where the evidence on harmful impact on human health is greatest. To achieve this, GI needs to be well-designed, with careful consideration of the context and conditions of the site, as well as placing, spacing and species choice. Where GI is used as a barrier to pollution dispersion, human exposure on both sides of the barrier should be considered to ensure, for example, that a road barrier designed to protect pedestrians from traffic pollution does not inadvertently increase pollution exposure for cyclists and vehicle occupants on the traffic side of the barrier.

  Getting more people walking and cycling rather than driving and so reducing overall levels of air pollution may be a more effective approach than relying on the direct effect of vegetation to improve air quality.

Figure 7: Greening facades is already practised by many private home owners and businesses. © Oxfordshire County Council

4.6.5 Evidence on value of investing in assets

Highlight Figures

- ✔ *One square metre of green roof can offset the annual particulate matter emissions of one car.*
- ✔ *Planting of vegetation in streets can reduce street-level pollution concentrations by up to 60%.*
- ✔ *London's urban forest is worth £126m p.a. for pollution removal.*
- ✔ *Oxfordshire's rural woodlands remove 400 tonnes of air pollutants and thereby save £6.5 million in healthcare cost.*

- A recent study estimated the annual value of vegetation in removing four air pollutants (PM2.5, SO_2, NO_2, O_3) as £1bn in the UK for health benefits (CEH/ONS, 2017).[217] Extrapolating this benefit on a land area basis, the value to Oxfordshire is an estimated £11m per annum. This puts the health value of Oxfordshire's woodlands alone at *c.* £6.8 m p.a. (woodland cover of 7% in Oxfordshire).
- Oxfordshire's woodlands remove approximately 400 tonnes of air pollutants from the county's air. This is worth £6.5 million through avoided healthcare cost (TOE2, 2016).[218]
- 5% green space can reduce pollution with an estimated effect of two deaths and two hospital admissions avoided per year (data model for East London; Tiwary *et al.,* 2009).[219]
- Trees at Wardown Park, Luton, cover 24% of the park area (5 ha of total of 20 ha). 1,221 trees have a combined leaf canopy surface of an estimated 4 ha. The trees in Wardown Park remove a total of 0.9 of a tonne of pollutants every year. This equates to a *c.* £19,000 /year when using UK social damage costs (Luton Council, 2012).[220]
- Planting of vegetation in street canyons can reduce street-level pollution concentrations. NO_2 was reduced by 40%, particulate matter by 60% (Pugh *et al*, 2012).[221]
- In some situations, trees in street canyons may retain pollutants at ground level increasing pollution levels. Careful design of street planting is required.[222]
- 2,000 m^2 of uncut grass on a green roof can remove up to 4000 kg of particulate matter. Green roof vegetation reduced sulphur dioxide by 37% and nitrous acid by 21% directly above a green roof. One square meter of green roof can offset the annual particulate matter emissions of one car (Rowe, 2011).[223]
- Green roofs can remove up to 95% of heavy metals from runoff. They also reduce nitrogen levels in run-off (GLA, 2004).[224]
- A rain garden with a 0.5 ha catchment removed 1.2 t of suspended and dissolved solids, 2 kg of nitrogen and 1 kg of phosphorous per year (Flynn *et al.*, 2013).[225]
- London's urban forest is worth £126m p.a. for pollution removal. It removes 2,200t pollution p.a. (Forestry Commission, 2015).[226]
- Total suspended particles (TSP) removal along roads by belts of vegetation can be as high as 65% (Islam *et al,* 2012).[227]
- The cost of installing 1 m^2 of green roof is between £55 and £110 (Rawlinson, 2006).[228]

4.6.6 Good practice in policy and implementation

- Several Oxfordshire strategic documents acknowledge the air pollution issue. This includes the Oxfordshire LTP (Sep 2015). They set out proposals to achieve better air quality.
- The **South Oxfordshire** District Council AQMA document has an extensive policy on air quality. It states: "Encourage and support the introduction of green walls, roofs and other green space on existing developments."
- The **Oxford** and **West Oxfordshire** Air Quality Action Plans refers to the importance of modal change to walking and cycling to tackle air pollution issues.
- The University of Manchester has its own green wall and green roof policy and guidance.[229]

- France has introduced legislation that requires all new development of a certain type and size to have either a green roof or solar panels.[230]
- New research shows that vegetation placed in the right location can make a significant contribution to improving air quality in more rural areas.[231]

4.6.7 Implications for strategy and policy

- Develop an overarching air quality strategy or action plan for the whole county that references district level action plans and other strategic policies.
- Develop a local air quality strategy/action plan, (where these do not yet exist).
- Take the following into account for air quality strategies and plans:
  - Role of walking and cycling in reducing air pollution.
  - Refer to Green Infrastructure in local air quality strategy/action plans as a potential solution to the problem.
  - Contribution of green roofs, green facades, trees and other forms of Green Infrastructure to reducing pollution; and
  - How to create a demand for this through, e.g. local development management policy.
- Develop a positive narrative in local biodiversity and tree strategies of how natural vegetation improves air quality.
- Consider Annex 2, i.e. the need for further evidence on assets and their analysis.

4.6.8 Practical actions to achieve outcomes

- Consider the Benefit: Cost Ratio of monitoring a wider range or air pollutants (see 4.2.1) across a greater number of the Oxfordshire air quality monitoring stations.
- Enhance the air quality monitoring network. This will aid spatial targeting and evidence-based implementation. It will also help to understand the full scale (and cost) of the problem.
- Target pilots and large-scale projects on green roofs, green walls and tree planting in areas of high air pollution (also listed below under 4.3.8 Climate Change).
- Projects and activities promoting walking and cycling will also reduce air pollution. This happens by reducing miles driven and reduced congestion. Encourage people to walk and cycle in areas where reducing air pollution is a priority. Safer and more pleasant environments will facilitate this. Ideally, an intervention would turn a vicious circle into a virtuous circle (from "bad air quality → people don't cycle" to "more people cycle → better air quality → even more people cycle").

4.7 Thriving biodiversity

Key Outcome

Networks of Green Infrastructure will provide great spaces for wildlife. Green Infrastructure will contribute to healthy ecosystems. This will give communities in Oxfordshire greater resilience against future challenges, such as climate change.

4.7.1 UK situation

- Public sector investment in biodiversity has gone down in England from its 2008/09 peak. It has declined by 14% to £345m in 2014/15. Voluntary sector investment has remained more stable at £215m. Volunteer time spent on the natural environment has dropped 23% from its peak in 2009 to approx. 5m hours in England in 2014. In the UK, 31% of the population have some or a high engagement with the topic "biodiversity loss". 16% are not engaged and 52% state to be not aware of the problem.[232]
- The area of agricultural and forestry land in England in HLS was 1.4m ha and 6.4m ha in ELS in 2014.

4.7.2 Strategic issues

- The Oxfordshire *State of Nature* (2017) report highlights some key issues:
  - Long-term declines in farmland and woodland biodiversity continue. Some associated species are at serious risk of local extinction, such as the turtle dove.
  - There is continued fragmentation and loss of connectivity across the county's landscapes. This effects the future viability of habitats and species.
- There are issues over ownership and charged-for access. For example, many smaller woodlands are in private ownership and not accessible. Charged-for high-profile natural greenspace sites include National Trust land and Blenheim Palace.

4.7.3 Baseline Evidence

- In Oxfordshire, approximately 4,200 ha of agricultural land were under some sort of Environmental Stewardship scheme between 2006 and 2014. The State of Nature in Oxfordshire report[233] and table in Chapter 5 provide more detail on habitats and species.
- There is a large number of nature conservation and environmental organisations operating in Oxfordshire. The more established organisations include BBOWT, RSPB, Earth Trust, Wild Oxfordshire, CPRE, Sylva Foundation and TOE2, TVERC and the AONBs (list not exhaustive).

4.7.4 Opportunities

- Currently only 2% of the county's land area have national statutory wildlife designations. A similar amount is designated as Local Wildlife Sites (together this makes just over 10,000 ha). 20% of the county is covered by Conservation Target Areas (CTA) with large areas of valuable and biodiversity-rich habitat.[234] These are identified in Local Plan policies.
- Develop clear evidence and criteria for prioritising biodiversity building on the CTA work.[235]
- Projects could increase people's access to biodiversity in urban areas.
- Active management of woodlands and forests creates biomass for renewable energy. This would also enhance woodland biodiversity.[236]
- There are significant minerals operations in Oxfordshire. The restoration of sites provides significant opportunities for new habitat creation, access and recreation.
- Investment in roadside ecology (e.g. hay meadows) via changed mowing regimes and biomass from road verges.
- Various tree diseases (e.g. Ash Dieback) may require restocking of a proportion of the county's tree population. Species of high biodiversity value, high noise and pollution mitigation properties and high drought resistance could replace ash.
- Biodiversity enhancements from housing development (planning conditions and obligations).
- Development and implementation of net biodiversity gain policies.
- Creating biophilic cities (green roofs, facades, street trees etc.).
- Housing development with "biodiversity by design".

Figure 9: A small tortoiseshell on brambles – one of the many examples of the beauty of wildlife. © Brillianto

4.7.5 Evidence on value of investing in asset

Highlight figures

Converting intensive agriculture to a mixture of woodland and pasture near cities can generate benefits of £1,300 per hectare. Investing £1 in restoring a river to a more natural state can generate benefits worth £7. Investing £1 in new woodland creation near urban areas can generate benefits worth of up to £9.

- Lifetime benefits of river restoration at the Mayes Brook development, London, are an estimated €31m (*c.* £27m[237]) over 40 years. The benefit-to-cost ratio was 7:1 (EA, 2013).[238]
  The creation of 100,000 ha wetland in the UK would create a net present value of £634m-£2.7 bn over 50 years (£7m-£54m p.a.) Benefits Cost Ratios of 3:1 would be typical, with 9:1 possible in some cases (Eftec, 2015).[239]
- The benefits of woodland in the UK are an estimated £1.5 bn/year. Examples include:
  - £1.7-£2.8 spend for each recreational visit.
  - £270/household/year for each household with a woodland landscape view.
  - £125,000 for each death avoided by 1 year due to particulate matter and SO_2 absorbed by trees
  - £600 for each 11-day hospital stay avoided due to reduced respiratory illness (Forestry Commission, 2003).[240]
- Locating new woodland planting of 250,000 hectares near towns and cities would generate net societal benefits in excess of £500m p.a. (Natural Capital Committee, 2015).[241]
- The City of Aalborg converted 900 ha of intensive agriculture into 500 ha of forest and 400 ha of pasture. This now protects groundwater from diffuse pollution. The project had the following benefits:
  - €750/ha forest/year for leisure and amenity benefit.
  - €108/ha forest/year of carbon benefit.
  - €489/ha/year drinking water benefit.

- Net social benefit (taking land purchase & cultivation/establishment cost into account) being €187ha/year.
- Nitrate levels in drinking water dropped from>120 mg/l to <10 mg/l over a 10-year period. (European Commission, 2002).[242]

4.7.6 Good practice in policy and implementation

- The recent publication of the Dasgupta Independent Review on the Economics of Biodiversity (HM Government 2020) and the OECD publication on Biodiversity: Finance and the Economic and Business Case for Action are helpful and inspiring documents to consider the importance of biodiversity and why it is worth investing in biodiversity.[243]
- *Biodiversity by design* (TCPA) covers many aspects of biophilic /biodiversity friendly design for new build and retrofitting.
- Various strategies, plans and pilots have promoted better use of road verges for biodiversity (e.g. O'Sullivan, 2017[244], Dorset County Council, 2012[245]). The *Nature after Minerals* project provides examples of good practice across the UK, some of it in Oxfordshire.
- The Oxfordshire Minerals & Waste Core Strategy makes strong references to biodiversity, Conservation Target Areas, enhancing Green Infrastructure, public health, recreation and flood risk mitigation.
- There are currently some good proposals for mineral site restoration, e.g. for Gill Mill in West Oxfordshire.[246] Disseminating learning and good practice from this and other sites to other minerals operators will be beneficial.
- The identification and enhancement of Conservation Target Areas is well embedded in Local Plan policy.
- The proposed new Nature Recovery Network for Oxfordshire (TVERC, 2019) is an excellent opportunity to build on the good work of developing the CTA[247], and in line with government policy.
- Oxford City and Cherwell Biodiversity Action Plans make good references and links to improving air quality, flood mitigation, access to natural greenspace, health and green space/Green Infrastructure respectively.
- The district level Flood Risk Assessments generally make good links to natural flood risk management and opportunities to enhance biodiversity.
- The Green Infrastructure Partnership, including Natural England, launched the LINET project in 2017. This will investigate opportunities for linear Green Infrastructure creation along major transport routes, e.g. in infrastructure projects such as HS2.[248]
- A recent initiative by Royal Botanic Garden Edinburgh and Butterfly Conservation Scotland encourages citizen living around Arthur's seat to plant rock roses on their roofs to encourage the spread of the Northern Brown Argus butterfly.[249]
- The Oxford Swift project involved volunteers to take simple surveys (RSPB, 2018).[250]

4.7.7 Implications for strategy and policy

- Make delivering net biodiversity gain, rather than just "no net loss" an aspiration in all relevant local planning documents.
- Develop urban biodiversity policies at county and local level.
- Implement policies and projects that address the key issues identified in the Oxfordshire State of Nature report. Build on the well-established network of Conservation Target Areas.[251] A published policy paper "Securing Nature's Benefits" is being updated to inform the next stage of the Oxfordshire Plan. This can take the proposed Nature Recovery Network for Oxfordshire forward.[252]

- Districts without a Biodiversity Strategy and action plan will benefit from having one.
- Refer more to climate change adaptation in existing biodiversity strategies, assessments and evidence reports for Local Plan development. Other topics to cover in more detail include biodiversity's contribution to air quality, flood mitigation and health and making a connection between traditional biodiversity conservation and Green Infrastructure. This includes demonstrating the value and social and economic benefits of biodiversity.
- Make stronger links to biodiversity and Green Infrastructure and consider their contribution in other strategies with other policy topics. Explore how investment in other policy areas could be less damaging to and more enhancing for biodiversity.
- Make the links outlined above in the Oxfordshire climate change adaptation plan, LTP, Health and Wellbeing Strategy, Local Flood Risk Management Strategy and any studies on the Oxford greenbelt.
- Consider Annex 2, i.e. the need for further evidence on assets and its analysis.

4.7.8 Practical actions to achieve outcomes

- Enhance or create multi-functional Green Infrastructure sites as buffers, stepping stones or linear connectors between high value biodiversity sites and CTA.
- Development Management – invest additional resources in the monitoring and enforcement of planning permissions to ensure that biodiversity conditions are achieved.
- Pilot projects followed by large-scale implementation based on GIS-analysis to establish target areas:
  - Road verge, river bank and canal management for biodiversity (e.g. meadows and invertebrates) to create more linear biodiversity/green corridors.
  - Green roofs with diverse flora (also for benefit of invertebrates).
  - Tree line and hedgerow planting for bats and other migrating species (both urban and rural).
  - Enhanced woodland management, including for woodfuel.
  - Priority habitat creation on amenity greenspace (also enhanced ANGSt provision, giving more people easy access to natural greenspace).
  - Mineral site restoration pipeline: strategic and spatial targeting in collaboration with mineral operators.

5. The case for investment in Green Infrastructure

5.1 Summary of the economic cost of sustainability challenges

The table below lists the top seven sustainability problems that the county faces. Green Infrastructure has the potential to make a significant contribution to addressing and mitigating these sustainability problems. There is robust evidence on the cost of the top seven issues. Evidence allows us to quantify and monetise the problem, including the annual cost for Oxfordshire.

Problem	Symptoms in Oxfordshire	Annual cost
Mental Health	55 suicides p.a., people with anxiety and depression, eating disorders, lost productivity	£ 1,300,000,000
Obesity	200,000 overweight adults and 100,000 obese adults (costs are in addition to those for inactive lifestyles)[253]	£ 427,000,000
Air pollution	Heart disease, *c.* 53,000 people receiving treatment for Asthma; *c.* 400 air pollution related deaths; loss in productive years	£ 207,000,000
Transport	Congestion: fuel & time wasted & increased cost of doing business	£ 170,000,000
Transport	31 fatal and 242 serious and 1240 minor accidents, of which 7 fatal casualties and 74 serious accidents amongst pedestrians and cyclists.	£ 135,000,000
Inactive lifestyles	65,000 people leading inactive lifestyles	£ 120,000,000
Noise	Urban road noise – nuisance and illnesses (avg. of range £98m-£140m)	£ 119,000,000
TOTAL	**Cost of top seven sustainability problems in Oxfordshire**	**£2,496,000,000**

Table 10: Summary table of the top seven sustainability challenges in Oxfordshire and their annual cost to Oxfordshire GVA.

The above figure is £2.5bn p.a. or £3,790 p.a. per person living in Oxfordshire. The top seven sustainability challenges in Oxfordshire incur a cost of over 10% of Oxfordshire GVA (£23.3bn in 2017/18).[254] In other words: they are a 10% brake on Oxfordshire GVA.

The respective sections in the Chapter 4 "Green Infrastructure – contribution to sustainability challenges" present the above figures in more detail and in the context of other evidence. The above figures are also in the boxes titled "Headline figure for the case for investment".

The table above excludes other sustainability challenges. This is for either of the following three reasons:

- No reliable economic data is available.
- The cost of that particular issue is much lower in scale.
- The evidence linking cause and effect between Green Infrastructure investment and tackling the issue is not robust or less tangible.
- However, that does not mean such problems do not exist or they do not have a financial cost.

Missing in above table are the cost of:

- Flooding.
- Other climate change costs.
- Other pollution, e.g. that caused by agriculture.
- Loss of soil from agricultural practices.
- Habitat and biodiversity loss.

Climate Change costs – according to Stern – could increase to 5% of national GDP if we do not take sufficient action. That would be an extra £1bn cost to the Oxfordshire Economy. This may include storms, droughts, flooding, need for air conditioning in the summer and other.

In the face of these figures there is a strong case for further investment in Green Infrastructure.

5.2 Investment Proposal

The annual cost of the top seven sustainability challenges in Oxfordshire is £2.5 bn (see section 5.1).

The evidence that Green Infrastructure can make a cost-effective and significant contribution to tackling these issues and thereby enabling the County's economy to continue to grow in a sustainable way is robust and well established (see summary in section 5.2 and detail in Chapter 4).

Section 3.2 and section 6.6 also show that meeting aims set out in this study will meet significant aims and targets of other key policy documents, such as OXIS and The Oxfordshire Plan 2050.

Existing economic studies on the value of Green Infrastructure suggest that a 4:1 Benefit Cost Ratio (BCR) is a conservative/reasonable assumption (see the summary in section 5.3 under the "benefit cost ratio" heading and more detail in Annex 4). That means for £1 invested £4 of benefit are generated.

There is robust evidence that Green Infrastructure can be a more cost-effective solution than alternative approaches to achieving a more sustainable economy (see Annex 4).

To make a substantial difference a substantial amount of investment is required.

The investment proposal is to:

- Invest over a period of 30 years (until 2050) initially.
- Invest £50 million in strategic and targeted Green Infrastructure interventions every year.
- At a Benefit: Cost Ratio of 4:1 this will generate an annual economic benefit of £200 million p.a.
  The economic benefit over the investment period of 30 years is £6 bn to enable the Oxfordshire Economy to continue to grow sustainably.

Investment		Benefit : Cost	Economic Benefit (cost avoided)		
Total	p.a.	Ratio	for period (yrs.)	total	p.a.
£1,500,000,000	£ 50,000,000	4:1	30	£ 6,000,000,000	£ 200,000,000

Table 11: Main figures for the investment proposal, showing investment and return on investment.

5.3 Rationale and comments on investment proposal

£50 million annual investment

Oxfordshire GVA grows by about 4% p.a., approximately £800m p.a. However, the sustainability brake is £2.5bn or 10% of GVA.

£50m investment in Green Infrastructure is equivalent to increasing the GVA by 1%. The £50m annual investment figure is a challenging, yet feasible investment target. It will need strong political will, leadership and vision. It is a political decision how much of a positive impact we want to make. Past investment has not been enough or we wouldn't have the problems we do.

Achieving that level of investment will however make a real difference. The annual economic benefit of £200m (by reducing the current cost of sustainability issues) represents a reduction in the scale of the sustainability challenge by *c.* 10%. This will generate a noticeable change in the county, further promoting Oxfordshire's credentials as a great place to live and work in now and in the future. It requires a step change in practice and investment. In terms of potential benefits, a *c.* 10% improvement to sustainability issues is certainly not the ceiling. Specific interventions can reduce specific problems by as much as 95% (see Annex 4), i.e. even more could be achieved with investment even greater than £50m p.a.

To put the £50 m annual investment proposal in perspective:

- Stern's ground breaking report[255] recommended investing 1% of national GDP to avoid climate change disaster. For Oxfordshire, that is £205,000,000 p.a. (£205 million). Investing in adaptation and mitigation is not the same as investing in Green Infrastructure. The two figures and aims behind them are not interchangeable. However, this sets the scale of a £50m annual investment in context.
- Stern also predicted that failing to avoid Climate Change damage, would cost 5% of national GDP p.a. For Oxfordshire, that is £1,000,000,000 (£1bn) p.a. economic damage in Oxfordshire. In a recent interview Stern said the global cost of global warming "is worse than I feared".[256]
- Likewise, the Oxfordshire Infrastructure Strategy (OXIS) quotes £279m Green Infrastructure investment over 25 years, or £11m pa.[257] At a BCR of 4:1, the avoided cost would be £44 m p.a. which is just *c.* 2% of the total costs of the sustainability challenges to economy. This is too small a proportion compared to the problem.[258]
- The city of Groningen, NL, recently decided to invest €85/head (*c.* £74/head[259]) in cycling. [260] The equivalent for Oxfordshire would be *c.* £48m p.a. invested just in cycling (grey-green continuum).
- Transport infrastructure had annual multi-million investment for decades. Green Infrastructure hasn't. It is estimated that to bring all roads within Oxfordshire alone up to a good state of repair would cost £165m and then an on-going year-on-year investment of approximately £20m per year to maintain that condition level (LTP4, 2016).[261]

Funding needs to come from public, private and voluntary sector investments as well as national government funding (for detail on funding sources and models see section 6.5 Funding mechanism).

Investment plan

- The county needs future plans to actively consider the negative cost of the sustainability issues.
- Developing a Green Infrastructure investment plan is one mechanism to achieve this. Given the complexity of the issues and the solutions it would be beneficial to establish a dedicated management group to develop and deliver the investment plan.
- To reach this scale of change, we need to invest a lot.
  - Chapter 4 sets out in detail why and how investment in these assets will address the problem.
  - Annex 3 sets out the existing assets we can work with and build on.
- It is recommended that the Green Infrastructure investment plan prioritises investment under the following criteria:
  (a) Thematic prioritisation (see Chapter 2 and Local Plans' objectives).
  (b) Prioritisation where Benefit: Cost Ratio is highest, i.e. where we achieve multi-functionality. That means to build on already available evidence on many quantifiable and monetizable benefits (see throughout Chapter 4 and Annex 4 focussing on the financial quantification) and to close gaps where evidence is missing.
  (c) Spatial prioritisation (see Annex 5 for methodologies).
  (d) The Green Infrastructure plan also needs to cover how to maintain new or enhanced assets and their benefits.

Benefit Cost Ratio (BCR)

- There are many studies showing that Green Infrastructure has a BCR of better than 1:1. Some of these studies are for specific interventions. They look at one type of benefit.
- Many Green Infrastructure interventions achieve many benefits at the same time. The summary of recommended practical actions illustrates this. Investment in Green Infrastructure will generate £X for flood mitigation, £Y for health, £Z for air quality and so on.
- We achieve the highest BCR when we design investment to achieve many benefits. We need to take many benefits of Green Infrastructure into account for the BCR calculation. The best BCR achieved for a UK Green Infrastructure investment programme is 30:1 (more detail in Annex 4).
- A very high 10:1 BCR figure is suggested by the Natural Economy Northwest study (with strong emphasis on robustness of environmental economics). The most recent study on the topic suggests that the benefit cost ratio could be as large as 36:1 (Vivid Economics & Barton Willmore, June 2020).[262] A 4:1 ratio is a more conservative estimate, yet reasonable figure.
- Achieving a better ratio will achieve a significant reduction in sustainability issues faster or with less investment or achieve a greater reduction in sustainability issue costs than originally anticipated.
- We also need to ensure that investment in Green Infrastructure is at least as cost-effective in tackling the problem as other alternative approaches (e.g. hard engineering; prescribing medication). Examples of this include SUDS schemes, health interventions, pollution control measures and many other types of schemes (see full examples and figures in Annex 4).
- Good Benefit Cost Ratios consider the cost to maintain the value and benefits of Green Infrastructure assets. A recent study by the Land Trust for Silverdale Country Park states that following investment, an annual budget of £70,000 maintains a Natural Capital asset value of £2.6 million.[263]
- A major Green Infrastructure investment plan needs to include input from an environmental economist to undertake a thorough calculation of BCR as part of an ongoing Monitoring and Evaluation.

6. Implementation

To achieve the aims of the study we need to fully understand the Green Infrastructure assets, what and where they are and what condition they are in. We need to analyse the assets, e.g. what benefits they already provide and what benefits they may provide in the future, as well as their spatial distribution relative to target audiences and beneficiaries (Section 6.1, Annex 2, Annex 3 and Annex 5).

Investment in Green Infrastructure is scalable. There are efficiency savings if we scale up delivery. Strategic impact and efficiency increase as we move on from on the ground delivery to projects to programmes.

The aim of this study is to set out a framework how implementation of a substantial £1.5 bn Green Infrastructure investment programme may be approached:

There are a number of on the ground delivery actions that any organisation or individual could undertake. Section 6.2 lists where they would be most beneficial to deliver and what aims they will contribute to.

Section 6.3 lists more strategic and complex aspects of implementation, larger projects that would require more planning, co-ordination and partnership working.

Section 6.4 explores some aspects of how partnership working will add value to any Green Infrastructure delivery.

Section 6.5 identifies a range of mechanisms that will help with funding the implementation.

Section 6.6 sets out how existing strategic documents can help deliver Green Infrastructure.

6.1. Analysing the assets for optimum benefits

Oxfordshire has substantial social, environmental, economic and intellectual assets.

We need to tap into all these assets to secure a more sustainable future.

Annex 3 lists the environmental assets. There are about 135,000 ha of Green Infrastructure assets in the country and 5,500 km of access routes. This information is an important part of what would constitute a full **Green Infrastructure audit**.

There are gaps in our knowledge and understanding of assets. This includes:

- Total area and overall number of certain types of assets.
- Proportion of assets being publicly/privately owned.
- Proportion of assets being accessible.
- Quality and condition of asset.
- Current management of asset.
- Features on sites.

Some data areas are under-represented in this study, especially socio-economic data. Further data and other forms of evidence may be available from the voluntary and public sector.

Annex 2 provides detailed examples of what extra evidence we need and what kind of analysis needs to be undertaken to make sound economic decisions about where to invest and in what kind of Green Infrastructure. In essence, to be able to make strategic decisions, the county needs a full **spatial mapping of all Green Infrastructure assets**.

Green Infrastructure is multi-functional. That means it can provide many benefits in the same location. But who needs which benefit where?

Spatial and functional analysis includes:

- Mapping of the assets to understand connectivity.
- Establish whether there are gaps in Green Infrastructure provision at a strategic scale.
- Mapping existing and potential functions and benefits of Green Infrastructure assets.
- Mapping where assets are relative to where people live, work or spent time for leisure and recreation.
- Identify any relevant correlation between gaps and housing growth.
- Use analysis to set standards for Green Infrastructure provision across local authority partners.
- Help identify pressures on Green Infrastructure assets or networks and identify opportunities to resolve them.

The Natural Greenspace Standard (ANGSt) is an example of a functionality assessment looking at one function. Oxfordshire has recently had an updated analysis of ANGSt. We need to do this kind of analysis for many other functions of Green Infrastructure, so we know what its current potential is.

A fundamental principle of the case for investment is that Green Infrastructure has potential to provide the solution to a problem. **Investment decisions need mapped (spatial) data for the solution (Green Infrastructure asset) and the environmental, social or economic problem.** The illustration below gives an example on the analysis of how accessible natural greenspaces can tackle health deprivation.

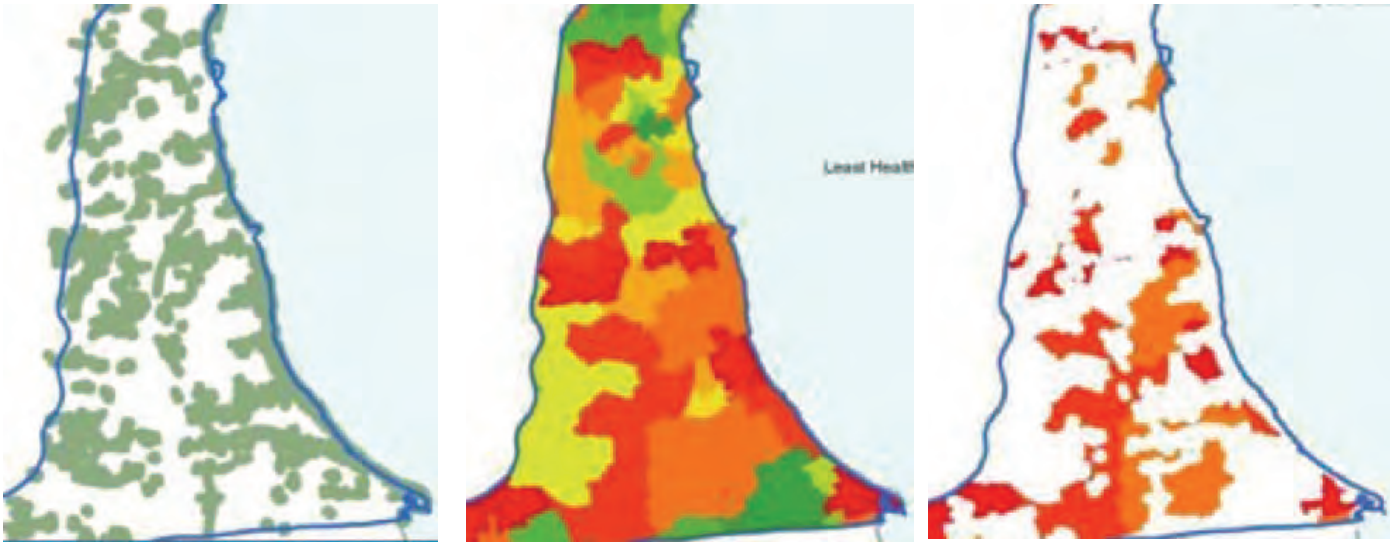


Figure 10: Example from East Durham – ANGSt Analysis 2009. From left to right:

Image 1: accessible natural green space provision with a 300m buffer (ANGSt criteria catchment for small sites of 2-20 ha).

Image 2: health deprivation in area based on 5 indicators (red = worst)

Image 3: areas lacking greenspace provision in the worst 30% of area for health deprivation. **These areas are a priority for investing in accessible natural green spaces to help tackle health deprivation.**

Annex 5 provides information on methods of spatial analysis of assets.

Green Infrastructure providing multiple functions and benefits means looking across policy areas and local authority departments or service areas. We need to identify shared interests in creating or enhancing Green Infrastructure.

Alignment with other measures to tackle the sustainability challenges is desirable. There will be opportunities for integrated delivery resulting in synergies (see also section 6.6 on how other policy and strategy documents can contribute to delivery).

6.2 Summary of delivery on the ground actions

The table below sets out types of actions on the ground, where to target each and the benefits and contribution towards the aims of this study

Targeted Location & how they will contribute to aims									
Measure	**Sustainable Transport**	**Climate Change Mitigation**	**Climate Change Adaptation**	**Air Quality**	**Noise Mitigation**	**Sustainable Housing**	**Flood risk Mitigation**	**Thriving Biodiversity**	**Access & Health**
Targeted Location (examples)	Along Access corridors, e.g. to schools; towards transport hubs	Anywhere, nr. Biomass facilities	UHI areas/sensitive receptors	AQMA/sensitive receptors/on the lee of major pollution sources	Noise map/sensitive receptors	Any areas within or near residential housing	Flood Zone 123 or upstream rivers	see below	high IMD/pollution/ noise; low ANGSt provision
Urban tree planting, green roofs, green facades	Shading & better microclimate	Carbon sequestration	Temperature mitigation, wildlife corridors	Air quality/pollution filtration	Noise reduction→ health benefits	Energy savings, health, SUDS & biodiversity benefits	Water storage & retention	"Fingers" connecting urban fringe to City Centre – habitat, migration corridors foraging area	Stress relief, relaxation, physical exercise, less antisocial behaviour
Enhanced functionality of existing urban (fringe) greenspaces	Noise & pollution mitigation	Higher carbon sequestration rates	Temperature moderation/cooling/wildlife corridors (connect CTA & other sites)	Denser vegetation for more pollution filtration	Denser vegetation for better noise reduction	As above	As above	Stepping stones, buffers or Wildlife corridors & habitat	More accessible, better features (benches/way markers)
Creation of new urban (fringe) greenspaces	green/wildlife corridors	Carbon sequestration	Temperature mitigation, wildlife corridors	Additional pollution filtration	Additional more tranquil places	As above	As above	Stepping stones, buffers or SANG to existing sites	Increasing ANGSt provision

Targeted Location & how they will contribute to aims									
Measure	**Sustainable Transport**	**Climate Change Mitigation**	**Climate Change Adaptation**	**Air Quality**	**Noise Mitigation**	**Sustainable Housing**	**Flood risk Mitigation**	**Thriving Biodiversity**	**Access & Health**
Woodland Creation	Avoiding soil erosion/earth slides onto infrastructure	Carbon sequestration, woodfuel	Temperature mitigation/area of cooler temperatures during heat waves	Air Quality/significant oxygen source & pollutant sink	Tree belts for noise mitigation	As above and Woodfuel source	As above	Habitat for woodland species, safe refuge areas	Stress relief, relaxation, physical exercise
More bicycle racks and cycle paths	At stations – Encourage modal shift	Reduced CO_2 emissions	N/A	Reduced car emissions	Reduced noise from transport	Health benefits	N/A	N/A	Physical exercise
Promoting walking & Cycling	Along busy roads/to & from employment areas/residential areas/points of interest	Reduced CO_2 emissions	N/A	Reduced car emissions	Reduced noise from transport	Health benefits	N/A	N/A	Physical exercise
Change in agricultural practice	N/A	Increased carbon storage	Soil fertility, draught resistance, erosion control, wildlife corridors	Reduced agricultural machinery emissions	Reduced noise from agric. machinery	Local food	Grass margins & tree planting for flood risk mitigation	CTA, Stepping stones, buffers or corridors Habitat creation	More attractive ROW

Table 12: summary of the on-the ground practical actions and how they will generate multiple benefits across the seven desired outcomes.

Chapter 4 covers good practice and case studies in each of the seven sections on how to deliver the above. Specialist consultants, professional bodies and literature provide further detail. For example, the Green Infrastructure Resource Library and the green roofs and green walls projects database are valuable online resources.

Following good practice will ensure the intended outcomes and that measures do not result in unintended negative consequences.

Implementation tools

A broad range of tools have emerged over recent years to help with analysing assets and planning investments. There are too many to name them all, but here a short selection:

- Nature Based Solutions Selection Tool, Urban Green Up, 2020[264]
- B£ST (Benefits Estimation Tool) - valuing the benefits of blue-green infrastructure, Susdrain 2019[265]
- Natural Capital Planning tool - free site assessment tool developed for the planning context, CEEP, 2018[266]
- Future Parks A toolkit to help build a sustainable future for parks and green spaces, The National Trust, 2018[267]

Further tools are described in detail on the Ecosystem Knowledge Network 'Tool Assessor' page.[268]

The ongoing work by Natural England on developing a set of Green Infrastructure standards (a 25 Year Environment Plan commitment) and guidance may also be helpful in this context.

6.3 Strategic projects

The table in section 6.2. presents a menu of specific actions that can happen in any appropriate location as a direct delivery on the ground. The following more strategic projects and activities support the above. They will need a greater level of planning, co-ordination, project design and partnership working.

Physical improvement projects

Pilots with socio-economic evaluation, establishing:

- Robust cost: benefit ratios.
- Lessons learnt (including what does not work).
- Good practice.
- Solutions that work locally.
- Delivery mechanisms and partnerships.
- Community engagement, ownership and long-term management of assets.
- Confidence in delivering a scaled-up operation of a type of investment.
- GIS-analysis would identify the most suitable locations.

- Successful pilots can then be rolled out as a delivery programme
- Pilots may include:
  - Green roofs & green facades (retrofitting).
  - SUDS (retrofitting).
  - Planting for noise abatement.
  - Planting for air quality improvements.
  - Renewable energy from biomass (e.g. wood fuel).
  - Changes to road verge management.
  - Shading of buildings with sensitive receptors (e.g. hospitals or old people's homes).

- Shading of routes for sensitive receptors (e.g. routes to primary schools)
- Carbon storage from biomass (e.g. tree planting).

- Development management and pilots on pro-active working, e.g. Minerals and Waste restoration sites pipeline.
- Payment for Ecosystem Services and retrofitting pilots.
- Incentive schemes (e.g. woodfuel/green roof/walls/planting trees).
- Major land use change initiatives.

Other types of projects

- Publish and/or refresh the ANGST analysis for the County. (Note: Natural England is currently working on developing a new set of Green Infrastructure standards)
- Investment in air quality & noise monitoring network.
- Create new Green Gym initiatives.
- Projects encouraging modal shift of transport.
- GP green gym prescription schemes.

6.4 Partnership working

Working towards Investment Plans

- Strategic work with partners could support and complement the types of "on the ground" implementation activities listed in the table in section 6.2. above. This may include:
  - Creation of a formal partnership.
  - Demonstration sites and events – showing good practice & raising awareness of resources, tools and support networks.
  - Events targeting specific sectors. This will inform and inspire using case studies and testimonials from converted sceptics.
  - Creation of case studies.
  - Work with political leaders.
- A partnership needs adequate co-ordination resources to keep it together. This will ensure every partner benefits from the collaboration.
- Organisations in Oxfordshire already have significant expertise in nature conservation and Green Infrastructure. Investment is already happening. Further work can build on this.
- Many charities use cost-effective ways to achieve outcomes (see also Annex 4).
- In this context the development of the Strategic Environmental Economic Investment Plan (SEEIP) in 2014/15 is a good example of partnership working.
- Areas of Outstanding Natural Beauty (AONB) already have AONB management plans. They cover a broad range of socio-economic and environmental objectives and deliver on Green Infrastructure in rural areas and for often more natural assets. They all explicitly refer to Green Infrastructure. They cover aspects such as access, biodiversity, Climate Change (some with reference to adaptation), health (and wellbeing), (natural) flood risk management. Two also refer to air quality.
  - The North Wessex Downs AONB Management Plan 2019 -2024[269]
  - The Cotswolds AONB Management Plan 2018-2023[270]
  - The Chilterns AONB Management Plan 2019-2024[271]
- Charities and community groups can access other funding sources than local authorities.

- Cross-sectoral and cross-departmental partnerships will bring new insights. This will generate new efficiencies and new expertise to tackle complex issues.
- Sectors to include are: health, transport, housing, regeneration, conservation, planning and many more
- Critical to getting an ambitious investment plan funded is to get all beneficiaries around one table.

The National Landscape Enterprise Networks (LENS) initiative[272] is exploring ways in which local businesses can invest in their local landscapes to support their business needs. Two demonstration projects completed in East Anglia (http://www.gov.uk/government/publications/25-year-environment-plandownload pdf) and Cumbria (http://www.3keel.com/wp-content/uploads/2018/01/healthy-ecosystems-cumbria-lens.pdfdownload pdf) identifying the business case for a broad range of sectors to invest in regional natural capital.

The Landscape Enterprise Networks (LENS) pilot project is being run in Oxfordshire, in collaboration between 3Keel, BBOWT and the Environment Agency. It is exploring ways in which local businesses can invest in Oxfordshire's landscapes to support their business needs. This could be a method by which funding for GI enhancements could be secured.[273]

A re-formed Oxfordshire Nature Partnership could play a role in taking forward Green Infrastructure investment.

Several Local Authorities and other geographic localities have worked together to develop investment plans. Many recent examples are using **Natural Capital Investment Plans** as an overarching principle. Section 3.1 of this document sets out how Green Infrastructure and Natural Capital are compatible as a concept. They have a similar approach in considering the natural environment as an essential asset. The natural environment asset is worth investing in to secure social, economic and environmental benefits in a sustainable way.

Locations that have adopted a Natural Capital investment plan approach through partnership working include:[274]

- North Devon
- The New Forest
- Greater Manchester
- Birmingham
- Surrey

The "Natural Capital in Oxfordshire report (ECI, 2020) can help Oxfordshire better understand its assets and their potential contribution.[275]

The following documents can help Oxfordshire decision makers to put this data from that report in the local context and apply it in policy making:

The eco-metric approach (ECI, 2020)[276]

The Dasgupta – Independent Review on the Economics of Biodiversity (HM Government, 2020)[277]

Biodiversity: Finance and the Economic and Business Case for Action (OECD, 2019)[278]

6.5 Funding mechanism

- There is a multitude of funding sources and funding mechanisms. The Green Infrastructure Resource Library (Brillianto 2017-2020) provides an extensive list of documents on funding sources or mechanisms for securing Green Infrastructure.
- The US Environmental Protection Agency has published Getting to Green: Paying for Green Infrastructure (Dec 2014). This covers several funding mechanisms and is broadly transferable to the UK.
- Funding sources change all the time. Existing schemes will be replaced by future schemes of a similar nature. Pro-active engagement with the topic will reap benefits.

6.5.1 Green Infrastructure bonds and business

- Businesses need to better understand how much they depend on the natural environment. How does a deterioration in a healthy natural environment increase the risk of natural disasters such as flooding? Armed with this knowledge business may then be more willing to invest in mitigation measures.
- Green Investment Bonds have entered the market in recent years. For example, the Washington DC Green Infrastructure Fund has tackled stormwater issues since 2013.[279] Discussion during the development of the SEEIP touched on this type of funding.
- Businesses likely to invest in this kind of bond include insurance companies, business that have property prone to flooding or housing developers. Some food and beverage sectors (e.g. dependence on clean drinking water) and water utility bodies may also find this relevant.
- One recent example is the Washington D.C. Green Infrastructure Fund. One example includes an insurance company investing $1.7m in better stormwater management.
- The Green Infrastructure Investment coalition formed out of the Paris Climate Agreement
- The Planning system can contribute more, e.g. towards a net biodiversity gain. This is a policy and political issue. It needs to be addressed at that level. There is enough proposed development in Oxfordshire to secure significant funding for Green Infrastructure investment.
- Developers could propose housing development incorporating more and higher quality, more functional Green Infrastructure, either in response to policy requirements or in a desire to set themselves apart from competitors with their green credentials and quality of life aspects of prospective future residents.

6.5.2 Payment for Ecosystem Services

- Ecosystem services are the benefits we can get from environmental assets (aka Natural Capital). The concept became more mainstream with Defra running a series of pilots from 2011-2013. Defra Payments for Ecosystem Services (PES) Pilot Projects: Review of key findings of Rounds 1 and 2 (Defra, Oct 2014) summarises these pilots.

6.5.3 The planning system

The planning system is complex. Changes will take time. The planning system is one important mechanism to get GI delivered. As in other locations, Oxfordshire has a two-tiered system, where District Councils have a role in preparing Local Plans every 5 years setting the rate and nature of development in their areas.

Including policies within Local Plans for Green Infrastructure requirements is the best way in ensuring new developments adequately deliver Green Infrastructure. Here some quick pointers:

- There are examples of specific policy driving GI implementation, e.g. a requirement for Bicester Eco-town to have 40% GI provision.
- Other mechanisms include:
  - S106 (e.g. commuted sums for long-term maintenance of Green Infrastructure assets).
  - Community Infrastructure Levy (incl. 123 schedules).

6.5.4. Natural capital investment plan

Rather than developing a Green Infrastructure investment plan, several Local Authorities and other geographies have developed Natural Capital investment plans.

6.5.5 Foundations and government grants

There are few funds that have "Green Infrastructure" in their programme wording or title, but many do fund one or several of the functions associated with Green Infrastructure.

- Foundation grants to the voluntary sector totalled £2.5bn in 2012/13. Government grants totalled £2.2bn (UK Civil Society Almanac 2015).[280]
- Examples of suitable government funding include:
  - Countryside Stewardship (Natural England).
  - Woodland Grant scheme (Forestry Commission).
  - The European Rural Development Fund can fund Green Infrastructure investment.
  - Central Government Funding (£108m Growth Deal, £1.2 bn City Deal and future iterations of this). The hooks are sustainability, innovation, flooding and other aspects. This funding helps to deliver various strategies and action plans listed in section 3.2.
  - Many of the above are very likely to have a post Brexit successor scheme. But at the point of preparing this document for print it is not clear what they may look like.
- A specialist environmental fundraiser facilitating grant bids would be a useful addition to the county's economic and environmental development capacity. The Trust for Oxfordshire's Environment is helping to establish capacity in this area.

6.6 County & district documents with potential to deliver Green Infrastructure

There are a number of Strategy and Policy and Action Plan documents that have potential to contribute directly to Green Infrastructure implementation:

Document (& link)	Clout	£scale	Specific Actions	Green Infrastructure potential	Hooks	Comment
Oxfordshire Infrastructure Strategy (OXIS, Sep 2017)	MH	(£ bns)	N/A	M	Green Infrastructure is one chapter in OXIS	(currently undergoing refresh)
			N	L/M	Tourism & sustainable agriculture	Implementation with help of Growth Deal & City Deal; limited life due to Brexit
Climate Change Adaptation Action Plan 2012-2015	L	N/A	Y	M/H	Climate change adaptation	Remains in development
Oxfordshire LTP/LTCP	M	£1.2 bn	(Y)	M/H	Active travel, cycling, air quality	Lists City Deal & Growth Deal; developer funds, Community Infrastructure Levy & other sources of funding as implementation mechanism
	L/M	?	(Y)	H	Green Infrastructure, health, access, biodiversity, sustainable transport	Update to 2006-2014 implementation plan under development
Oxfordshire's Joint Health and Wellbeing Strategy 2018-2023	M	N/A	N	L	Health & Wellbeing	Sets priorities & targets, makes reference to "action plans to deliver the improvements "
Oxfordshire Local Flood Risk Management Strategy	M/H					
Oxfordshire's Biodiversity Action Plan	L	N/A	Y	M	Biodiversity	Effectively out of date/superseded by NEWP
State of Nature report	L	N/A	N	L/M	Biodiversity	
In a Nutshell a strategy for the sustainable management of Oxfordshire's woodlands and trees	L	c.£100m	N	M	Biodiversity, woodfuel, non-timber benefits of woodlands	Benefits of investment/implementation stated as £79m, but no detail on cost

Document (& link)	Clout	£scale	Specific Actions	Green Infrastructure potential	Hooks	Comment
District-level						
AONB Management Plans	M	£1ms	Y	M/H	GI, air quality, biodiversity, flooding, Climate Change, health	
Infrastructure Delivery Plan & 123 schedules	M	£10ms	Y	M	Green Infrastructure/housing	Potential depends on whether dedicated Green Infrastructure section in IDP (by 31 December 2020 an Infrastructure Funding Statement will replace the 123 schedule lists).
Any transport, noise, flooding, air pollution, transport, housing health, action/implementation plans or major project	M	£100 ms	Y	M/H	Various	See comments on policy good practice and recommendations
Proposed large-scale infrastructure projects, e.g. the Oxford-Cambridge Expressway, the Oxford flood relief channel and other major infrastructure programmes	H	£ bns	Y	M/H	Various	Actual projects being delivered need to be shaped & influenced by considerations on Green Infrastructure investment e.g. Abingdon FRC *c.*£130m
Local Authority Plans	H	£bns	N	H	Healthy place shaping, climate change adaptation, flooding, biodiversity, sustainable transport, air quality	Please see detail in: Annex 1.
Cherwell District Council Local Plan 2011- 2031 - 2016 - adopted https://www.cherwell.gov.uk/info/83/local-plans/376/adopted-cherwell-local-plan-2011-2031-part-1						
Oxford City Council Local Plan 2036 - (wip) -Oxford City Council - https://www.oxford.gov.uk/downloads/20264/local_plan						
South Oxfordshire Local Plan 2034 -2019 - to be adopted by December 2020. http://www.southoxon.gov.uk/services-and-advice/planning-and-building/planning-policy/local-plan-2034						
Vale of White Horse District Council Local Plan 2031 - 2016 - http://www.whitehorsedc.gov.uk/services-and-advice/planning-and-building/planning-policy/local-plan-2031/local-plan-2031-part-1						
West Oxfordshire Local Plan 2031 - 2018 - adopted, https://westoxon.gov.uk/localplan2031						

Table 13: Potential of a range of strategic documents to contribute towards delivering Green Infrastructure.

Other county level documents are currently under development or under consideration. The following also have potential for Green Infrastructure delivery: Joint Strategic Plan, Energy Strategy, Countryside Economy Strategy, Oxfordshire Industrial Strategy, One Planet Oxfordshire, Oxford-Cambridge growth corridor. (compare with section 3.2)

7. Overall recommendations

To achieve the aims set out in this study, the following need to be considered:

1. **Develop a summary business case based on Government green book rules.[281] It needs to include the cost and consequences of not taking any action.**
   Chapter 4 presents robust evidence on the current cost of unsustainable practice. It also lists robust evidence of the possible solutions and their cost-effectiveness.

2. **Develop a vision for Oxfordshire's Green Infrastructure that inspires and co-ordinates action.**
   How can Green Infrastructure be an integral part of achieving a more sustainable future?
   Section 2.1 sets out a vision. A vision developed in partnership and through a consensus-based approach will help to establish the common ground.

3. **Build partnerships able to deal with the scale and complexity of the challenge.**
   This needs a partnership of all relevant organisations. It will need both those holding physical and intellectual assets and resources and those who represent the users and beneficiaries of Green Infrastructure assets. This includes:
   - Decision makers
   - Political leaders
   - Businesses
   - NHS & other health organisations
   - Highways Agency & other transport organisations
   - Planners
   - Nature Conservation Charities
   - Education sector
   - Communities

4. **Invest in filling data and other evidence gaps to ensure good decision making.**
   Section 6.1 and Annex 2 highlight gaps in evidence.

5. **Invest in robust analysis of assets and data to ensure targeted and effective delivery.**
   How to match the asset as a solution to a problem?
   Establish where exactly, how and to what benefit investment in Green Infrastructure can make a positive contribution. More evidence and analysis are required. This includes:
   (a) A full quantitative and qualitative audit of the assets.
   (b) Understanding the current functions of multi-functional Green Infrastructure assets and their spatial distribution (see methods in Annex 5).

6. **The scale of investment recommended is £50m p.a. for 30 years.**
   This investment will come from a broad range of local organisations and stakeholders as well as national grants and other funding sources. This will bring a step-change in the level of benefits that Green Infrastructure brings to Oxfordshire residents and make a meaningful contribution to addressing the key sustainability challenges.
   This will need a strategic decision by key decision makers, including the Councils, OxLEP and the Growth Board and a clearer idea as to sources of potential funding.

7. **Manage the Green Infrastructure investment program well.**

   This level of investment will require an appropriate level of programme management to deliver it.

8. **Build on previous work and existing strategies to embed Green Infrastructure at the heart of the Oxfordshire Plan 2050.**

   Partners need to develop more robust principles and project assessment criteria. These need to relate to aims stated in this study, OXIS, Oxfordshire Plan 2050 and other key county documents and consider an economic return on investment. Assess Green Infrastructure potential of the spatial options for growth that will be the focus of the next Oxfordshire Plan 2050 consultation.

9. **Apply good practice in Green Infrastructure delivery.**

   The Approach to Green Infrastructure delivery needs to be:
   - Strategic, prioritised and targeted (based on spatial analysis of assets).
   - Wholehearted and supported by political decision makers.
   - Integrated across departments and sectors.
   - Co-ordinated.
   - Adequately funded.
   - Using all available levers and mechanisms.

10. **Identify funders, potential investors, funding mechanisms and specific funding sources.**

    Build on the material presented in section 6.5 and other good practice.

11. **Link at policy and delivery level.**

    Consider how to amend or improve other strategic documents, in particular the OXIS refresh and how to use Green Infrastructure evidence to influence spatial options and other aspects of the Oxfordshire Plan 2050, as well as Local Plan policy. This will create a coherent and integrated plan for investment in Green Infrastructure. This will also utilise the potential from synergies between different policy areas. Policy makers and academics have developed conceptual frameworks for analysing integration of a topic into policy (see Annex 6).

Annex

Annex 1: Oxfordshire Strategies, Plan and studies

Section 3.2 lists the key Oxfordshire Documents or Strategies with strategic objectives or specific targets. The table below provides further relevant strategies, plans and studies.

Title (link)	Date	Author	comment
Climate Change Adaptation Action Plan 2012-2015	May 2012	OCC	Draft framework, no specific objectives.
Oxfordshire Air Quality, OCC	Web	OCC	Website.
Oxford Green Belt Study	Oct 2015	LUC	Assess the Oxford Green Belt in context of paragraph 80 of the National Planning Policy Framework (NPPF).
Oxfordshire's Rights of Way Management Plan 2015-2025 (aka ROWIP)	Nov 2014	OCC	Final, adopted; refers to the Strategic Objectives of the Corporate Plan 2014-2018 A thriving Oxfordshire" and those of the LTP.
Oxfordshire's Biodiversity Action Plan, 2010, OCC, WO	Pre 2011	OCC/WO	Document "superseded" by NEWP summary document does not contain objectives or specific targets, except for habitat creation of certain types of habitat.
State of Nature Report	March 2017	WO *et al*.	The best information currently available has been used to paint a picture of the state of Oxfordshire's natural habitats and species, including long-term trends as well as more recent losses and gains.
In a Nutshell, a strategy for the sustainable management of Oxfordshire's woodlands and trees	Oct 2016	TOE2, Sylva *et al*.	Draft; suggests objectives for an action plan, including management, creation of woodland, renewable energy, forest products, biodiversity, climate change, landscape and people.
Cycling Design Standards & Walking Design Standards	2017	OCC	Provide a guide to developers, planners and engineers.
Oxfordshire Energy Strategy	2019		Acknowledges the importance of biomass, such as wood fuel and biofuel in their contribution to climate change mitigation. It also sets out key investment priorities.[282]
One Planet Living Oxfordshire	2019	Bioregional	https://storage.googleapis.com/www.bioregional.com/downloads/OPO-our-shared-vision-final.pdf

Title (link)	Date	Author	comment
Oxfordshire Local Industrial Strategy	2019	OXLEP	https://www.oxfordshirelep.com/sites/default/files/uploads/Oxfordshire-SINGLE-PAGE_1.pdf
Oxfordshire Joint Health and Wellbeing Strategy (2018-23)	2019	OCC	https://www.oxfordshire.gov.uk/sites/default/files/file/constitution/oxfordshirejointhwbstrategy.pdf
Oxfordshire Plan 2050	2019	OCC & District Councils	Previously known as Joint Statutory Spatial Plan, see https://oxfordshireplan.org/ first consultation with 9 topic papers, ongoing work in 2020
Oxfordshire Infrastructure Strategy (OxIS)	2017	AECOM for Oxfordshire Growth Board	https://www.oxfordshiregrowthboard.org/wp-content/uploads/2018/04/oxis_stage2.pdf, ongoing refresh in 2020. Draft version of this document have already fed into that refresh.
AONB Management Plan	2019	North Wessex Downs AONB	http://www.northwessexdowns.org.uk/publications-resources/aonb-management-plan.html
AONB Management Plan	2018	Cotswolds AONB	https://www.cotswoldsaonb.org.uk/planning/cotswolds-aonb-management-plan/
AONB Management Plan	2019	Chilterns AONB	https://www.chilternsaonb.org/conservation-board/management-plan.html
Cherwell District Council Local Plan 2011- 2031 - 2016 - adopted https://www.cherwell.gov.uk/info/83/local-plans/376/adopted-cherwell-local-plan-2011-2031-part-1			
Oxford City Council Local Plan 2036 - (wip) -Oxford City Council - https://www.oxford.gov.uk/downloads/20264/local_plan			
South Oxfordshire Local Plan 2034 -2019 - to be adopted by December 2020 http://www.southoxon.gov.uk/services-and-advice/planning-and-building/planning-policy/local-plan-2034			
Vale of White Horse District Council Local Plan 2031 - 2016 - http://www.whitehorsedc.gov.uk/services-and-advice/planning-and-building/planning-policy/local-plan-2031/local-plan-2031-part-1			
West Oxfordshire Local Plan 2031 - 2018 - adopted, https://westoxon.gov.uk/localplan2031			

How Green Infrastructure relates to other Infrastructure

Infrastructure type (in OXIS)	Generic link to Green Infrastructure	Opportunities for joint delivery	Threat to Green Infrastructure	Benefit of Green Infrastructure to Infrastructure Type
Transport	Walking, cycling, ROW network	Green Infrastructure corridors along transport corridors, green bridges Green Infrastructure transport corridors to public transport hubs Footpaths, cycleways, bridleways – grey-green continuum	Habitat fragmentation Direct habitat loss Unfavourable magt. of green corridors along transport corridors (mowing/chopping down trees)	Noise & pollution mitigation Flood protection Shading of footpaths/cycle routes/roads/tracks (summer heat) Resilience – less likely to be flooded or affected by erosion
Education	Environmental Education	Forest Schools, NGO environmental education provision, nature conservation volunteering	Loss of habitat from new school build	Noise & pollution mitigation Flood protection Reduction in aggression/anti-social behaviour Better learning environment Shading of school buildings from heat
Health services	Natural Greenspace health benefits	Green gyms, green exercise, green play, walking for health groups, nature conservation volunteering; hospital grounds creation/improvement; natural Health Service; promotion of healthy lifestyles, e.g. Walking & cycling	Loss of habitat from new hospital build	Noise, stress & pollution mitigation Flood protection Reduction in aggression/anti-social behaviour Better learning environment Exercise benefits for mental and physical health Disease prevention & rehabilitation Evaporative cooling around hospital grounds/buildings
Other strategic community & environmental infrastructure e.g. waste management		Planting schemes around these sites	Loss of habitat from new hospital build Leakage of nutrients/pollutants	Visual/noise/smell screening of facilities

Infrastructure type (in OXIS)	Generic link to Green Infrastructure	Opportunities for joint delivery	Threat to Green Infrastructure	Benefit of Green Infrastructure to Infrastructure Type
Energy & Utilities	Bio-energy Water quality	Green corridors along energy & utilities corridors Green Infrastructure along rivers for water quality & flood prevention	Loss of habitat Pollution to nutrient – sensitive sites Water abstraction Power-lines & bird strike	Renewable energy e.g. woodfuel → CC reduction targets Visual/noise screening of facilities Water retention and filtration/purification Resilience – less likely to be flooded or affected by erosion
Flooding & Water management	SUDS & Flood risk mitigation	SUDS in housing development Up-stream land use change	Invasive alien species Water abstraction	Water retention Water filtration/purification Climate Change Adaptation Flood Risk mitigation
Broadband & Connectivity	(this may reduce transport → benefit)			Quality environment as setting for entrepreneur/business start-ups (in rural areas)??

OXIS and Green Infrastructure

The **Oxfordshire Infrastructure Strategy** (OxIS), 2017, recently considered Green Infrastructure at a strategic level. The report acknowledges the benefits Green Infrastructure can have within a range of sectors including health, the sustainable management of water, flood management, transport and connectivity. In its Key Findings AECOM (p195) concluded that:

- Green infrastructure assets are likely to come under pressure from development that could undermine their value.
- There has been limited forward-planning for Green Infrastructure.
- Relative lack of evidence on Green Infrastructure meaning that accurate assessments of Green Infrastructure need cannot be undertaken.
- The potential impact of new development should be assessed on a landscape scale so that the character and quality of the nationally important AONBs are enhanced/mitigated.
- The impact of increased visitors on the AONBs should be managed through the development of recreation and support infrastructure.
- The "Blue network" (i.e. rivers and canals) is likely to be increasingly utilised for recreation and could suffer from over abstraction.
- The impact of development on the wider ecology is less well understood.
- Good practice would be to provide a connected network of Green Infrastructure to support biodiversity.
- Existing deficits in accessible natural and semi-natural space is likely to be exacerbated by demands from the residents of new development.
- Additional strategic space for recreation will be needed, as well as smaller more localised spaces.

Annex 2: Data gaps and Evidence & and Analysis Requirements

Preparatory work for this study included a quick audit of available data (see also Annex 3 Green Infrastructure assets). Section 6.1 sets out the rationale why a robust analysis of the assets, their current and potential future functions and associated benefits. right place into the needed and desired benefits.

This is important so that the proposed Green Infrastructure investment plan can invest with confidence in the right place in the right way to maximise benefits to people and financial return on investment.

The following sections give specific examples of what kind of analysis may be required.

Housing Development

- GIS analysis of the fragmentation of Conservation Target Areas (CTA) through recent or proposed housing and other development.
- GIS analysis of loss of Priority Habitat through recent or proposed housing development.
- GIS analysis of the Accessible Natural Greenspace Standard (ANGSt) provision in new housing development vs. existing development. (Note: Natural England is currently working on developing a new set of Green Infrastructure standards, due to launch in spring 2022).
- Assessment whether ANGSt provision for new housing development is better than for existing housing development and/or helping to increase the overall ANGSt provision.
- GIS analysis of new housing development contribution to ANGSt provision of existing housing. development. (Has new housing development made a net contribution to ANGSt provision (before and after) or has more been lost than replaced?)
- Area developed for housing p.a. and how much of what habitat has been gained and lost as a consequence.

Sustainable Transport

To better understand the baseline and the challenges regarding sustainable transport and Green Infrastructure the following need to be considered:

- What are the reasons for not cycling (to work)? E.g. lack of provision of cycle tracks? Concerns about safety?
- Congestion caused by cyclists on roads where overtaking is difficult – what is the economic and health and safety impact?
- GIS analysis: proportion of town roads with dedicated cycle tracks (county low/high provision areas compared to English average).
- GIS analysis: proportion of typical commuter routes with dedicated cycle tracks (and comparison with England average).
- GIS analysis: transport hubs and provision of cycle tracks leading to it.
- GIS analysis: transport hubs and provision of green corridors leading up to it.
- GIS analysis: current and proposed roads fragmentation of CTA and loss of natural habitat.
- GIS ANALYSIS: transport infrastructure in flood zone 1,2,3.
- GIS ANALYSIS: Oxfordshire Road noise[283] hot spots vs. property prices or health problems.

Health

- GIS analysis of health deprivation *vs*. accessible natural greenspace/ANGSt/accessible woodland standards. (Note: Natural England is currently working on developing a new set of Green Infrastructure standards).
- GIS analysis mapping obesity/coronary heart disease/asthma/anti-social behaviour/crime *vs* accessible natural greenspace.
- Evidence on how much of different Green Infrastructure assets (especially woodland, but also grassland and other types of assets) is accessible for recreation, relaxation, environmental education.
- More GIS analysis and evidence gathering is required in the following areas:
  - GIS analysis: potential to close gaps in ROW network to create more circular routes.
  - GIS analysis: ANGSt priorities for improving% of population to have standard met. Where are the places, where investment will make the greatest difference?
  - GIS analysis: potential for creation of new green gyms: green gyms vs. catchment (IMD or other evidence of need).
  - GIS analysis: potential for shelter trees/green roofs facades in noisiest areas.
  - GIS analysis: potential for shelter trees/green roofs facades in areas with highest air pollution/highest occurrence of Asthma/coronary heart & lung diseases.
  - GIS analysis: greenspace provision for education within catchment of primary schools.
  - GIS analysis: potential to separate walking/cycling via trees/hedges from noisy/polluted/dangerous roads.
  - GIS analysis: potential for reduction of anti-social/aggressive behaviour through creation of/better design of green spaces (evidence for need IMD or other data).

Access to Green Space

More evidence and GIS analysis need to be gathered/conducted respectively to better understand the opportunities around people access to greenspace and health, including:

- A full functionality and needs assessment of Green Infrastructure assets according to the methodology developed by the North West Green Infrastructure Partnership.[284]
- Evidence on skills gaps in professions relevant to green space management.
- Further local analysis of the barriers to accessing green spaces and the countryside – motivation/culture change, variety and function of green spaces, proximity and amount, promotion via health care providers.
- Rights of way density per SOA (in Colour-coding) vs. e.g. health deprivation [GIS].
- Accessible natural Green Infrastructure density per SOA (Colour-coding) vs. e.g. health deprivation [GIS]
- ANGSt analysis: % of population meeting ANGSt 1,2,3,4 level [GIS] more in Annex 2.
- Mapping ANGSt analysis vs. e.g. health deprivation [GIS].
- ANGSt analysis: How much does taking all charged-for natural greenspaces out of the figures reduce the ANGSt provision?
- Oxfordshire Investment in Rights of Way management Plan implementation (*vs* England average and historic trend).
- ROW/inhabitant (*vs* England average).
- Total area of accessible natural greenspace/woodland (*vs* other counties).

Climate change

To better understand the baseline and the challenges regarding climate change and Green Infrastructure the following need to be considered:

- Baseline: Current surface areas of green roofs and green facades.
- Potential area for green roofs (taking historic buildings and other factors into account).
- Current number and condition of street trees.
- GIS analysis: Urban heat island effect temperature measurements *vs* excess heat deaths (especially in areas of sensitive receptors such as hospitals and old people's homes).
- GIS analysis: UHI effect *vs* mapped green space.
- GIS analysis mapping relatively cool areas during heat waves *vs* green space cover – do we already have areas where this is working?
- GIS analysis: potential for green roofs/facades/tree planting in areas most affected by Urban Heat Island effect.
- Feasibility study on surfaces suitable for green roofs and green facades.
- Modelling the energy savings, emission reductions and carbon sequestration a certain percentage of suitable surfaces being converted to a green roof or wall respectively will achieve.

Flood Risk

- GIS analysis of how much (developed) land is in Flood zone 1,2,3 – total/% population living in those.
- GIS analysis of the change of amount of woodland habitat and natural grassland within 1 km of rivers in last 40 years (regarding flood risk mitigation).
- Cost of the 2013/14 winter floods in Oxfordshire.

Air Quality

To better understand the baseline and the challenges regarding air pollution and Green Infrastructure the following need to be considered:

- Air pollution measurements and modelling and required station density.
- GIS analysis: area of AQMA and population living in AQMA (% of SOA).
- GIS analysis: Green Infrastructure provision in AQMA (*vs* average Green Infrastructure provision in urban areas/across the county).
- GIS analysis: air quality monitoring stations *vs*. population – statistic: % population who has NO/PM/ other monitoring within relevant distance of where they live.
- GIS analysis: air pollution levels *vs*. premature deaths/occurrence of lung cancer/asthma.

For example, (GIS) analysis needs to establish how many people live in the County's 13 Air Quality Management Areas and how many sensitive receptors (nurseries, schools, hospitals, and old people's homes) are present. Other target areas will be most polluted roads (to be established using GIS analysis and pollution data or data models.

Biodiversity

- GIS analysis of the climate change vulnerability of habitats (models exist with Natural England).
- GIS analysis of Conservation Target Area or Priority Habitat change *vs*. recent and projected housing/industrial/infrastructure development.
- GIS analysis of the level and causes of fragmentation of habitats. An Assessment of existing habitat networks and any recent Green Infrastructure implementation against Lawton principles as set out in Natural Environment White Paper.
- GIS analysis of accessible natural greenspaces (ANGSt) in urban areas and what this means for access to natural greenspace). (Note: Natural England is currently working on developing a new set of Green Infrastructure standards).
- GIS analysis to establish the proportion or total land area of high biodiversity value not being protected by a nature conservation designation.
- GIS analysis: potential for creating linear habitats/habitat corridors along roads, rail, rivers – how many ha? How many miles?
- GIS analysis: potential for woodfuel production on Green Infrastructure assets.
- GIS analysis: potential for priority habitat creation on amenity greenspaces.
- GIS analysis: pipeline of mineral site restoration – contribution to ANGSt/CTA enlargement/higher connectivity.
- **Oxfordshire** data for Agri-Environment Schemes (Countryside Stewardship) and whether this is below or above average for UK, whether it is in priority locations and contributing to desired outcomes.
- Establish total area of all CTA, priority habitat, designations.
- Any data on nature conservation volunteering, £investment, land managed by these?

Annex 3: Green Infrastructure assets

Measure	[N]	Area [ha]	Primary function	Food	Recreation /health	Nature conservation	Air quality	Noise mitigation	Flood mitigation
Permanent pasture (agricultural grassland)		70,568	Food	H	M	M	L	L	M
Of which biodiversity rich		6,273	Nature	M	L	H	L	L	M
Conservation Target Areas (CTA)*1	36	52,600	Nature	M	M	H	L	L	M-H
Woodland	8,538	23,203	Recreation	L	M	M	M	M	H
Road verges		c16,000	N/A	L	L	H	H	H	M
Artificial, non-agricultural vegetated areas		5,911	Various	L	M	L	M	M	M
Other Semi-natural habitat (heathland/marsh/bog/fens)		5,650	Nature	L	M	H	L	L	H
Nature reserves & designations (LNR/NNR/SSSI/SAC)[285]	129	5505	Nature	L	M	H	L	L	M
Land in agri-environment schemes (e.g. Countryside Stewardship Scheme)		4,207	Nature	M	L	H	L	L	M
Parks/gardens/cemeteries/amenity greenspace	1,606	3,021	Amenity	L	H	M	M	M	M
Residential/private gardens			Amenity	M	H	M	L	L	M
Road verges			Amenity	L	L	L	L	L	L
Allotments	228	251	Food	H	M	M	L	L	L
Traditional Orchards	876	323	Nature	H	M	H	M	M	M

(There is some overlap in the categories above, e.g. many biodiversity rich grasslands are also LNR/NNR/SSSI/SAC) multiple sources.)

*1 not all of the land covered by CTA is habitat. It does also include smaller settlements, roads, agricultural land etc.

Measure	[N]	Area [ha]	Primary function	Food	Recreation /health	Nature conservation	Air quality	Noise mitigation	Flood mitigation
Inland waters	203	489	Recreation	L	H	M	L	L	L
Urban trees			Amenity	L	H	H	H	H	H
Hedgerows			Nature	L	M	H	L	L	M
Rivers & canals	8	1,302km	Recreation	L	H	M	L	L	L
Right of Way (ROW)/	5,908	4,221km	Recreation	L	H	L	H	H	L
Other footpaths & cycleways	?	?	Recreation	L	H	L	H	H	L

(There is some overlap in the categories above, e.g. many biodiversity rich grasslands are also LNR/NNR/SSSI/SAC) multiple sources)

*1 not all of the land covered by CTA is habitat. It does also include smaller settlements, roads, agricultural land etc.

Detail on Access network

- **Oxfordshire** has 2,600 miles (4,221 km) Rights of Way. Of this, 879 miles (1,417km) (33.5%) can be used by cyclists and horse riders. The Thames Path National Trail follows the river for 180 miles from its source in the Cotswolds through Oxfordshire. The Ridgeway National Trail is one of the oldest walking or riding routes in Britain and runs for 87 miles through Oxfordshire. Other themed walking routes include:
  - Oxfordshire Way
  - D'Arcy Dalton Way
  - Wychwood Way
  - Oxford Canal Walk
  - Oxford Green Belt Way
  - Chilterns Way
  - Shakespeare's Way
  - Seven Shires Way[286]

Annex 4: Detailed evidence & rationale for the Case for investment in Green Infrastructure

The seven key problems alone account for an annual cost of £2.5 billion. That is approximately 10% of Oxfordshire GVA. For many issues and problems, no quantitative or at least no monetizable data on cost are available.

There are two principle questions we need to answer:

1. How much positive change could we possibly achieve by investing in Green Infrastructure?
2. How cost-effective will investment be (compared to doing nothing or using a technical solution not involving Green Infrastructure)?

Benefit-Cost Ratios (BCR) of Green Infrastructure investments

- Using the best alternative for SUDS design for the Sun Valley Watershed, California, improved the Benefits Cost Ratio of SUDS from 1:1 to **1.7:1**.[287]
- The city of Portland, USA, found the benefits: cost ratio for a private household green roof to be **1.8:1** after a 40-year period. This calculation does not include any benefits for wider society, such as air quality or biodiversity, but only direct benefits to owner of property (i.e. return on investment). The main benefits were reduced energy costs, better stormwater management and an increased roof longevity.[288]
- The benefit-cost ratio of ongoing investment in and maintenance of 5 municipal forests in the US was found to be between **1.4:1 and 3:1**. The main economic benefits were related to carbon sequestration, air quality, flood management and property value.[289]
- A payment for Ecosystem Services pilot for Poole Harbour found that nitrogen mitigation through reducing agricultural pollution had a benefit-cost ratio of **2.6:1** (benefits £4.9m, costs £1.9m). Another pilot for Pumlumon, Wales, estimated benefit-cost ratio of around **3:1** (main benefits visitor spend, water table and carbon sequestration).[290]
- An i-Tree assessment for Lisbon states the benefit-cost ratio for investment in street trees as **4.5:1**.[291]
- Assessed over 40 years, the lifetime benefits of river restoration at the Mayes Brook development, London, were estimated at €31m (*c.*£27m[292]) – a benefit-to-cost ratio of **7:1**.[293]
- For wetland creation on around 100,000 hectares, benefits-cost ratios of **3:1** are typical, with to 9:1 possible in some cases (Natural Capital Committee, 2015).[294]
- A 7km cycleway in Glasgow is delivering a social return invested with benefits of increased exercise and a safer, greener community at a benefit -cost ratio of **7:1**.[295]
- The Mersey Forest stated its benefit-cost ratio for its overall programme as **10:1** in 2009.[296]
- For an investment of £9.6 million in parks and greenspace by City of Edinburgh Council, benefits worth £114m are generated. This is a Benefit Cost ratio of **12:1.** benefits include 41 million for health and wellbeing, 36 million for social equality and £51 million for local businesses (City of Edinburgh Council, 2015).[297]
- The Land Trust state their BCR for money invested by the Trust towards crime and anti-social behaviour reduction as **23:1**.[298]
- The BCR for investment in London's public parks is **27:1** (Mayor of London, 2017).[299]
- The Land Trust state their BCR for money invested by the Trust to secure health benefits as **30:1**.[300]
- South West Water has found as part of a Payment for Ecosystem Service (PES) pilot, that reducing pollution at source rather than investing in engineering solutions to treat polluted water downstream has a benefit-cost ratio of some **65:1**.[301]
- A recent study by the Land Trust for Silverdale Country Park states that following significant investment that an annual maintenance budget of £70,000 maintains a Natural Capital asset value of £2.6 million.[302]

Green Infrastructure cost compared with a technical solution

- Capital costs of traditional drainage are more than double the capital costs of SUDS, annual maintenance capital costs are **20 – 25%** cheaper for SUDS. SUDS are around half the cost over a 60-year life span.[303]
- SUDS for new small to medium housing development of moderate density (40 properties/ha) are £500-£2000 (8-33%) cheaper per property than traditional drainage systems.[304]
- A payment for Ecosystem Services pilot for Poole Harbour found that nitrogen mitigation through reducing agricultural pollution could cost **£4.9m less** than nitrogen stripping alternatives over 50 years.[305]
- The 20-year costs to New York City are estimated to be 12% lower using a combination of Grey and Green Infrastructure for sustainable drainage compared to a Grey-Infrastructure only. (5.3 bn *vs* $6.8bn – a saving of $1.5bn). This is expected to reduce combined sewer overflows and providing multiple additional benefits for the community.[306]
- The capital cost of implementing the Green Infrastructure plan for Lancaster, Pennsylvania, is estimated to be $50m, avoiding Grey Infrastructure capital costs of just under $125m. The estimated additional value of avoided costs for a 25-year period for reduced pumping and treatment costs of water and reduced grey infrastructure cost is estimated at $121m.[307]

Green Infrastructure cost for specific outcomes compared with sector standard

- Research in a deprived area of Belfast found that just 2-10% of inactive people in local community taking up exercise by providing a new accessible and attractive green space resulted in a cost effective solution to reduce loss in Disability Adjusted Life Year (DALY) ranging from £4,469/DALY to £18,411/DALY. (UK healthcare sector considers any intervention less than £20,000-£30,000/DALY to be cost-effective.)[308] **That is 39 – 85% less** than the cost of what is considered "cost-effective".

What is a realistic and achievable percentage change

The rates of achievable change vary significantly between different interventions and benefits of Green Infrastructure investment:

- Increasing deposition by the planting of vegetation in street canyons (i.e. street surrounded by tall buildings) can reduce street-level concentrations in those canyons by as much as **40%** for NO_2 and **60%** for particulate matter.[309]
- Sulphur dioxide and nitrous acid were reduced **37% and 21%,** respectively, directly above a green roof.[310]
- Green roofs are accepted as removing 75% of total suspended solids, also known as particulate matter (PM).[311]
- FERA estimated in 2010 that the UK's environmental stewardship schemes reduce emissions by **between 0.4% and 0.5%** of the 1990 Kyoto baseline over a 100-year time frame. This amounts to net savings of 5.1 million tonnes of CO_2 equivalent (worth £264 million).[312]
- A 2015 Defra consultation document found that farmers adhering to 9 basic rules would generate net present value of costs to farm businesses of £84m and environmental benefit of £484m and a **6.6% reduction** in phosphorus and greater reductions in other pollutants.[313]
- After investing a total of £15.5million into the renewal of Glasgow Green between 1998 and 2006, the number of businesses in and around the green increased by **16%**, employers by **28%** (compared to 3% and 13% respectively for Glasgow as a whole).[314]

- During an extreme rainfall event (of 300l/s/ha), green roofs can retain between **30 and 90%** of rainfall depending on the depth of substrate (between 2 and >50 cm) upon previous full water saturation with a 24-hour dropping-off period at roof gradients up to 15%.
- Modelling conducted on Manchester found that adding green roofs to all buildings in town centres, retail and high-density residential could reduce run off by **17-20%**. Increasing green cover by 10% in urban residential areas reduces run-off from these areas from a 28 mm precipitation event by **5%**.[315]
- The sheltering effect of trees could save **3 to 9%** of energy bills.[316]
- People who have good access to green space are **24%** more likely to be physically active.[317]
- A Japanese study from 2010 on "forest bathing" show that forest environments promote wellbeing. In particular, the Higher Frequency (HF) of the heart Rate Variability (HRV) was significantly enhanced in the forest settings (**56%** enhancement after viewing; **102%** enhancement after walking).[318]
- Research in Belgium in 2009 found that a 10m-wide green roof can reduce noise levels from a 70mph car 15m away by 5db on the 2nd floor of a building (reducing noise by **50%**).[319]
- A study of the impact of noise on house prices in Birmingham found that a 1 decibel increase in road traffic noise reduces the selling price of a property by between **0.2 and 0.6%**. Over the lifetime of the property, a decrease in noise levels from 56 to 55 decibels would be worth £31.49 per household per year.[320]
- A property located on the edge of a park can attract a premium of between **0.4 and 19%**.[321]
- A 2010 GLA study found that with each hectare of park space within 1km of housing increases house prices **by 0.08%**. Additionally, the presence of a regional or metropolitan park within 600 metres was found to add between **1.9% and 2.9%** to total house value.[322]
- For some statistics comparable values for other counties are available.

Studies stating what a 1% change would achieve

The following statements do not consider a feasible percentage change, but focus on the linear response of outcome relative to investment:

- A 2005 UK report estimated if that green space facilitated physical exercise so that the proportion of sedentary adults in the UK population fell by 1% would result in a total saving of £1.44bn p.a. In particular, the estimated reduction in the number deaths and cases of chronic heart disease, stroke and colon cancer was calculated to equate to approximately £1.05bn, £299m, and £98m respectively in healthcare savings each year.[323]
- A hedonic pricing study conducted for the UK National Ecosystem Assessment found that on average, a 1% increase in the amount of greenspace in a ward was responsible for £2,020 (approximately 1%) of the value of a house in England.[324]
- A 2010 study by LSE estimated that changes in natural and green space that resulted in a 1% decrease in sedentary behaviour in the UK population would provide a total economic health benefit of £2bn (using WTP (Willingness to Pay)-based values) p.a. for a range of physical and mental health conditions.[325]

Studies stating feasible level of intervention/change in baseline

- Reducing the proportion of insufficiently active people by just 5% could save £500m in the UK.[326]
- 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 £500m per year, of which 17% (or £85m) would be a direct saving to the NHS.[327]
- Research in a deprived area of Belfast found that just **2-10%** of inactive people in local community taking up exercise by providing a new accessible and attractive green space resulted in a cost-effective solution to reduce loss in Disability Adjusted Life Year (DALY) ranging from £4,469/DALY to £18,411/DALY. 225.
- If the UK wetland stock was increased by 10%, the additional water quality benefit is estimated to be worth £292 per hectare per year for inland wetlands, and £1793 per hectare per year for coastal wetlands.[328]
- A longitudinal study using Cancer Norfolk data found the incidence of diabetes in the least green neighbourhoods would fall **by 10.7%** in older people if they were as green as the average neighbourhood observed across the study.[329]
- The potential value of physical activity when **20%** of the Inner London population within 2km of green space are active 30 mins 5 days a week represents £8.7m savings to national economy and £1.8m directly to NHS.[330]
- Beijing hopes to reduce PM2.5 concentrations by **25%** by 2017.[331]
- A relatively modest assumption of a 25% reduction in costs of flooding and water pollution would represent up to £6m per catchment per year.[332]
- Getting the proportion of people in **Oxfordshire** who work full time and usually cycle to work from its current baseline (3.3%) to Cambridge levels (12%)[333] would nearly quadruple this number (363% increase).
- Getting the proportion of adults in **Oxfordshire** who cycle at least once a week from its current baseline (18.4%) to the levels of Cambridge (52%)[334], would nearly triple this number (282% increase).

Conclusion

- How much change we can achieve is possibly far more limited by our aspirations and willingness to invest than by nature's capacity to deliver ecosystem services.
- The proposed £50 m annual investment would result in c 10% reduction in damaging costs. In terms of potential achievable change, this is a realistic starting point. A more detailed feasibility study would be required to establish what positive change and cost saving can be achieved.

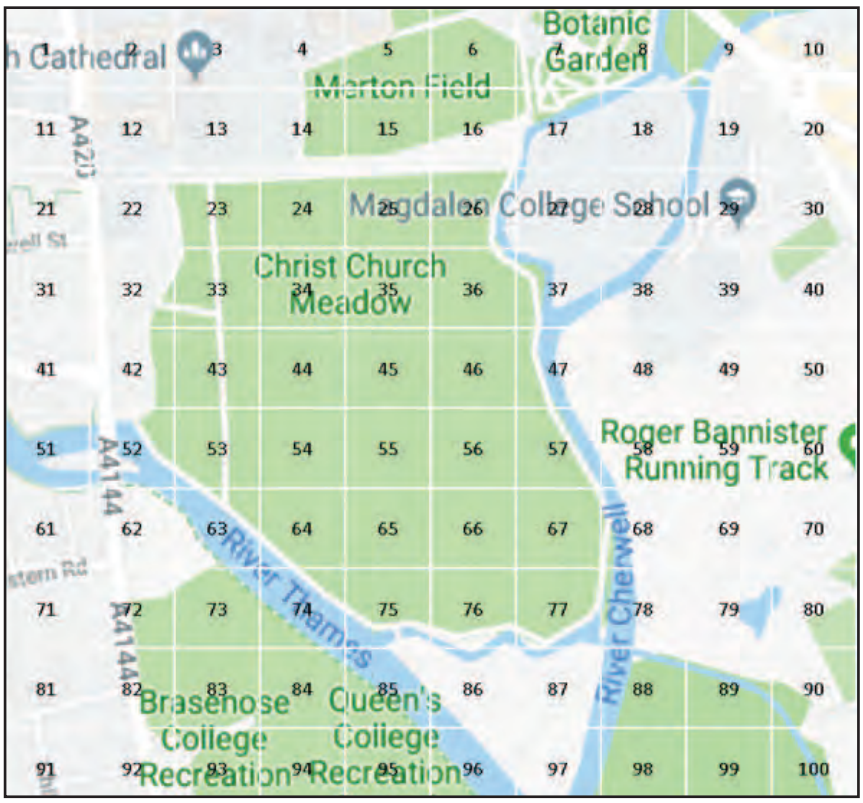
Annex 5: Spatial analysis of Green Infrastructure

This version of the Study does not provide detailed spatial analysis for the whole of the county. The following provides a quick overview of spatial approaches to assessing Green Infrastructure settings best applied at the local level. The approaches can be modified to suit resources and data availability and combined with one another.

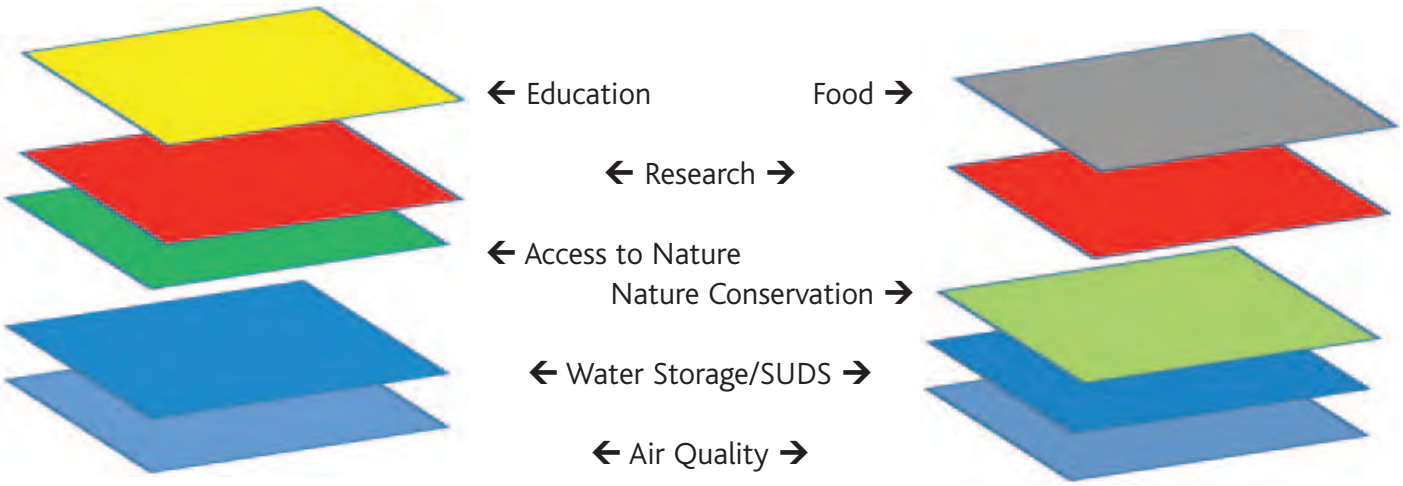
Functionality and needs assessment

- This is described in the North West Green Infrastructure guide (hands on guide how to develop Green Infrastructure strategy); and a supplementary technical document: green Infrastructure mapping method on the steps of data mapping, functionality and needs assessment.

- The basic idea is that a local Green Infrastructure strategy is developed in 5 steps:
  1. Form a partnership to set vision & Goals.
  2. Do an audit of Green Infrastructure assets and map resources.
  3. Functional Assessment.
  4. Needs Assessment.
  5. Action Plan.
- The Functional Assessment:
  - Assesses current situation – what the Green Infrastructure is doing, where it is functioning well and needs to be maintained, where it needs to be improved.
  - Assesses future situation – what are the threats to Green Infrastructure, where are the opportunities for improvement, how it might need to change, how to secure change.



Simplified Illustration of Functionality Assessment based on Oxford City Centre. Functions for Square 7 and 45 below for illustrative purposes only: Underlying map taken from Google maps.[335]



Square 7 – Botanic Garden

Square 7 – Centre of Christ Church Meadow

Accessible Natural Green Space Standard (ANGSt) and mapping

- This is a well-established standard developed by English Nature (now Natural England) in the 1990s. Natural England is currently developing a new Green Infrastructure Standard (to meet a commitment in the 25 Year Environment Plan). An ANGST analysis for Oxfordshire exists as an internal unpublished report.
- It is a (people) catchment-based approach proposing a size-dependent distance that people need to move to access a greenspace from their home.
  - 2^{+} ha → 300m
  - 20^{+} ha → 2 km
  - 100^{+} ha → 5 km
  - 500^{+} ha → 10 km

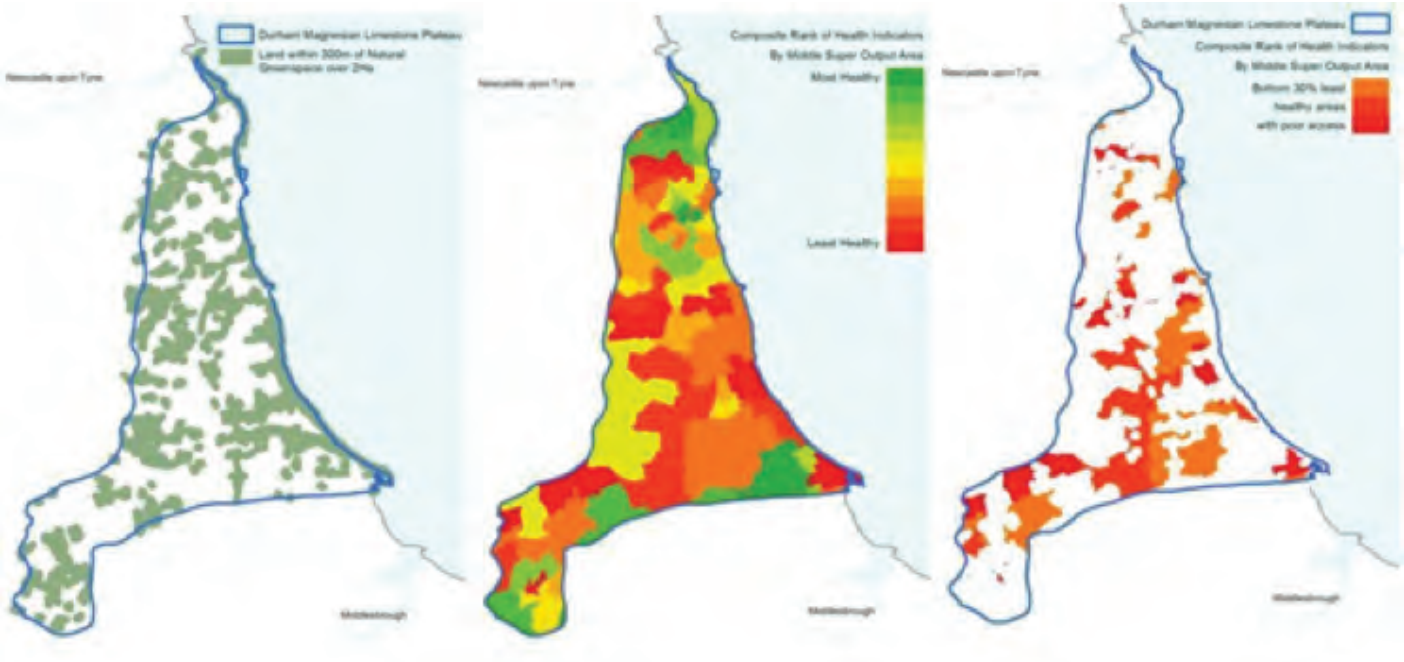
ANGSt Analysis

1. Determine size, if natural and if accessible for all possible land parcels.
2. Map for each of the four tiers separately:
   - Greenspace + catchment.
   - (NB: 500 ha sites contribute to all lower tier provisions, i.e. if someone lives within 300m of a 500+ ha site, they have their 2+ ha tier met).
3. Calculate area covered/not covered by all catchments in that tier.
4. More importantly: Calculate population reached/not reached by all catchments in that tier (using % cover of SOA as a good approximation.
   This is the baseline.

Taking action for ANGSt analysis and baseline

- Most studies and Local Authorities propose to focus on the lowest tier (as research suggests this can have the greatest positive impact on quality of life).
- Some Local Authorities set themselves targets by when they want to improve baseline by how much
- A spatial targeting approach looks at:
  - Improving baseline by creating new green spaces or making existing one "natural" or "accessible" (promotion, opening up private land).
  - Opportunities: New Housing development may play a role in creating new accessible greenspaces and increasing baseline for existing residents.
  - Factors such as (health) deprivation, multifunctionality of green spaces and need for other functions need to be taken into consideration.
  - By overlaying ANGSt catchments with other layers representing need or problems in a **GIS ANALYSIS**, real strength can be added to a strategic analysis (**see images next page**).
- This spatial targeting approach needs to be captured in local policy and properly implemented through suitable mechanisms.
- Large green roofs on public (buildings) may contribute to ANGSt.

Where deprivation and health problems persist despite ANGSt standards being met, investment in revenue-based activity (green gyms etc.) and enhancement of functionality and features (benches, way markers, vegetation clearing, lighting, additional play equipment etc.) need to be considered. Natural England is currently working on developing a new set of Green Infrastructure standards. this may provide helpful insight, guidance and principles how to apply a Green Infrastructure standard in the 21st century context.



Above images: Example from County Durham – NCA 15 ANGSt Analysis 2009

Image 1 shows the accessible natural green space provision with a 300m buffer (ANGSt criteria catchment for sites of 2-20 ha).

Image 2 shows the health deprivation in area based on 5 indicators.

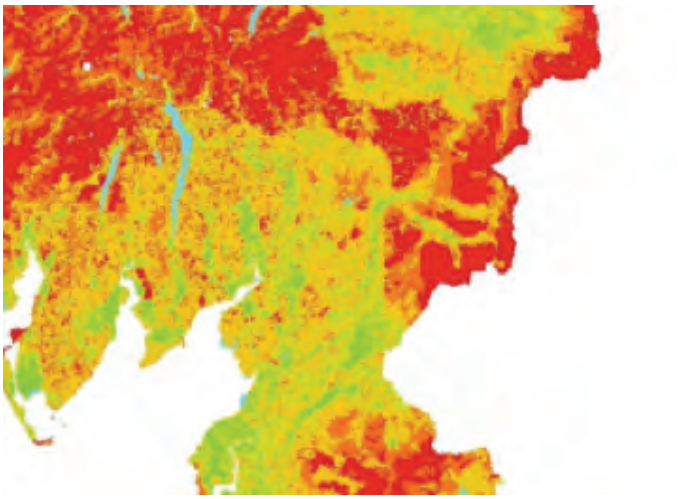
Image 3 shows the areas lacking greenspace provision in the worst 30% of area in terms of health deprivation.

- The catchment based approach returns most powerful analytical results, when greenspace catchments are mapped against other factors, e.g. health deprivation.
- The original methodology is covered in Understanding the relevance and application of the Access to Green Space Standard (Natural England 2008)
- Examples of ANGSt Analysis include:
  - greenspace and access audit with ANGSt analysis (Limestone Landscapes/County Durham, March 2009).
  - An analysis of accessible natural greenspace provision in Norfolk, Suffolk, Essex and Hertfordshire (Natural England, 2015).

Problem mapping (pinch points)

This approach is similar to a functionality and needs assessment. It starts by mapping the most pressing problems in an area (air pollution, soil erosion, flooding etc.) that Green Infrastructure interventions have potential to address. Ratings for each unit/pixel are then overlaid where several problems occur in the same place suggesting the most urgent need for action.

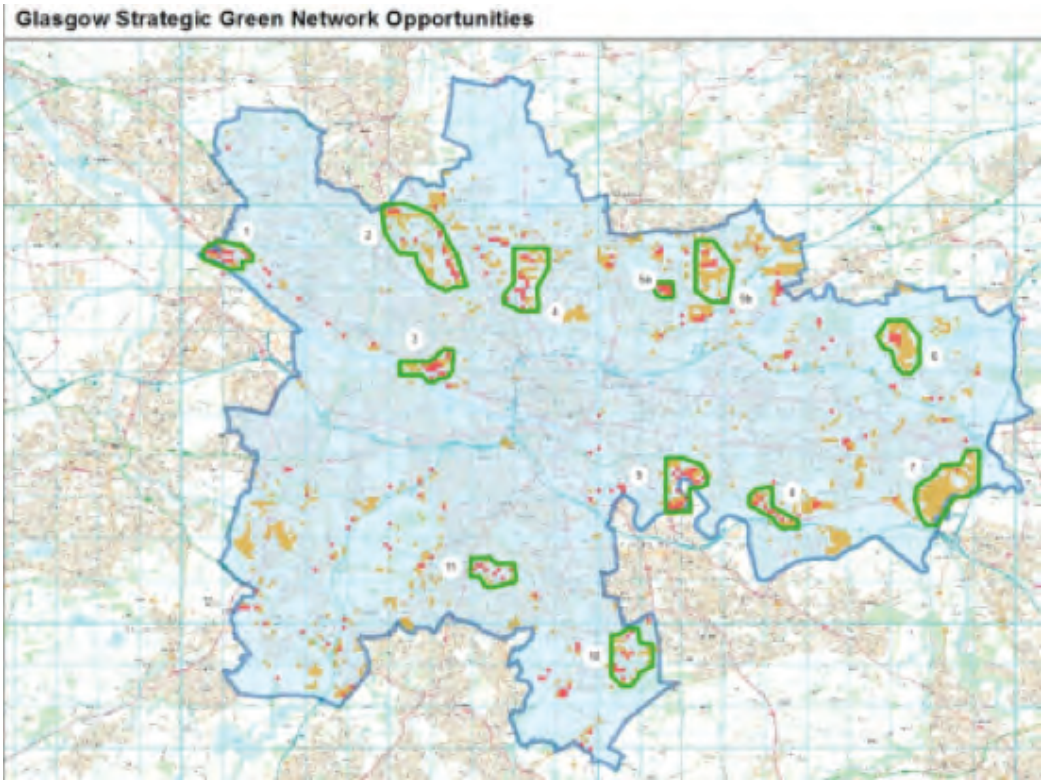
Green Infrastructure Solutions to Pinch Point Issues in the North West – how can Green Infrastructure enable sustainable development (The Mersey Forest *et al.*, 2010); focuses on threats that needs to be addressed as policy priorities in the North West, including flood risk, urban heat islands, inadequate water supply and loss of carbon storage.



© The Mersey Forest

Opportunity mapping

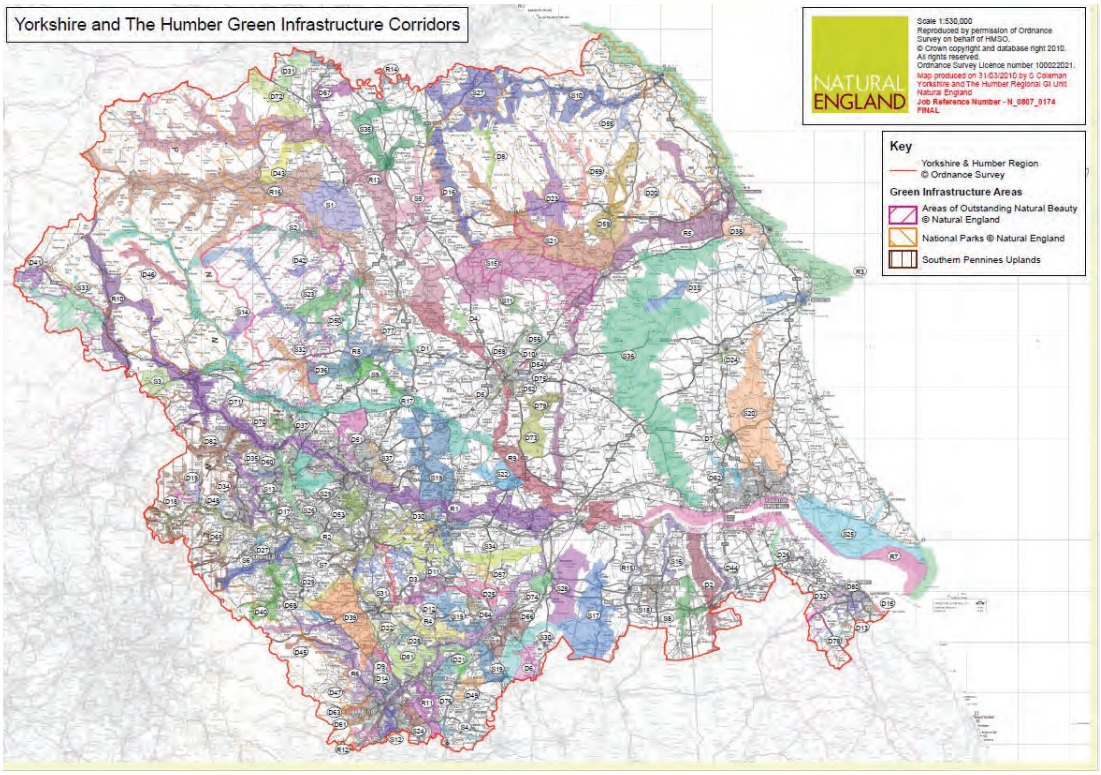
- This is often used in the biodiversity context. Many counties have Biodiversity Opportunity Areas (BOAs). They are called Conservation target Areas (CTA) in Oxfordshire.
- Some studies that have applied this approach for Green Infrastructure are:
  - Green Network Opportunity Mapping Glasgow City (GCVCN, Feb 2014).
  - North East Derbyshire Green Infrastructure Study (September 2017).



© Glasgow City Vision Green Network

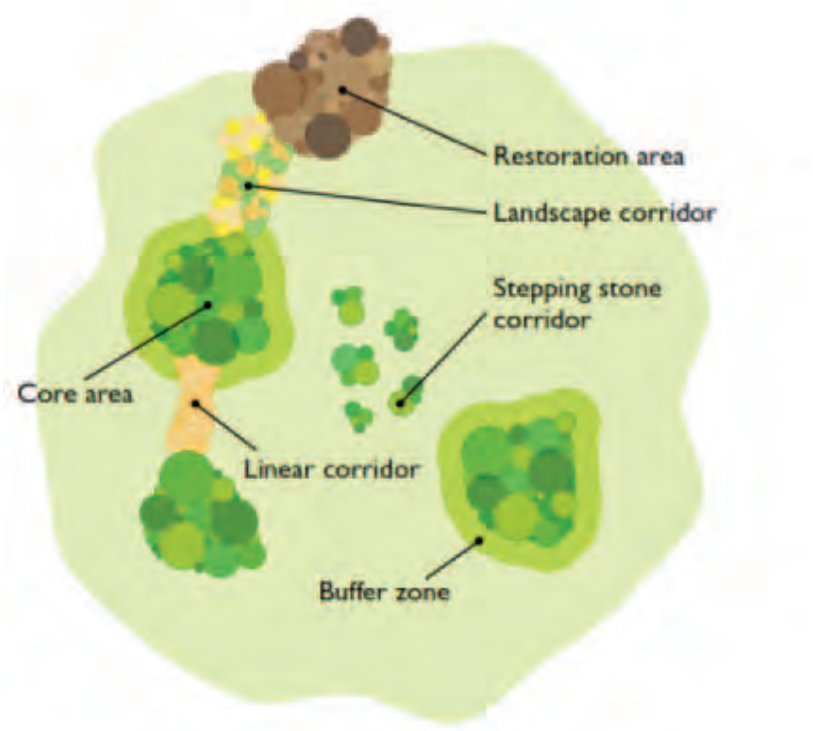
Green Infrastructure and ecological corridors

- The most detailed methodology for developing Green Infrastructure corridors has probably been developed in Yorkshire and the Humber.



Green Infrastructure corridors in Yorkshire & the Humber. © Natural England

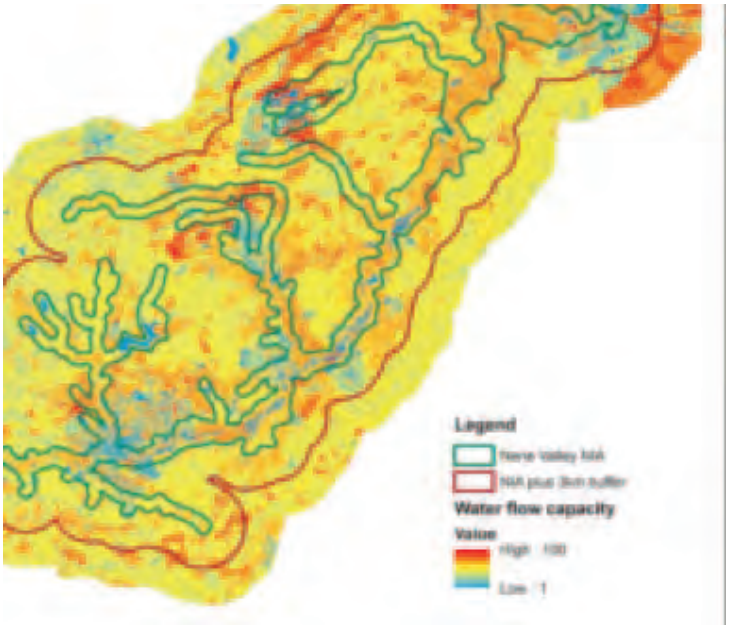
- Green Infrastructure Corridor methodology (Natural England and Local Authorities, March 2011) a worked example how to develop Green Infrastructure or ecological corridors showing methodology, data on each corridor and GIS data sets for download.
- Other examples include the Stockton Green Infrastructure Strategy (2011) in combination with the Tees Valley Green Infrastructure strategy (2008).
- In Oxfordshire the concept or Conservation Target Areas is well established. However, this is not a continuous network, but rather a collection of separate areas of high-value biodiversity. Using Lawton Principles (see below; as set out in Natural Environment White Paper; Defra; June 2011) these could be connected to a county wide Green Infrastructure network.



Lawton Principles for creating networks of habitats including Green Infrastructure. © Defra

Natural Capital mapping

- A number of natural capital mapping methodologies and case studies have emerged over recent years. For example:
  - Natural Capital maps focussing on agriculture and soil (Centre for Ecology and Hydrology and Natural England, March 2016).
  - Natural capital assessment at the national and sub-national level – A guide for Environmental practitioners (UNEP, 2016).
  - Natural Capital Investment Strategy for Surrey (Surrey Nature Partnership, Feb 2015).
  - Natural capital and ecosystem services in the Nene Valley: mapping and valuation (Natural Capital Solutions and University of Northampton, Oct 2016).



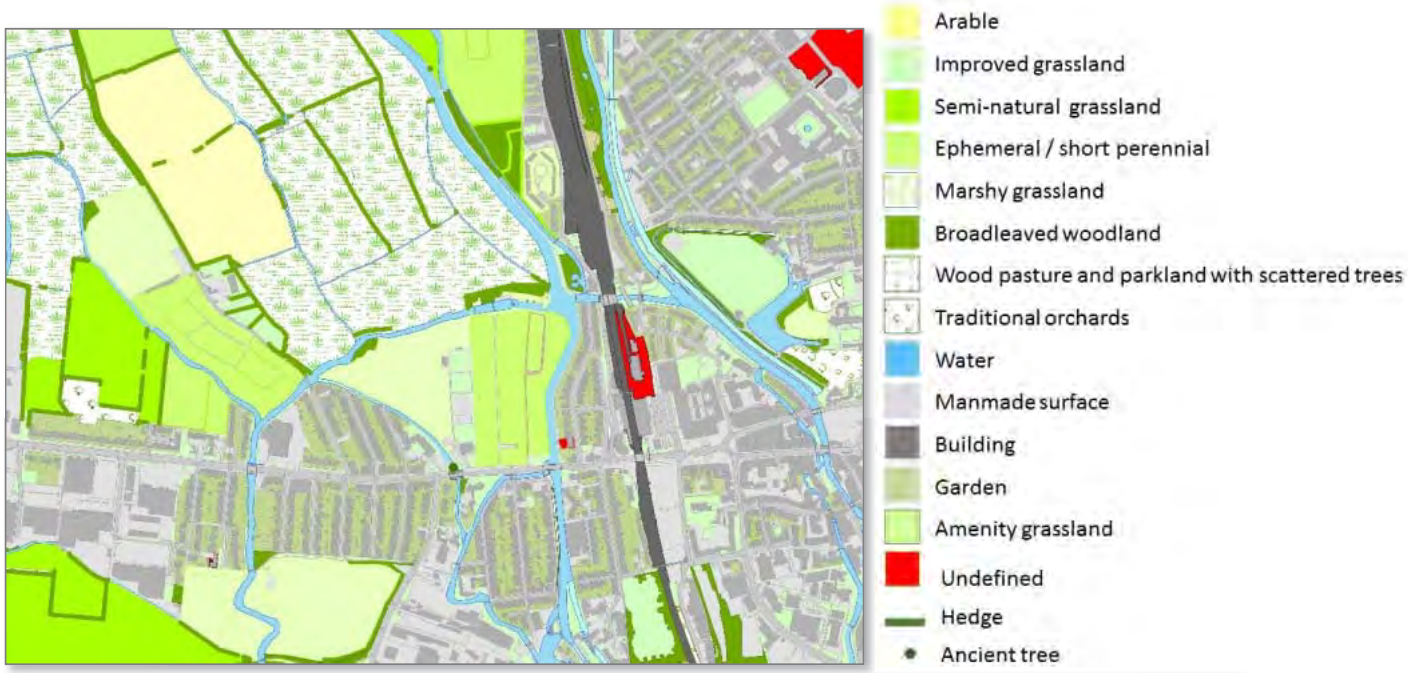
Natural flood risk management mapping from Nene Valley mapping. © Natural Capital Solutions

The eco-metric approach & Natural capital mapping in Oxfordshire

The eco-metric is an extension of the biodiversity metric which shows how changes in natural capital affect the delivery of wider ecosystem services to achieve net biodiversity gain. Ecosystem services include regulation of flooding, erosion, air quality and climate, provision of food and water, and cultural services such as recreation and aesthetic value. work by work by Defra, Natural England and The University of Oxford (ECI), phase 3 completed in March 2020.[336]

Building on this, important progress on natural capital mapping was made with the publication of a report by The University of Oxford in 2020.

The Natural Capital in Oxfordshire report[337] used a habitat scoring system and mapped 9 key Ecosystem Services these habitats provide across Oxfordshire in a greater level of detail. The next steps include identifying the gaps between supply and demand (see also sections above) and to develop scenarios for different forms of development in New Towns, town extensions, infilling, peri-urban, rural and urban. It is anticipated that this information can be integrated into the Oxfordshire Plan 2050.[338]



Complete base map for the Oxford station area, including hedges and ancient trees.

Annex 6 Policy Integration

The following is a conceptual model for measuring the level of integration of a policy topic into policy: [339]

Level of integration	Conceptual integration	Operational integration	Implementation integration
Comprehensive and explicit	Explicit recognition of all ecosystem services, including the recognition of ecosystem services and natural capital as underpinning elements of human wellbeing.	Dedicated instruments exist for addressing ecosystem services and natural capital in a comprehensive manner within a policy area.	The dedicated instruments and measures are implemented, with due procedures in place to support the implementation (e.g. funding), monitor their effectiveness (e.g. ex-post assessments) and adopt changes if needed (e.g. process for adaptive governance).
Explicit but not comprehensive	Some explicit integration (e.g. some specific ecosystem services), including some recognition of ecosystem services and natural capital as underpinning elements of human wellbeing.	Some instruments exist that proactively address/build on the understanding of ecosystem services and natural capita within the policy area.	The existing instruments and measures and implemented, with some procedures in place to support and/or monitor the implementation (as per above).
Implicit and incomprehensive	Implicit and indirect integration, generally focus on preventing negative impacts of a policy sector on ecosystem services and natural capital.	No dedicated instruments exists for directly addressing ecosystem services and natural capital. Some aspects – mainly focusing on avoiding negative impacts on (some) ecosystem services – integrated into sectorial instruments.	The existing indirect instruments and measures are implemented, with procedures in place to support and/or monitor the implementation. The framework for implementation does not, however, explicitly or comprehensively cover ecosystem services or natural capital.
No specific integration	No recognition (direct/indirect) of ecosystem services and natural capital.	No recognition exists that would in any way address ecosystem services and natural capital.	No implementation of any instruments or measures linked to.

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