5 London's environment

Key Findings

- Maintenance of natural capital, those elements of the natural environment which provide goods and services has declined over time. However maintaining natural capital is fundamental to ensuring continued economic development for London.

- Climate change remains a significant risk to the London economy. Although, London's CO_2 emissions have fallen 11 per cent since 1990, global emissions continue to rise rapidly and this presents a risk to both London's economy and environment. However, measures to decarbonise energy supply and improve energy efficiency both locally and globally can generate economic opportunities for London.

- Air quality in London has improved in recent years; London is now compliant for eight out of nine regulated pollutants and ranked 15th out of 36 of the world's biggest cities. However, poor air quality continues to create significant economic costs in the capital – estimated to be equivalent to 140,000 life-years lost, or £3.7 billion.

- London's continued expansion of population and business, as well as the competition for land use, means that the need for infrastructure for waste and recycling, water, and energy supply in London would be expected to grow in the future.

- London ranked 11th overall on the Siemens Green City Index, which compared thirty European cities across eight categories – carbon emissions, energy, buildings, transport, water, waste and land use, air quality and environmental governance. Although city indices may, more generally, have limitations, they do highlight areas where London could improve.

Introduction

The environment is a fundamental part of London's economy, it impacts upon the health and quality of life of Londoners, but it also has an important role in the function of the London economy, as its resources are used by people and businesses to produce and provide goods and services. Therefore, maintaining high environmental standards and developing infrastructure that both meets the needs of London's economy and is resilient to current and future challenges, is essential to ensure London's continued competitiveness.

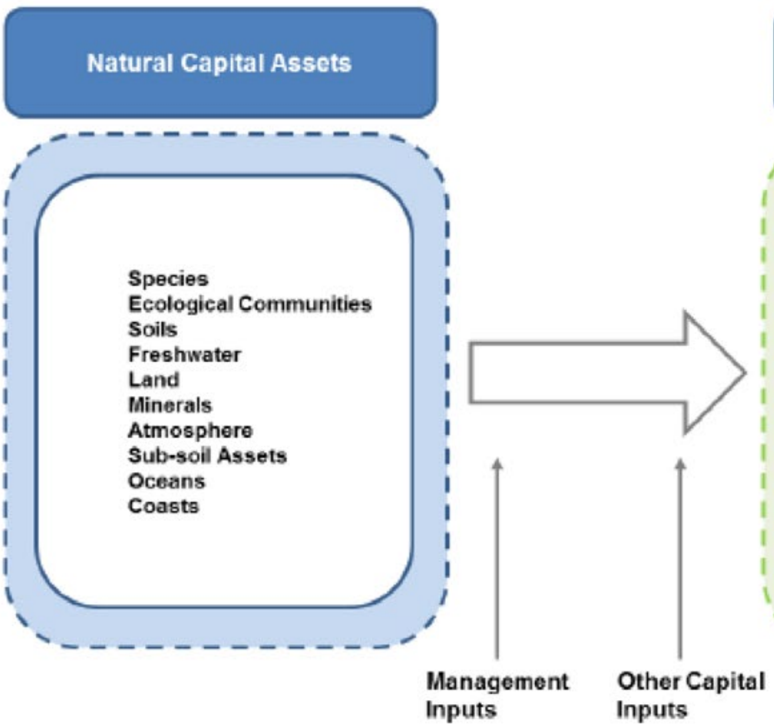
With population projected to grow over the next thirty years, the pressures on resources and the natural environment will continue to expand. Therefore, to maintain and improve quality of life for Londoners, as well as safeguarding economic growth into the future, interventions to protect London's environmental assets will need to be undertaken. Many of the issues explored in this chapter are examples of market failure, typically through negative externalities.

This chapter also introduces the concept of natural capital, which refers to the elements of the natural environment which provide goods and services to people such as clean air, clean water, food and recreation.[1] Through industrialisation, population change and increased demands for goods and services, the stock of natural capital has declined over time, particularly in cities like London, which could prove detrimental for future economic growth. For example, increased incidence of poor air quality impacts on the health of residents, potentially causing costs through lost work, falls in productivity, and increased healthcare costs.

Development of the concept of natural capital has been undertaken by the Natural Capital Committee (NCC), which was established by Government to report to the Economic Affairs Committee.[2] The NCC has produced three reports on the State of Natural Capital exploring the natural capital concept and new valuation, accounting and appraisal methods that can help reveal the real value of the natural environment and the benefits that are provided by environmental assets.[3] For example, by maintaining the atmosphere (the asset) free of pollution, the benefit that is derived from this is clean air, therefore mitigating the negative externalities (and hence costs) associated with poor air quality. The natural capital framework is illustrated in Figure 5.1 below. The NCC has developed a natural capital accounting framework which has been piloted on a number of green infrastructure assets, including the Beam Parklands in Dagenham, East London and through the application of the i-Tree eco methodology to London. These examples are described in more detail later in this chapter, in the section on Green Infrastructure.

In summary, economic benefits can be obtained from better protecting and improving natural capital in order to maintain the existing economic benefits provided and mitigates the potential economic losses from the depletion or degradation of natural capital. Work on the natural capital framework and environmental valuation is still ongoing, with much more scope for further research about how the economic benefits of the environment can be valued and accounted for in public policy decisions.[4]

Figure 5.1: Natural capital assets and type of benefits



Source: Natural Capital Committee[5]

The following sections outline the current state of the environment in London across the environmental issues listed below:

- Climate change
- Air quality
- Noise pollution
- Flood risk and drainage
- Water supply
- Green infrastructure
- Energy use
- Waste and recycling
- London's environmental ranking compared to other global cities.

Each of these sections also discusses the economic costs and risks associated with each of these environmental issues.

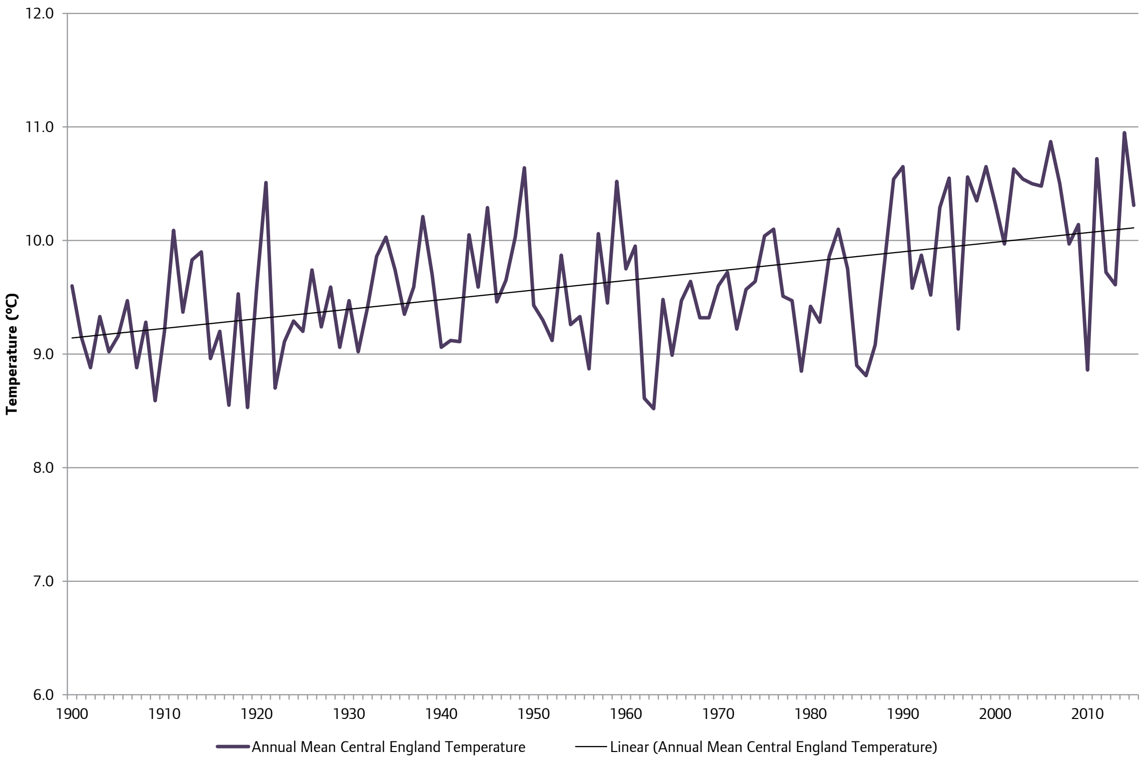
Climate Change

The pre-eminent environmental risk to the global economy, and therefore by extension to the UK and London comes from climate change. This links directly to the concept of natural capital, since many of our natural capital assets are directly impacted by climate change. Within the UK, a major study on the potential impacts of climate change was produced by Lord Stern in 2006, where he summarised that "climate change will affect the basic elements of life for people around the world – access to water, food production, health, and the environment. Hundreds of millions of people could suffer hunger, water shortages and coastal flooding as the world warms". His review estimated that if no action was taken to reduce emissions, greenhouse gas concentrations "could reach double its pre-industrial level as early as 2035, virtually committing us to a global average temperature rise of over two degrees Celsius".[6]

The scale of the potential costs of not mitigating against climate change driven by anthropogenic emissions of greenhouse gases is large. The Stern Review estimated that the overall costs of not acting would be equivalent to 5 per cent of global GDP per year; whereas through acting to reduce greenhouse gas emissions, the costs could be limited to 1 per cent of global GDP a year.

To put climate change in context, the following chart outlines how average temperatures have changed here in the UK. Using historical data from Hadley Centre Central England Temperature (HadCET) dataset, over the course of the last hundred years, temperatures have increased gradually (with the linear trend line showing an increase of just under 1 degree Celsius between 1900 and 2015); and 2014 being the warmest year on record for mean HadCET.[7]

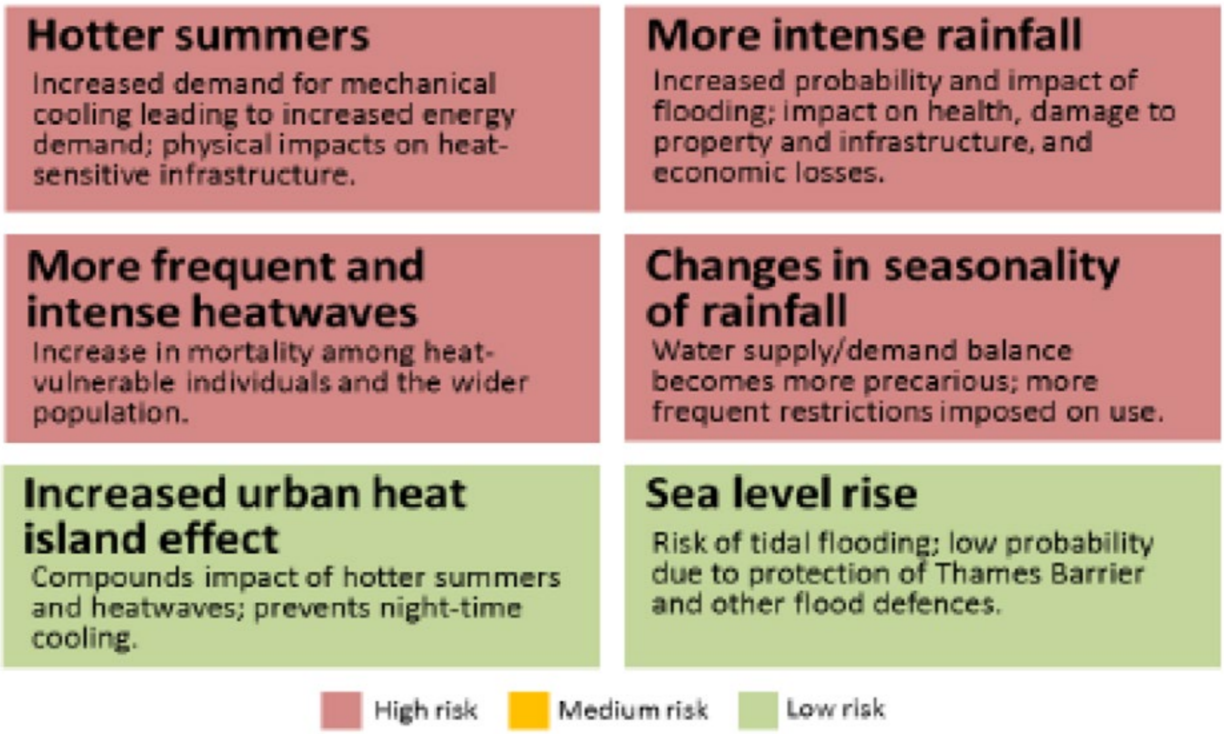
Figure 5.2: Central England Temperature – Mean Annual Data, 1900 – 2015



Source: HadCET, accessed from the Met Office

Analysis from the Carbon Disclosure Project outlined six current and anticipated effects of climate change for London, as outlined in the diagram below:

Figure 5.3: Current and anticipated effects of climate change in London



Source: Carbon Disclosure Project, data provided for the CDP Cities 2013 report, GLA, 2013[8]

Each of these effects could be seen to impact on London's economy in different ways, for example, hotter summers and more frequent and intense heatwaves may act to reduce productivity and economic output as a result of heat-related illness, as well as effects on infrastructure, for example through buckling of train tracks or increased call on electricity and energy supplies for air conditioning. Increased rainfall and sea level rise could lead to a greater risk of flooding or a greater area exposed to flood risk (see Chapter 4). Finally, with increased industrialisation, urban heat effects may create a greater reliance on household energy usage for air conditioning and may reduce people's quality of life.

Opportunities for London

With an increased risk of climate change, there may be opportunities for London's economy to lead in mitigation; for example building upon London's highly skilled workforce to develop specialisation in low-carbon technologies, or building upon its pre-existing specialism for business and professional services (shown by calculations of the Index of Specialisation, given in Chapter 1) by becoming a centre for low carbon finance and building in the development of the green economy. Research undertaken by kMatrix for the GLA estimated that the low carbon and environmental goods and services sector (LCEGS) in London comprised over 10,900 businesses and employed over 192,000 people, with companies in this sector achieving sales of £30.4 billion. Between 2007/08 and 2014/15, sales of companies in the LCEGS sector have grown by 45 per cent.[9]

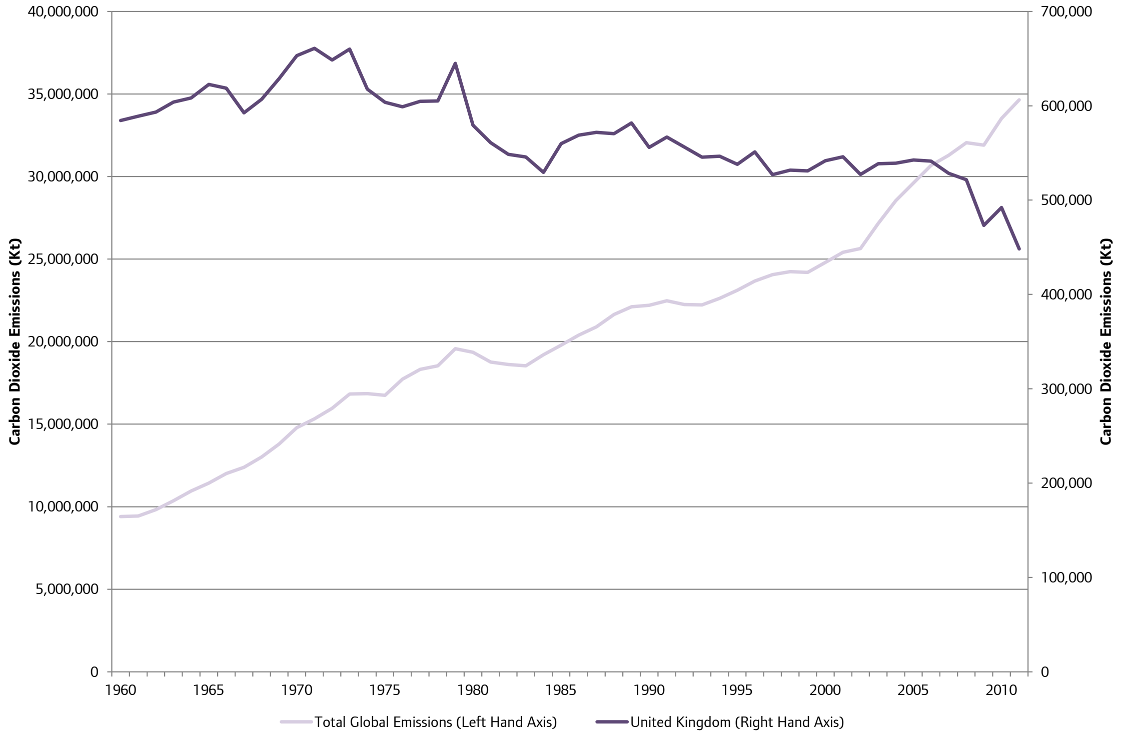
Within low carbon finance, the London Stock Exchange hosts the FTSE Environmental Markets Index Series markets; the FTSE Environment Technology Index has constituent companies with a market cap of $296 billion[10], and the FTSE Environmental Opportunities All-Share has a total market cap of $2.50 trillion.[11] It is however an area in which other global cities have looked to develop specialism in, for example the growth of New York in green finance, and the Tokyo Stock Exchange being the first location to host a market for carbon trading.

However, as was referenced in the Stern Review, "climate change is the greatest market failure the world has ever seen, and it interacts with other market imperfections".[12] The impacts of climate change are therefore intrinsically linked with the notion of natural capital, since there are a number of natural capital assets which could be impacted through climate change, whether it is in the land, ecology or biodiversity.

Carbon Emissions in London

One of the major causes of global climate change has been through industrialisation, particularly over the last century. Data from the World Bank for the last 50 years show that global carbon dioxide emissions have more than trebled, due to the rapid industrialisation of developing economies (as well as for more advanced economies). For the United Kingdom, emissions have largely stayed constant and have fallen in recent times, as shown in Figures 5.4 and 5.5.

Figure 5.4: Comparison of trends in carbon emissions, global and UK emissions



Source: World Bank

Similar to trends for the UK, carbon dioxide emissions in London has been falling in both per capita and absolute terms, as shown in Table 5.1 and Figure 5.5. Between 2005 and 2013, total CO_2 emissions in London fell by 11.6 per cent; with emissions by industry type falling by 9.9 per cent for industry and commercial, 11.4 per cent for domestic, and 15.3 per cent from transport.

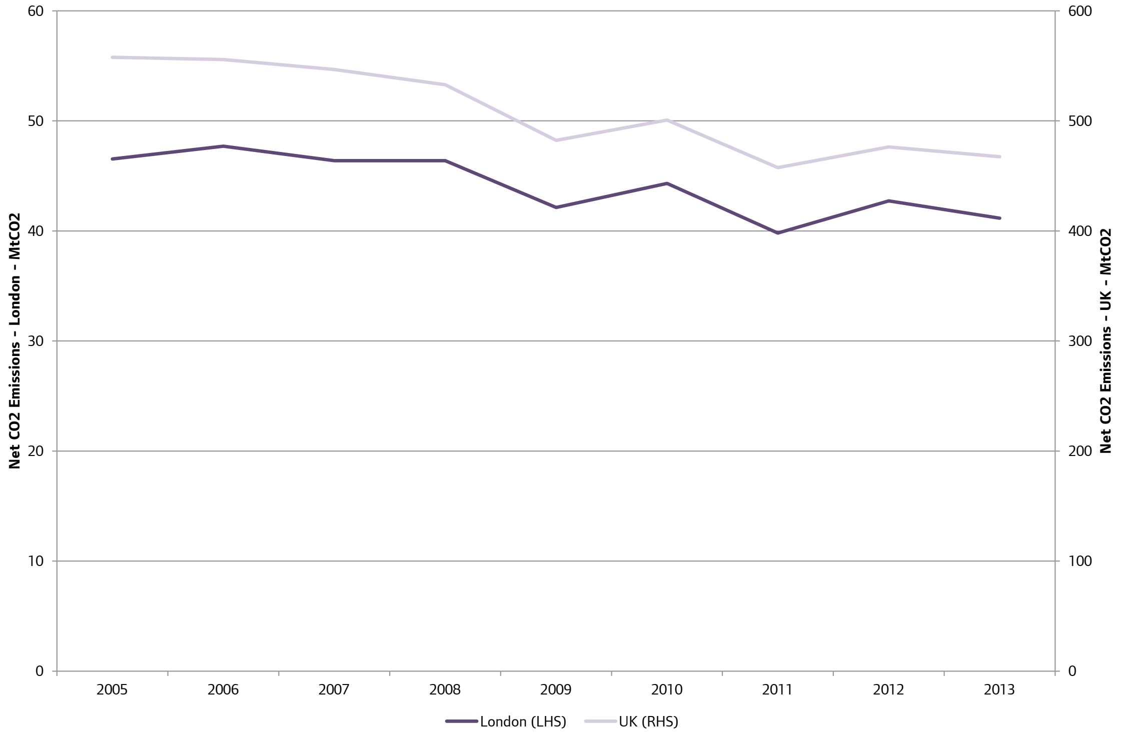
There are a variety of reasons which could explain the falls in carbon dioxide emissions. These include a less carbon intensive national grid; a decline of capital intensive industries (partially shown by employment data in the manufacturing sector); the impact of energy efficiency programmes (both for industrial and residential property); personal choices in energy use (to become more energy efficient so as to guard against rising energy costs); as well as the improvements in the environmental performance of the transport system (through increased take-up of lower emission vehicles, implementation of emissions standards, and increased modal shift, such as to cycling and walking).

Table 5.1: Local CO_2 emissions by industry type, $ktCO_2$, 2005 – 2013

Year	Industry and Commercial	Domestic	Transport	Total	CO_2 per capita estimate
2005	20,332.6	17,142.4	9,016.1	46,538.2	6.2
2006	21,697.0	17,055.4	8,893.2	47,689.3	6.3
2007	20,892.1	16,642.3	8,808.2	46,383.5	6.0
2008	21,162.6	16,845.6	8,332.6	46,378.8	5.9
2009	18,727.1	15,235.6	8,122.3	42,121.4	5.3
2010	19,883.0	16,371.9	8,027.7	44,316.2	5.5
2011	17,630.3	14,331.3	7,819.5	39,812.0	4.9
2012	19,425.5	15,491.4	7,783.5	42,728.3	5.1
2013	18,311.8	15,184.5	7,637.4	41,159.7	4.9
Absolute change 2005 – 2013	-2,020.8	-1,957.9	-1,378.7	-5,378.5	--
Percentage Change	-9.9%	-11.4%	-15.3%	-11.6%	--

Source: DECC. Note: Per capita estimate based on ONS Mid-Year Population estimates

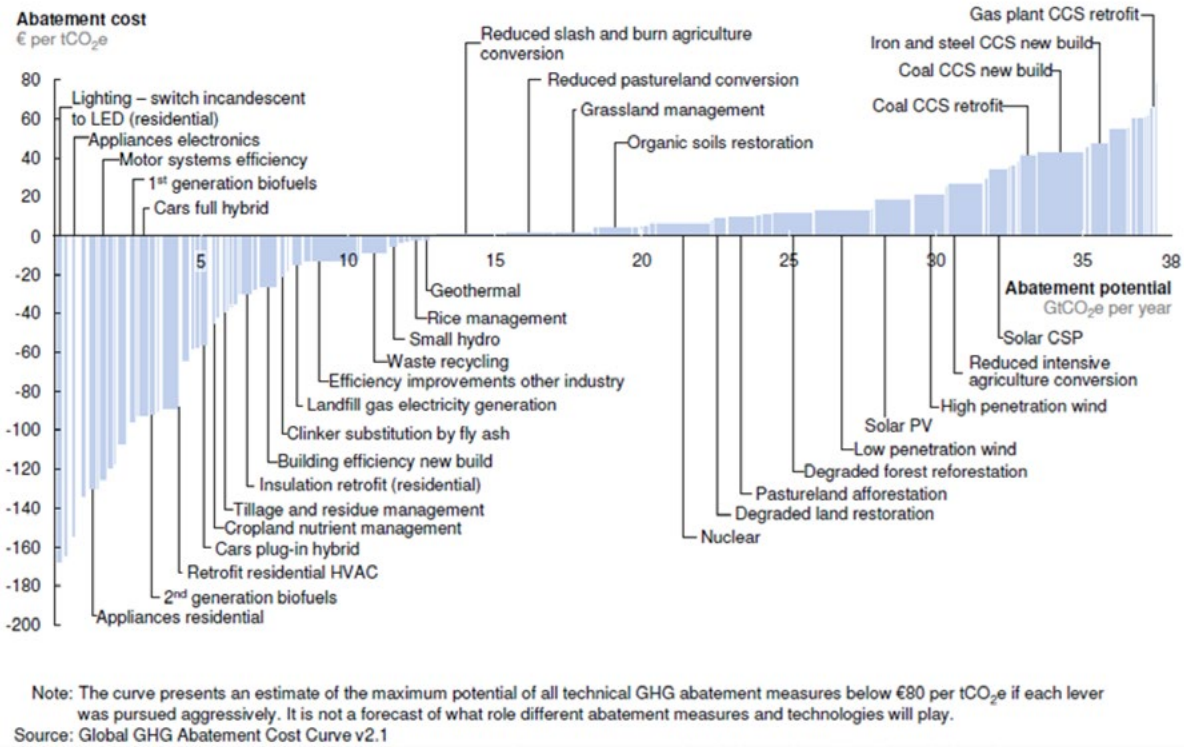
Figure 5.5: Trends in UK and London CO_2 emissions



Source: DECC

Despite trends for reductions in carbon emissions over time, for developed nations to meet carbon reduction targets, a variety of programmes and activities need to take place, each of which will have different capacity to reduce carbon emissions at various level of cost. The diagram in Figure 5.6 outlines the potential capability of measures to contribute towards emission reduction, comparing the abatement potential with the marginal abatement cost per tonne of carbon dioxide equivalent.

Figure 5.6: Global greenhouse gas abatement costs curve beyond business as usual, 2030



Source: McKinsey & Company

Air Quality

Significant improvements in air quality have occurred across the UK in recent decades as a result of interventions to reduce emissions in areas such as industry and transport. For example within London, this has resulted from the implementation of one of the world's largest bus retrofit programmes, vehicle licensing requirements for taxis and a new Low Emission Zone for construction machinery.

According to the European Environment Agency, "air pollution is the top environmental risk factor for premature death in Europe; it increases the incidence of a wide range of diseases and has several environmental impacts, damaging vegetation and ecosystems".[13]

London's air quality has significant implications for the health of Londoners, and by extension, this can impact on the productivity of London's workers and the potential for sustained economic growth. Air quality and wider environmental aspects such as access to green space are also important factors in attracting (and maintaining) people to live in the capital, as shown in a variety of city ranking indices (such as the Siemens Green City Index).

Furthermore, analysis undertaken for the GLA shows populations living in the most deprived areas are on average currently more exposed to poor air quality than those in less deprived areas. 51 per cent of the Local Super Output Areas (i.e. roughly wards) within the most deprived 10 per cent of London have concentrations above the Nitrogen Dioxide (NO_2) EU limit value. This is in contrast to the 10 per cent least deprived areas, which are on average 1 per cent above the NO_2 EU limit value.[14]

Health Impacts

Owing to the large number of variables that influence the health impacts of air pollution, scientific understanding of this complex relationship is continually advancing. For this reason, in 2014 the GLA and TfL commissioned a study by King's College London to better understand the health impacts of air pollution in London based on the latest evidence. For the first time, the study included the health impacts of NO_2 as well as fine particles[15] ($PM_{2.5}$).

The health impacts were estimated for 2010 as this was the latest available 'base' year for the London Atmospheric Emission Inventory and associated air quality modelling[16].

The report estimated that for fine particles, the total mortality burden from long-term exposure was estimated at 52,630 life-years lost, equivalent to 3,537 deaths at typical ages and an estimated 88,113 life years lost for NO_2, equivalent to 5,879 deaths.

Short-term exposure to $PM_{2.5}$ and NO_2 were associated with 1,990 and 420 respiratory hospital admissions respectively, and 740 cardiovascular admissions associated with fine particulates. Within the report it is assumed that there is a 30 per cent overlap between NO_2 and $PM_{2.5}$ emissions, therefore total impacts of poor air pollution are estimated at 140,743 life-years lost, equivalent to 9,416 deaths at typical ages.

Pollution concentrations in London, and therefore the associated health impacts, can be attributed to broad emissions sources. Sources outside London make the largest contribution to the estimated mortality burden from long term exposure to $PM_{2.5}$ in London as a whole, as well as being responsible for the majority of health effects associated with short term exposure to air pollution in London. External sources are responsible for just under half of the mortality burden associated with NO_2. Furthermore, 75 per cent of the cardiovascular hospital admissions associated with $PM_{2.5}$ result from sources outside London. This underlines the importance of coordinated national and European action to directly address sources of pollution and their transboundary effects.[17]

The estimated annual economic costs of the above health impacts for both pollutants ranged from £1.4 billion to £3.7 billion, depending on whether the costs associated with long term exposure to NO_2 were included.

Measured Concentrations

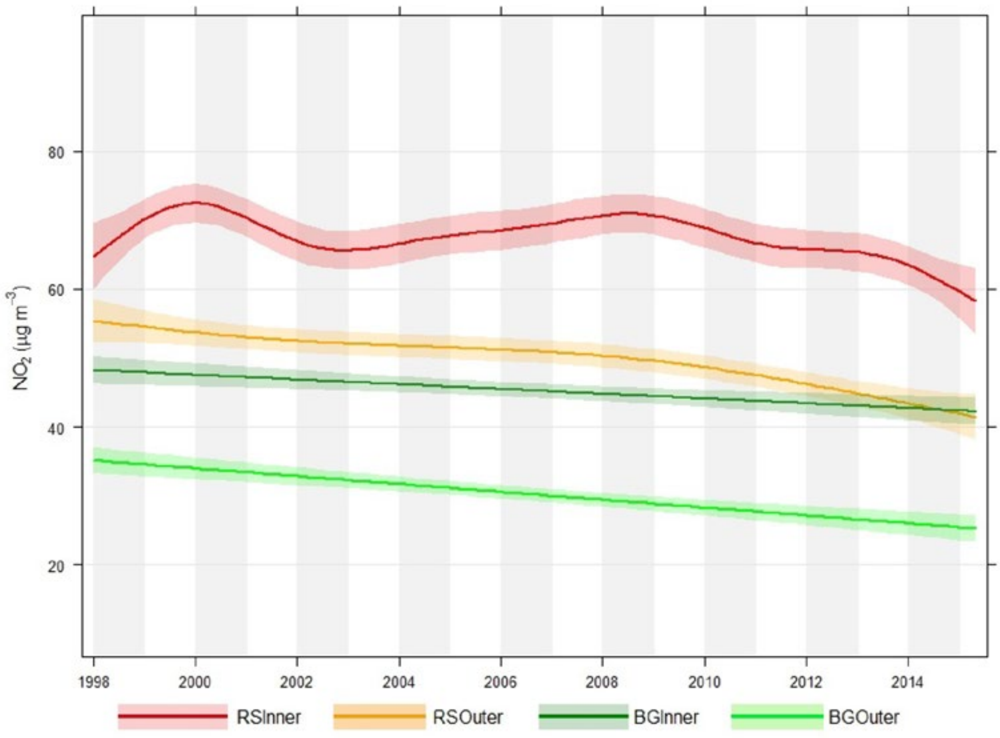
London has a large air quality monitoring network, funded by London boroughs, the GLA, TfL and Heathrow Airport. Many of these sites are part of the London Air Quality Network (LAQN)[18], managed by King's College London's Environmental Research Group.

Figures 5.7 and 5.8 show that overall, there has been a gradual reduction in NO_2 and PM_{10} concentrations at background sites in Inner and Outer London and Outer London roadside sites. Inner London NO_2 roadside sites have a more variable trend but have seen a steeper decline from 2012. This decline is also reflected in the Inner London PM_{10} roadside sites.

This is supported by analysis at most individual monitoring sites, although the dynamic nature of air pollution and the way it is affected by multiple factors (temporary issues like construction activity, weather, local road layouts etc.), means concentrations at some sites can go up while the overall trend across the city is improving.

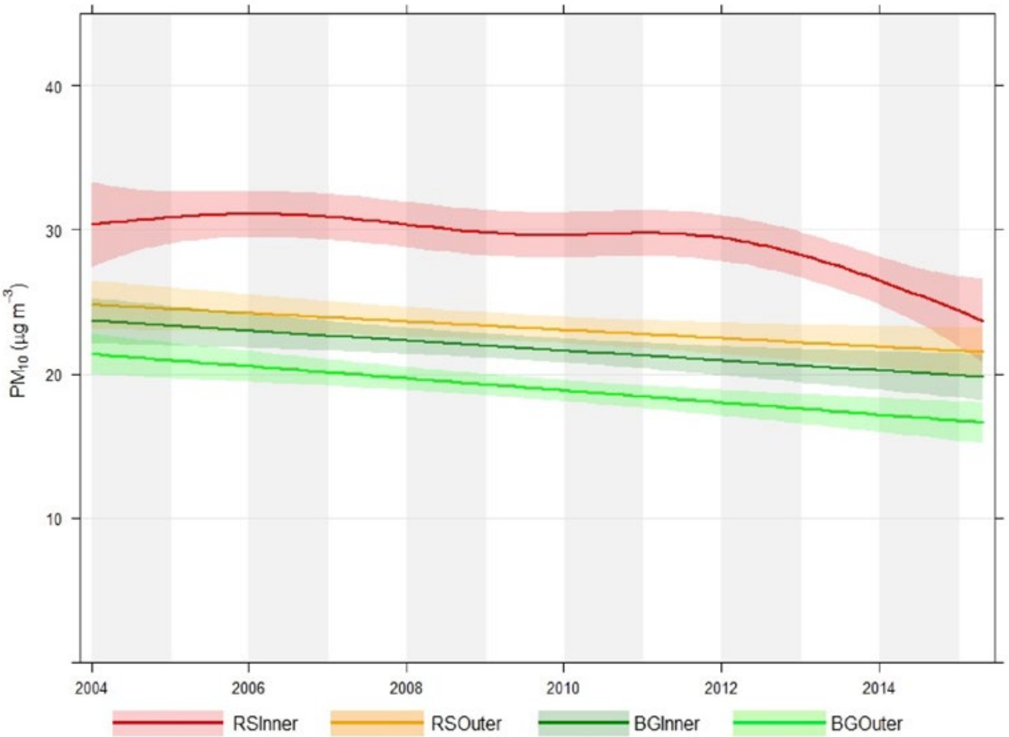
This network gives an opportunity to understand trends in London's air quality. One way to view air quality monitoring data is to group monitors based on their location and distance from the roadside and look at the average concentrations. For example, roadside monitors are within five metres of roads, whilst background sites are away from major sources.

Figure 5.7: Trends in NO_2, 1998 to 2014



Source - the London Air Quality Network and analysis by King's College London (BG = "background", not next to a road. RS = "Roadside" and "Inner" and "Outer", refer to Iinner and Outer London).

Figure 5.8: Trends in PM_{10}, 2004 to 2014[19]



Source - the London Air Quality Network and analysis by King's College London. (BG = "background", not next to a road. RS = "Roadside" and "Inner" and "Outer", refer to Inner and Outer London).

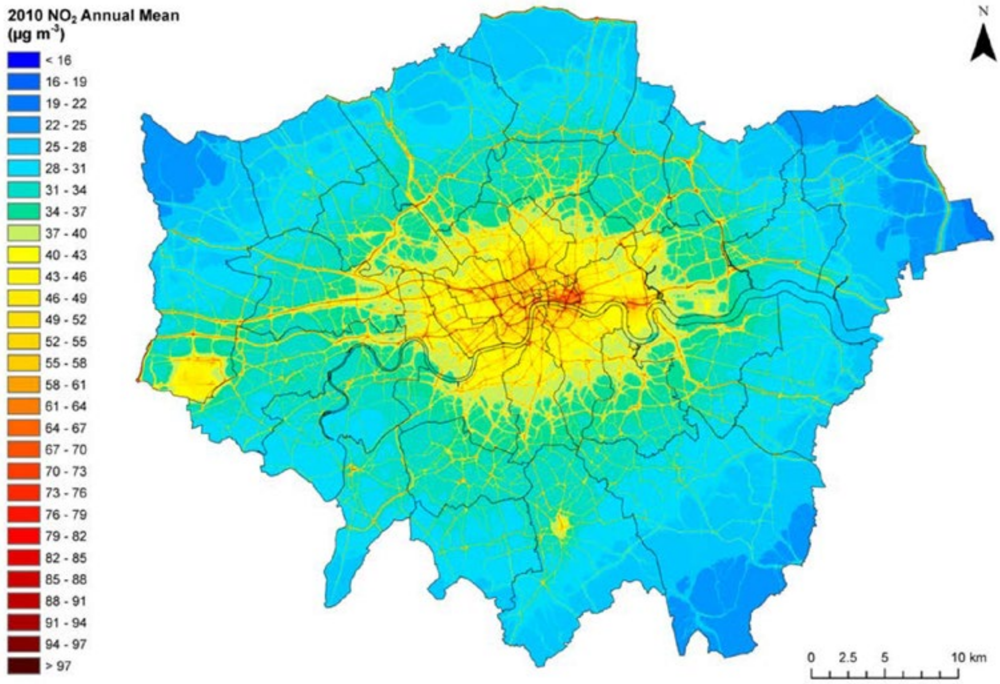
These averages do not however reflect the variability between individual site characteristics and trends. They do reflect all pollution sources experienced at a monitoring site and not just locally emitted pollution or road based pollution specifically.

Pollutant concentrations in London are affected by emissions in London, pollution from outside London and the UK, and other factors such as weather. Using sophisticated statistical models it is possible to 'remove' the weather effect from trends in concentrations of the main pollutants monitored at sites in the LAQN. This allows for the production of trends where the impact of variable weather conditions is reduced. This analysis was conducted by the Environmental Research Group at King's College and has shown the following trends from 2008 to 2013:

- NO_x roadside sites show a downward trend of 1.25 per cent per year, equating to a total reduction over the six year period of 7.5 per cent
- NO_2 roadside sites show a downward trend of 2.1 per cent per year, equating to a total reduction over the six year period of 12.6 per cent.
- PM_{10} roadside sites show a downward trend of 1.4 per cent per year, equating to a total reduction over the six year period of 8.4 per cent
- PM_{10} background sites a downward trend of 0.65 per cent per year, equating to a total reduction over the six year period of 3.9 per cent
- $PM_{2.5}$ roadside and background sites show a downward trend of 2.2 per cent per year equating to a total reduction over the six year period of 13.2 per cent.
- Black Carbon[20] (only monitored at three sites) has shown small decreases but these are not considered statistically significant.

While the picture at the London level shows that air quality has improved, incidence of poorer air quality is observed where there is a greater agglomeration of business activity and transport links. The following chart shows how air quality gets relatively poorer in areas closer to the centre of the city.

Map 5.1: NO_2 annual mean concentrations (mg/m³) for the year 2010



Source: Cleaner Air for London

These data also highlight significant variations in pollution at certain times of the day. As would be expected, air quality is generally poorer in the rush hour periods and this may have significant impacts to certain groups, whether it is children walking to school or commuters going to work. Together, Map 5.1 and Figures 5.9 – 5.10 highlight the highly spatial and temporal nature of air quality in London.

Figure 5.9: Average NO_2 pollution by hour, London mean roadside and background, August 2015

Source: GLA Economics calculations; King's College London data (accessed at London Datastore)

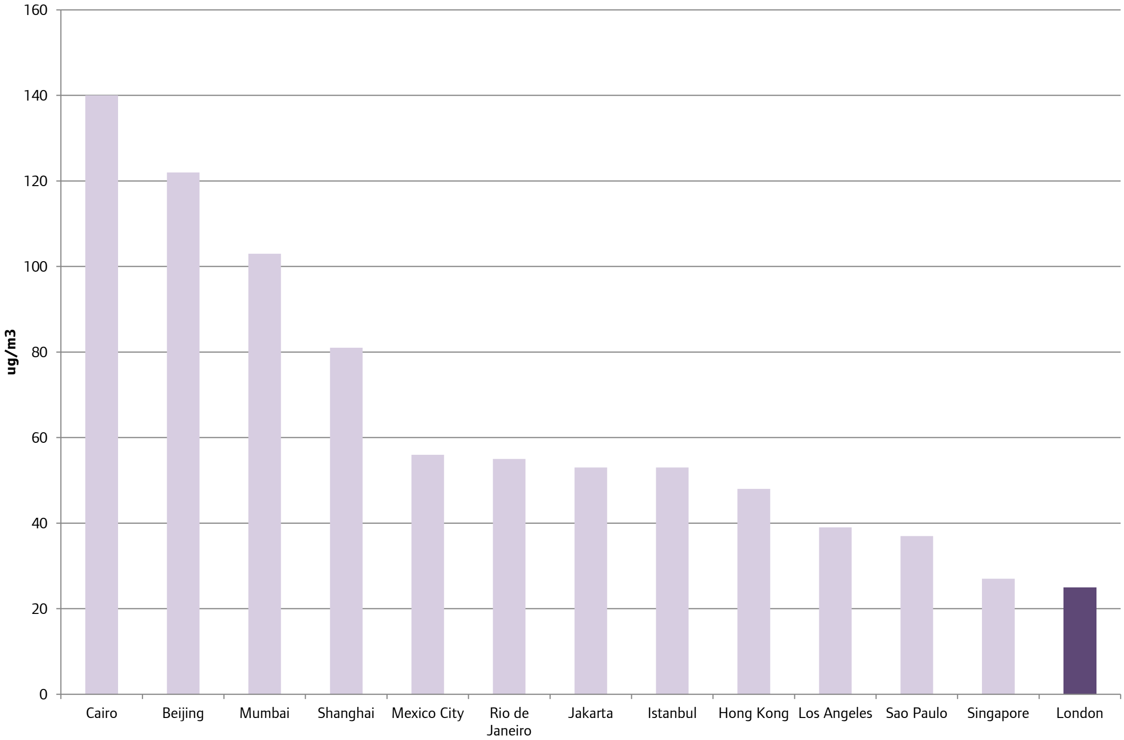
Figure 5.10: Average PM_{10} pollution by hour, London mean roadside and background, August 2015

Source: GLA Economics calculations; King's College London data (accessed at London Datastore)

Looking forward, there are two offsetting effects which could impact on the environmental, medical and economic effects of air quality in London. While emission standards are more stringent, through implementation of standards such as Euro V and Euro VI[21]; population increase and increased business activity may mean that congestion on London's roads could increase. Lower road speeds are associated with higher levels of pollution at traffic hotspots, which could create areas of comparatively poorer air quality.

Despite the UK being at risk of penalty from the European Commission due to poor air quality[22], London's air quality performs comparatively well compared to other major cities. Data compiled by AMEC Environment & Infrastructure shows that London's air quality is comparatively much better than many non-EU cities, with many of the cities shown in Figure 5.11 being within emerging economies.

Figure 5.11: Five year annual averages, PM_{10} pollution, 2008 – 2012, London compared to non-EU cities



Source: AMEC Environment & Infrastructure

Compared to other cities, London's air quality is similar to that of other major non-EU global cities, but does not approach the top of the rankings, as is shown in Table 5.2. This index developed by AMEC Environment & Infrastructure, for the GLA, has two elements; a traffic focussed index which prioritises the two main pollutants related to traffic, those being NO_2 and PM_{10}; and a health impacts index, which gives a higher priority to particulate emissions due to the severity of impacts from particulates compared to other pollutants. The combination of these two elements is known as the Citywide index.

Within the two components of this ranking, London performs worse on the traffic focussed index (placing 17th out of 36 cities), but performs better on health impacts (9th out of 36). The rankings shown in Table 5.2 are presented as an average of five years (2008 – 2012); for each individual year, London's position has held relatively constant, reaching a high of 12th position in 2012, but placed 17th in both 2010 and 2011.[23]

It should be mentioned that most of the cities which place above London in this ranking tend to be smaller populations and urban areas. When considering London against other major global cities of its size, London's air quality is assessed as poorer than Singapore and Paris, but better than New York, Hong Kong and Shanghai; as shown in Table 5.2.

Table 5.2: Citywide Index, five year average 2008-2012

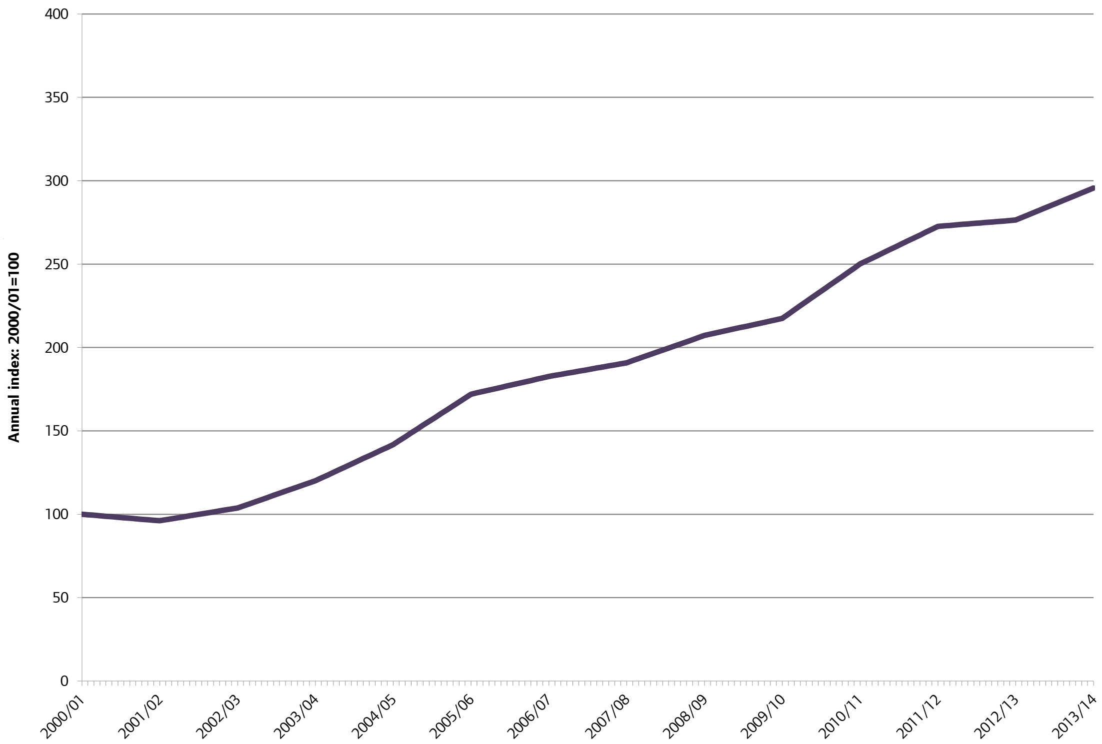
Position	City
1	Vancouver
2	Sydney
3	Stockholm
4	Vienna
5	Berlin
8	Singapore
12	Paris
15	London
17	New York
30	Hong Kong
34 (of 36)	Shanghai

Source: AMEC Environment & Infrastructure

Cycling in London

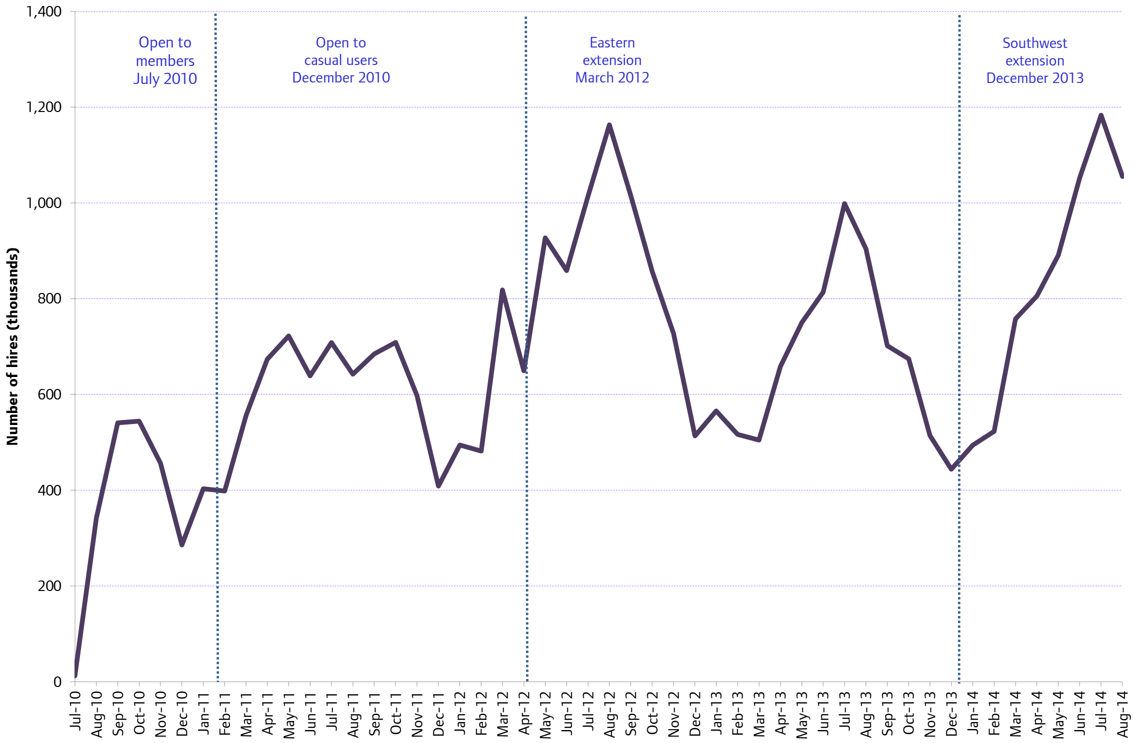
A feature of transport in the capital over the last decade has been the growth in cycling. Data for the TfL Road Network (which includes major roads) has found that between 2000/01 and 2013/14, cycling grew by 196 per cent[24]. Figure 5.12 shows the annual index of cycling trips undertaken on the road network. The Cycle Hire programme has contributed to this growth (Figure 5.13), what is unclear though is whether there have been shifts away from car usage to cycling, therefore improvements in air quality may not be as a result of this, rather reduced congestion and increased road speeds may contribute to improved environmental quality.

Figure 5.12: Annual index of cycle journeys on the Transport for London road network



Source: Travel in London report; TfL Surface Transport

Figure 5.13: Trend in monthly cycle hires, Cycle Hire Scheme



Source: Travel in London, TfL

Impacts of noise

Noise can directly impact on people's quality of life and wellbeing, and by extension impact on productivity, the natural environment, and the attractiveness of a location to live and work. The analysis of the impacts of noise is particularly relevant in light of potential airport expansion in the South East.

Analysis undertaken by Defra on the impacts of noise on sleep disturbance, annoyance, hypertension and productivity looked to value each of these areas in turn, as well as providing a review of available literature on the topic. The most prominent of these was on sleep disturbance. The World Health Organisation estimated that across Western Europe, prevailing levels of noise cost between 1.0 and 1.6 million disability-adjusted life years lost each year.[25] Using Department of Health estimates, the social cost would therefore be between £60 billion and £100 billion per year across Western Europe[26]. Sleep disturbance was the single biggest health impact (at 903,000 life years), followed by annoyance (654,000) and much smaller impacts on ischaemic heart disease, cognitive impairment of children, and tinnitus.[27]

Data from Defra shows the number of people in London exposed to noise levels beyond 55dB, through to greater than 75dB; by roadside, railway and for industry; and these data are shown in Table 5.3.

Table 5.3: Number of people exposed to roadside, railway and industrial noise above thresholds, Greater London, 2011

Type	>55dB	>65dB	>75dB
Roadside	2,378,200	1,027,200	99,200
Railway	525,200	158,100	15,200
Industrial	23,600	7,500	3,000

Type	>50dB	>60dB	>70dB
Roadside – Night	1,665,400	649,400	900
Railway – Night	388,700	95,100	6,400
Industrial - Night	20,500	6,700	2,700

Source: Defra

Aviation noise also affects many people in London. A 2013 report from TfL noted that 766,100 people lived within the ≥ 55 Lden[28] contour of Heathrow[29], and at least another 17,800 people[30] living within the ≥ 55 Lden contour of London city airport. This indicates that aviation noise is a significant environmental issue in London, particularly in light of the proposed expansion of Heathrow, which according to TfL could increase the noise exposure impact in London by £300 million per year (or £6.2 billion between 2030 – 2050) after accounting for annoyance, health and productivity impacts.

Water

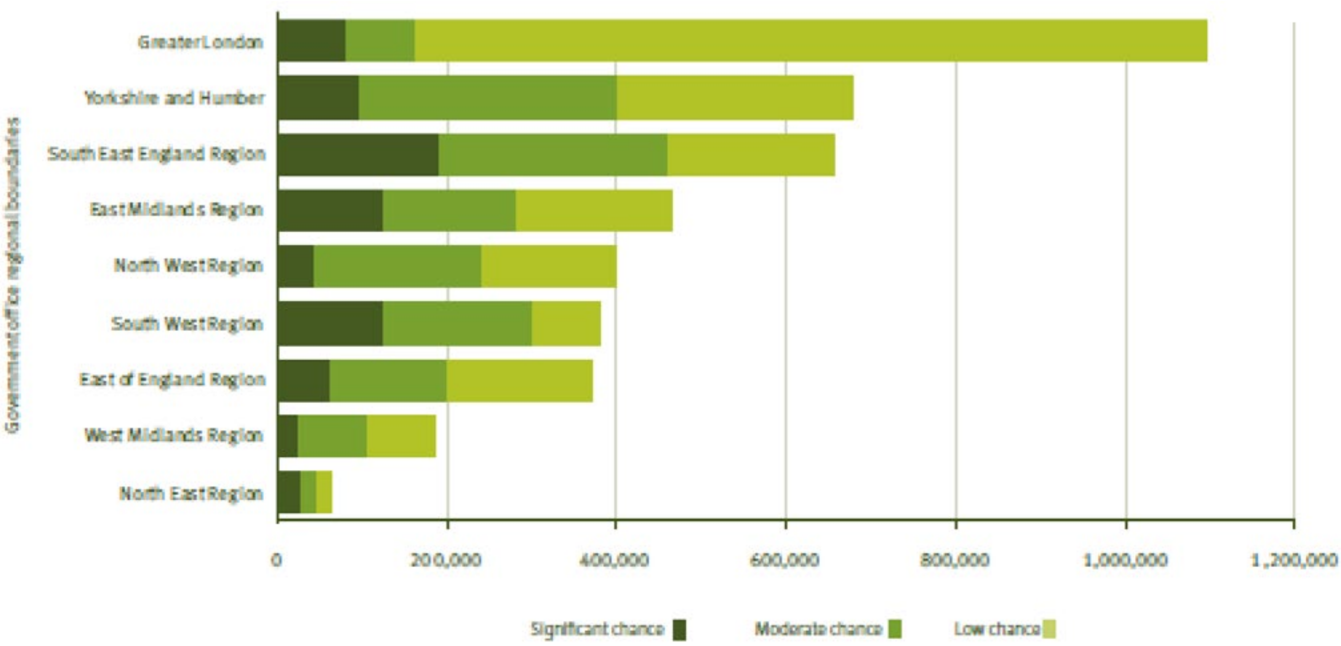
Water is a fundamental part of the natural environment; it services households and industry through consumption and sewerage. Due to London's geographic location, the Thames has played an important part in the development of the capital as a centre for trade, through the import and export of goods and services.

Flood Risk and Drainage

16 per cent of London's land area is within a floodplain and further areas are at risk of surface water flooding. Well over a million people are in these floodplains, although for the majority, the risks are actually low – see figure 5.14. However, as a city close to sea level, it is vulnerable to many of the negative impacts of climate change. In particular, sea level rise, and increased expectations of more intense rainfall mean that the capital faces an increased risk of flooding. To address this risk, the Thames tidal flood defences protect over £200 billion of property from tidal flood risk and the Environment Agency is progressing with the Thames Estuary 2100 project that will ensure this protection is maintained through the rest of the century.

The understanding of the risk of surface water flood risk has improved greatly over the past 5 years through the Drain London project and updated Environment Agency risk mapping. Each of London's 33 Lead Local Flood Authorities are now exploring ways to manage and reduce surface water flood risk.

Figure 5.14: Numbers of people living in a floodplain by region



Source: NaFRA; Environment Agency

Water Supply

The South East of England is classified by the Environment Agency as being in "serious" water stress. This means that in an average year more water is abstracted from the environment to meet our demands than is sustainable in the long term, meaning that more water is abstracted from the environment to meet our demands than is sustainable in the long term. Many water companies in the South East have been set 'sustainability reduction targets' by the Environment Agency to reduce the amount of water they take from the environment. These, together with climate change and population growth, have led Thames Water to estimate that by 2050, without further action, London's demand for water will exceed the available sustainable supply by 522 million litres per day by 2050. Thames Water is therefore working to identify and assess the resilience of long-term water resource options to meet London's growing demand whilst at the same time being affordable and sustainable. These options include a new reservoir near Oxford, bringing water via canal from the River Severn, effluent reuse (treatment of water from sewage treatment works) and further desalination.

Most of London's water companies have also committed to reduce demand for water through:

- Installing smart meters to incentivise households to be more water efficient (Thames Water plan to install 900,000 meters over the next 5 years)
- Retrofitting homes to become more water efficient
- Using the new metering capability to better detect leaks
- Investigating 'smart' tariffs to further incentivise water efficiency when water resources are low.

Sewerage

London's sewerage system has been developed over the past 150 years. The recent completion of the £650 million Lee Tunnel in East London should prevent sewer overflows into the River Lee near Stratford. This will be complemented by the £4 billion Thames Tideway Tunnel which is due to be complete in 2023. Together these two projects alongside major upgrades at London's sewage treatment works that are either on-going or complete should mean that London's sewerage system can help to reduce pollution in London's waterways.

Green Infrastructure

What is Green Infrastructure?
Green infrastructure is the network of green spaces (as well as features such as street trees and green roofs) that is planned, designed and managed to deliver a range of benefits, including: ● healthy living; ● mitigating flooding; ● improving air and water quality; ● cooling the urban environment; ● encouraging walking and cycling; and ● enhancing biodiversity and ecological resilience.

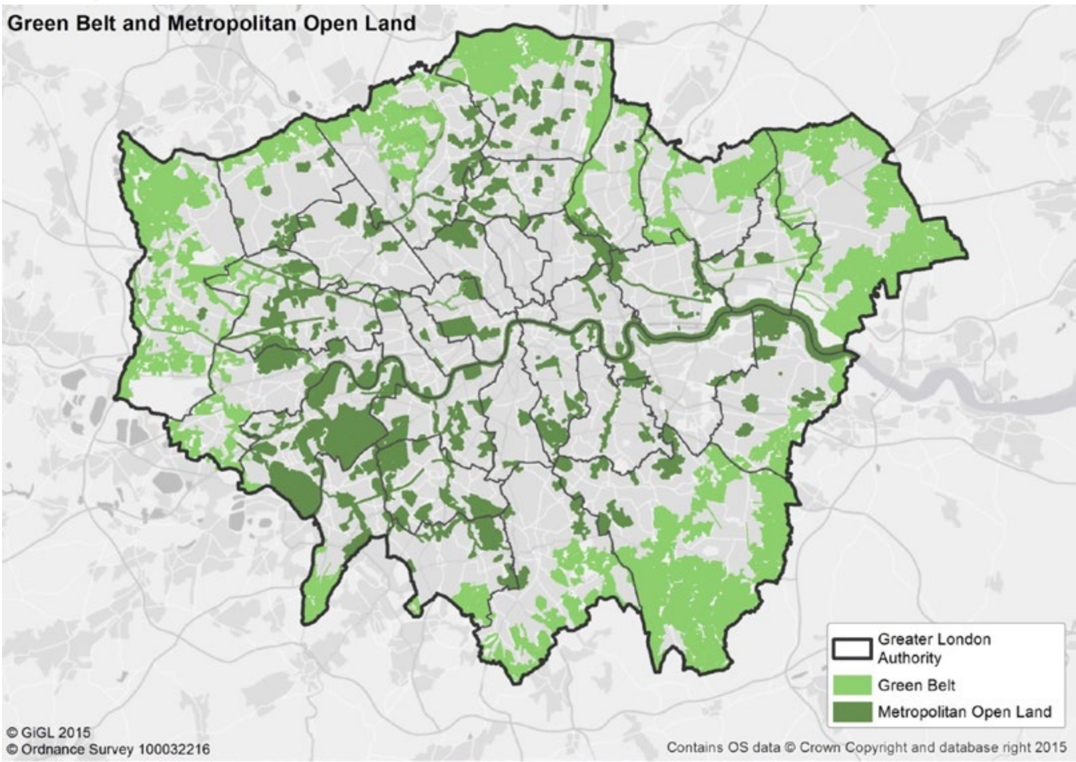
London is already a green city, with over 47 per cent of its total area classified as green or blue, and has over 8 million trees. As set out by the NCC, green infrastructure is an integral part of the urban environment upon which the prosperity and viability of the city depends.

Better valuing the services and benefits provided by green infrastructure is necessary so that these are properly accounted for when deciding, for example, how to enhance resilience or improve public health.

The economic benefits are wide ranging. A study undertaken by Natural England estimated that the savings to the NHS through having increased access to green space for every household in England equated to £2.1 billion per annum. Access to green space has considerable distributional effects for households and land owners, with previous analysis from GLA Economics modelling that house prices within 600 metres of a regional or metropolitan park were between 1.9 per cent and 2.9 per cent higher[31].

Within an environmental context, the scale of economic impacts is potentially much higher. The Natural Capital account for Beam Valley Parklands, for example, indicate that this space (which has been designed to provide flood storage in addition to a healthy space for play and recreation) has a net natural capital asset value of approximately £42 million in present value terms, and it provides £591,000 per annum in flood prevention benefits and £770,000 per annum in community benefits largely related to improved health and well-being[32].

Map 5.2: Green spaces in London



Source: GLA Intelligence Unit. Note: This map only includes Green Belt and Metropolitan Open Land, not all green spaces in London.

Programmes of planting trees in urban areas have been undertaken to provide a range of both environmental and wellbeing benefits. These include aesthetic improvements to areas and these becoming a focal point for residents; but they can also act as a means of carbon storage, improve biodiversity, help to reduce localised flooding, and potentially enable reductions in energy usage through helping to cool areas in the summer and provide insulation in the winter. The London i-Tree Eco assessment has looked to provide monetised costs for the environmental benefits and replacement costs of trees currently in the Capital; estimating that London's urban forest provides total benefits of £132.7 million per annum.[33]

Energy Use

The UK is a net importer of gas and other fuels making London's energy supply reliant upon international energy supplies and markets. Over the last decade energy usage in London has fallen; between 2005 and 2013, total energy consumption in London fell by 15.5 per cent, as shown in Figure 5.15. Table 5.4 shows this decrease in energy consumption was consistent across the domestic, commercial and transport sectors

London comprises around 8.9 per cent of the UK's total energy consumption, which is considerably smaller than London's proportion of the UK population[34] (13.2 per cent) and of economic output (22.5 per cent); this is partially explained by density of London, with per capita energy consumption being lower in urban areas.

London's energy system is changing with an increasing demand for electricity and an increasing demand in the Central Activities Zone and during peak times. Currently, higher levels of development and recent increases in London's population are putting more pressure on an already stressed distribution network (40 per cent of London's electricity substations are already under stress). This is resulting in isolated incidents of demand exceeding supply (witnessed by blackouts in the West End for example). It is estimated that the electricity investment requirement to meet short term new demand is £210 million over eight to nine substations. The alternative to capital investments is to explore further the role of demand side management and load shifting.[35]

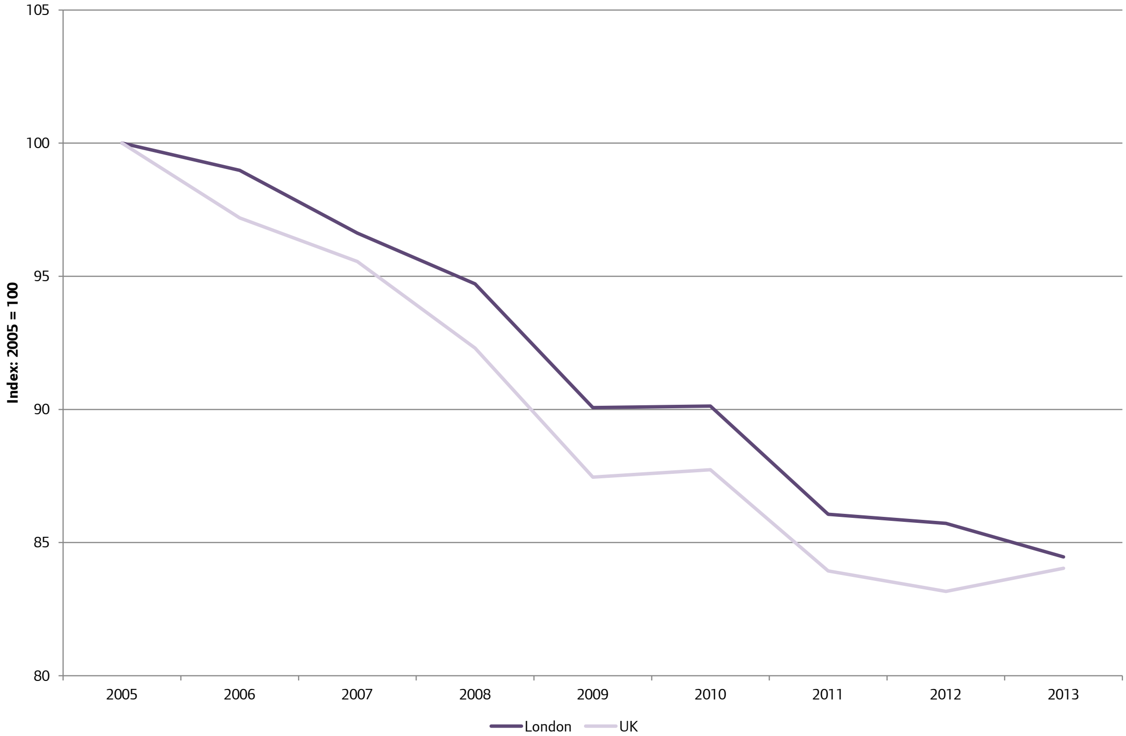
With London's population estimated to increase by around 3 million people, and add an additional 1.6 million homes by 2050, London's need for energy may increase – an expected 20 per cent increase in demand[36].

Table 5.4: Total sub-national energy consumption, London, by consuming sector, GWh

Year	Industry and Commercial	Domestic	Transport	All Fuels Consumption
2009	52,457.5	58,621.1	29,663.4	140,893.6
2010	53,336.8	58,504.6	28,963.7	140,992.2
2011	50,472.4	55,752.0	28,098.5	134,627.0
2012	50,980.5	55,234.2	27,590.8	134,091.7
2013	50,121.5	54,436.7	27,249.0	132,124.6
Absolute change 2009 – 2013	-2,336.0	-4,184.4	-2,414.4	-8,769.0
Percentage change	-4.5%	-7.1%	-8.1%	-6.2%

Source: DECC. Note: Totals do not add due to the exclusion of bioenergy and waste.

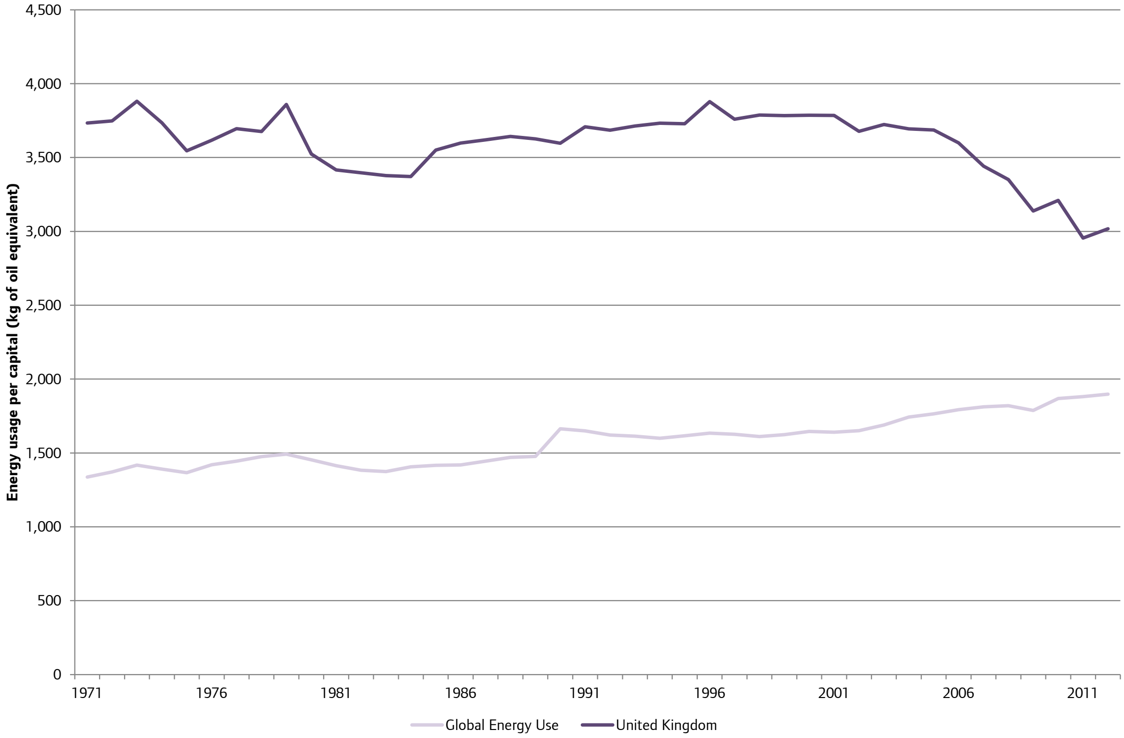
Figure 5.15: Trends in UK and London energy consumption



Source: DECC

In a similar way to carbon dioxide emissions, energy emissions per capita for the United Kingdom have fallen. In contrast, there has been an increase in energy emissions per capita globally, as a result of globalisation and industrialisation. The following chart shows the trends over the last forty years:

Figure 5.16: Energy usage per capita



Source: World Bank

Waste and Recycling

As a major population centre, London produces a significant quantity of household waste. In addition, as a centre for business, the Capital also produces a large quantity of commercial waste, all of which needs to either be serviced in the capital, or exported elsewhere. As London comprises 13.2 per cent of the total UK population and 22.5 per cent of total economic output, it follows that the capital will produce a significant proportion of the total waste generated in the UK.

How London produces and services waste has significant implications for London's natural environment. Resources (such as land, water etc.) are used in the production of goods and services, therefore consideration needs to be given in the how industrial activity impacts upon London's natural capital. A growing population and increased business activity also has implications in where waste remediation and recycling activity can take place in the capital, especially in the context of the competition and cost of land (as highlighted in Chapter 2). It may be increasingly common for London's waste to be transported further towards the periphery of the capital or even outside. The implications of this include increased emissions related to the transport of waste via greater distances.

In this regard, there are opportunities for London to change how it treats waste, reducing the scale of waste going to landfill (therefore depleting London's natural capital), and encouraging other uses of materials. One particular example where London's economy can adapt to changes in land use, business activity and the future needs of London's population is through the movement towards a more circular economy. A circular economy is one that keeps products, components and materials at their highest use and value at all times. It is an alternative to the current linear economy where we take make, use and dispose of product, components and materials. A circular economy can stimulate innovation in areas like product design, re-use and remanufacturing facilities, business models as well as new forms of finance. In this scenario, the implications are a reduced demand for landfill, an increased demand repair, re-use, re manufacturing and recycling (and hence infrastructure). Analysis undertaken by WRAP for the London Sustainable Development Commission, the London Waste and Recycling Board, and the GLA[37], estimates that total employment in the circular economy was 46,700 in 2013. Modelling from GLA Economics estimates that the total GVA in the circular economy would be approximately £2.8 billion in 2013.[38]

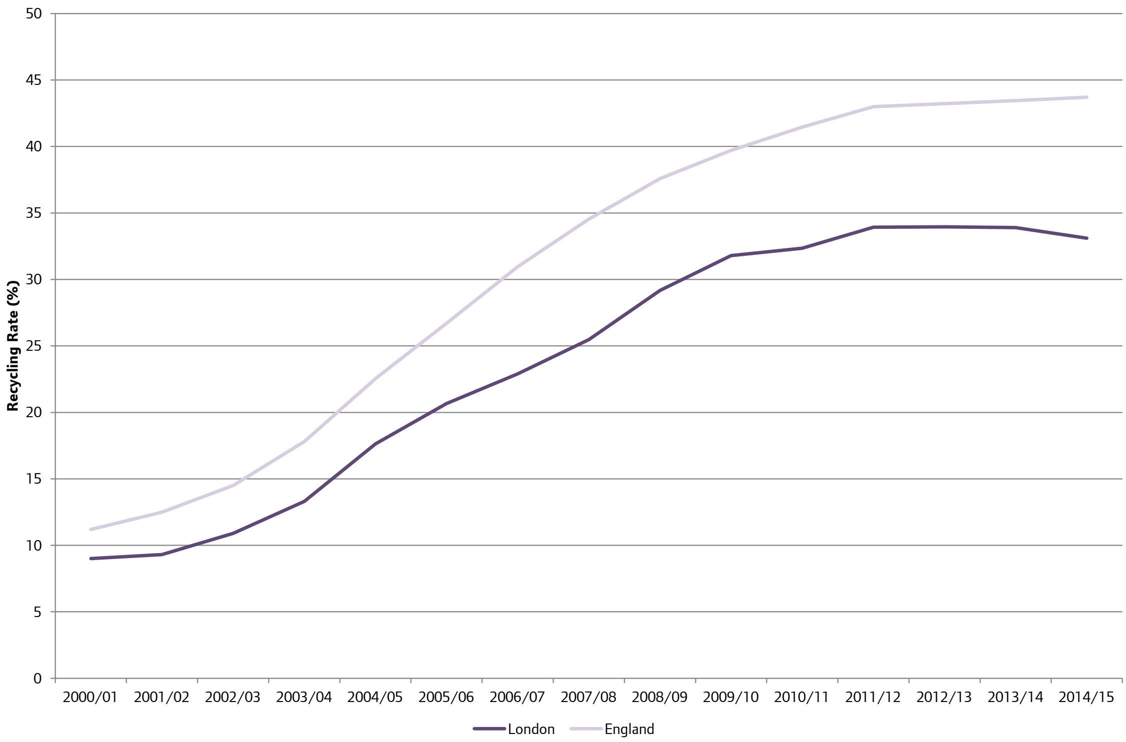
Data on household waste are widely available from Defra, however data on commercial waste are not as complete at the regional level; therefore only household waste statistics are provided. For context, it is estimated that 47.6 million tonnes of commercial and industrial waste were generated in the UK in 2012; it would not be unreasonable to assert that London would account for at least its population share of total commercial waste.[39]

Data on local authority controlled waste is reported to Defra, verified and published annually. However data on commercial waste is not collected in the same way and therefore for the purposes of modelling and plan making, Defra survey data collected at a London level is used and the latest projections can be found in the London Plan. In 2013, it is estimated that London produced 4.7 million tonnes of commercial and industrial waste accounting for about 32 percent of London's total waste. It is estimated that London produces 7.2 million tonnes of construction, demolition and excavation waste each year equating to 48 percent of all waste arisings.

Data for 2014/15 shows that 3.66 million tonnes of waste were collected by local authorities in London (about 20 per cent of total waste arising). However total household waste has fallen by 18.2 per cent in London since 2000/01, and despite a growth in population, total waste arisings have, year-on-year, generally remained largely steady or declined. However, when waste arisings per head are considered, there has been a steady decline over time. A downward trend is expected to continue due to a mixture of light weighting of goods and packaging, and increased numbers living in houses in multiple occupation.[40]

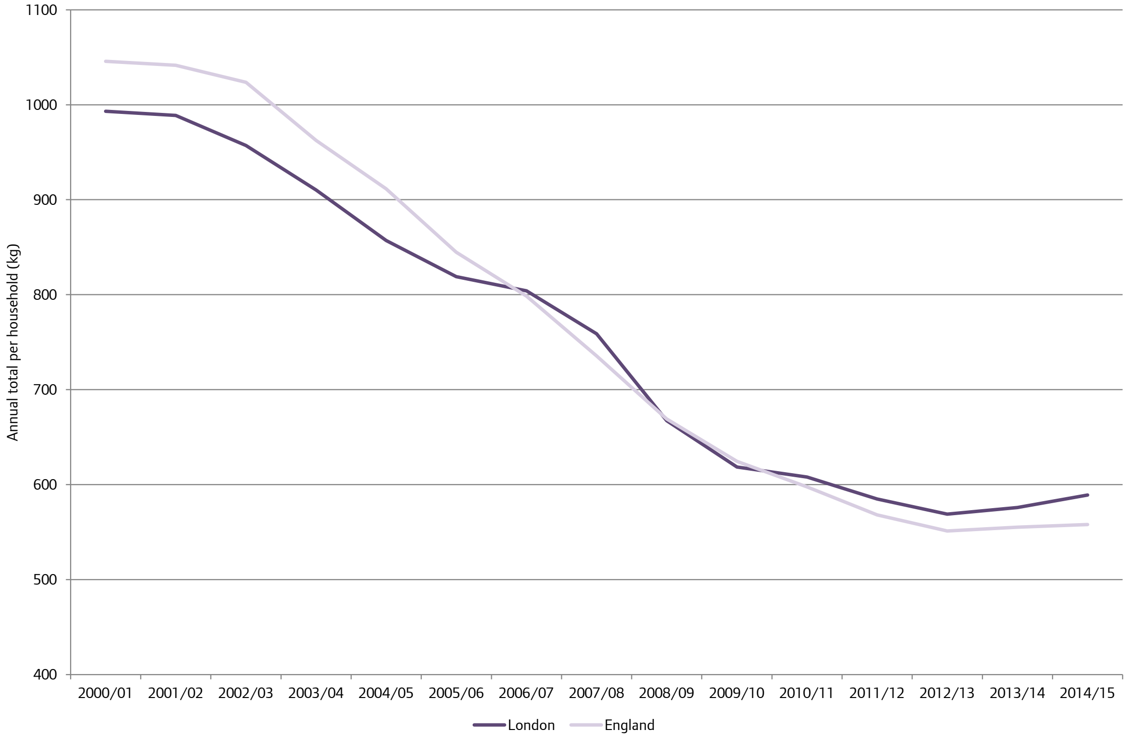
Data shows that London typically lags behind other regions in the proportions of household waste sent to recycling; in 2014/15, household recycling rates were just over ten percentage points lower than the average for England as a whole. At the same time though, London has higher than average levels of household waste per household – but the lowest levels of household waste generated per person; measures to encourage households to reduce waste levels have shown impact, with average household annual waste falling by 42 per cent since 2000/01.

Figure 5.17: Household recycling rates in London and England as a whole; 2000/01 – 2014/15



Source: Defra

Figure 5.18: Annual household waste totals per household



Source: Defra

With increasing trends in recycling, there has been a decreasing trend in the amount of waste sent to landfill, which has important implications for London and its infrastructure. Table 5.5 shows the trends of household recycling, household waste and waste sent to landfill over the last six financial years:

Table 5.5: Data on household waste indicators, London

	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15
Household Recycling Rate	31.8%	32.4%	33.9%	34.0%	33.9%	33.1%
Percentage of local authority waste sent to landfill	48.7%	44.7%	30.6%	25.5%	24.4%	20.6%
Residual household waste per household	618kg	608kg	585kg	569kg	576kg	589kg

Source: Defra

London's position in the global context

The Siemens Green City Index compared thirty European cities across eight categories – carbon emissions, energy, buildings, transport, water, waste and land use, air quality and environmental governance – based upon quantitative data and as well as subjective assessment of a city's aspirations for greening their city. A limitation of this index is that the reference date is 2009, therefore many cities will have progressed in that time, but it gives an indication of how London performs comparatively against other cities.

Overall, London ranked 11th, but across the indicators, the capital varied between 8th and 16th, providing an indication that improvement could be made across a wide range of areas, as shown in the following table:

Table 5.6: London's position within Siemens Green City Index indicators

Category	London's ranking	Leading city	Second city	Third city
CO_2	10th	Oslo	Stockholm	Zurich
Energy	10th	Oslo	Copenhagen	Vienna
Buildings	10th	Berlin, Stockholm (equal 1st)		Oslo
Transport	16th	Stockholm	Amsterdam	Copenhagen
Water	8th	Amsterdam	Vienna	Berlin
Waste and land use	11th	Amsterdam	Zurich	Helsinki
Air quality	12th	Vilnius	Stockholm	Helsinki
Environmental governance	15th	Brussels, Copenhagen, Helsinki and Stockholm (equal 1st)		

Source: Siemens Green City Index

An important caveat associated with city indices, is that establishing comparable measures between international cities can be difficult and in many cases there may not be data available, or may be drawn from less recent analysis which may not be reflective of the current situation. Furthermore, any indicator (or composite) of indicators generally results in a simplification of often complex and interlinked systems. Therefore, these results should be interpreted cautiously when they are used to inform policy development and debate.[41]

Chapter 5 endnotes

1 Natural Capital Committee, 2015, "The State of Natural Capital, Protecting and Improving Natural Capital for Prosperity and Wellbeing: Third Report to the Economic Affairs Committee"
2 Natural Capital Committee - http:www.naturalcapitalcommittee.org/why-we-were-set-up.html
3 State of Natural Capital Reports - http://www.naturalcapitialcommittee.org/state-of-natutal-committee - reports.html
4 Natural Capital Committee, 2015, page 19 – 20.
5 Natural Capital Committee, 2015, page 19
6 "Stern Review: The Economics of Climate Change", 2006; page vi
7 Parker, D. E.; Legg, T. P. and Folland, C. K., 1992, "A new daily Central England Temperature Series, 1772-1991"; International Journal of Climatology, Volume 12, pp. 317 – 342. Full dataset for 1659 to 2015 accessed at www.metoffice.gov.uk/hadobs/hadcet. The temperature data are based on a "roughly triangular area of the United Kingdom enclosed by Lancashire, London and Bristol".
8 "Weathering the Storm: The Impact of Climate Change on London's Economy", London Assembly, 2015; page 10
9 "London's Low Carbon Market Snapshot 2015", kMatrix, page 4.
10 "FTSE Environmental Technology Index Series", Factsheet, 30 November 2015
11 "FTSE Environmental Opportunities Index Series", Factsheet, 30 November 2015
12 "Stern Review: The Economics of Climate Change", 2006; page viii
13 Drawn from Natural Capital Committee, State of Natural Capital, 3rd Report
14 Aether, "Analysing Air Pollution Exposure in London".
15 PM2.5 and PM10 refer to particulate matter (PM). This is the term used to describe condensed phase (solid or liquid) particles suspended in the atmosphere. Their potential for causing health problems is directly linked to the size of the particles. PM2.5 refer to particles that are smaller than 2.5 micrograms in diameter; these are considered to have more harmful health effects than PM10, which refer to particles at 10 micrograms in diameter.
16 As such, the analysis does not reflect the impact of many of the interventions outlined in the Mayor's Air Quality Strategy (published in 2010) and implemented since this date, such as tighter Low Emission Zone standards and age limits for taxis introduced in 2012.
17 King's College London, "Understanding the Health Impacts of Air Pollution in London"
18 www.londonair.org.uk
19 Due to monitoring methodological changes a time series can only be derived for PM_{10} from 2004
20 Black carbon is formed through the incomplete combustion of fossil fuels, biofuels, and biomass. It is emitted directly into the atmosphere in the form of fine particles ($PM_{2.5}$). Source: United States Environmental Protection Agency.
21 Euro V and Euro VI refer to the most recent European emission standards for exhaust emissions of new vehicles sold in EU member states. These apply separately for diesel and petrol engines, as well as for passenger vehicles, commercial vehicles, trucks, and buses
22 The UK was taken to court by the European Commission for persistent air pollution problems: http://europa.eu/rapid/press-release_IP-14-154_en.htm. It is unclear what penalties the UK could receive if found guilty, however is likely to be financial.
23 "Comparison of Air Quality in London with a number of world and European cities", AMEC Environment & Infrastructure, Table 10.6, page 61.
24 "Travel in London 7", Transport for London, page 101.
25 "Burden of disease from environmental noise: Quantification of healthy life years lost in Europe", World Health Organisation; Executive Summary page xvii.
26 Calculation on economic impact undertaken by Defra on World Health Organisation analysis of disability-adjusted life years lost through environmental noise "Environmental Noise: Valuing impacts on: sleep disturbance, annoyance, hypertension, productivity and quiet", page 9.
27 "Burden of disease from environmental noise: Quantification of healthy life years lost in Europe", World Health Organisation; Executive Summary page xvii.
28 Lden – is the A-weighted long-term average sound level for the day-evening-night noise indicator in decibels (24 hours).
29 TFL, Airports Commission Discussion Paper 05: The Mayor of London's Response
30 London City Airport, Noise Action Plan, 2010-2015
31 Valuing Greenness Green spaces, house prices and Londoners' priorities https://www.london.gov.uk/sites/default/files/valuing_greenness_report.pdf
32 Beam Parklands Natural Capital Account
33 Treeconomics London, (2015), "Valuing London's Urban Forest: Results of the London i-Tree Eco Project" http://www.forestry.gov.uk/pdf/2890-Forest_Report_Pages.pdf/$FILE/2890-Forest_Report_Pages.pdf. Monetised annual benefits outlined on page 10; benefits of tree planting provided on pages 16 and 17.
34 Based upon 2014 ONS mid-year population estimates.
35 Such examples include the London Energy Plan Tool launching in February 2016 which will look at a number of scenarios that can deal with this issue.
36 https://www.london.gov.uk/what-we-do/business-and-economy/better-infrastructure/london-infrastructure-plan-2050
37 WRAP, 2015, "Employment and the Circular Economy: Job creation through resource efficiency in London".
38 This has been calculated using the methodology established to calculate GVA and GVA per job for specific industries based on the selection of specific SIC codes, first referenced in GLA Economics Current Issues Note 44; alongside the selection of SIC codes relating to the circular economy.

39 "Digest of Waste and Resource Statistics – 2015 Edition", Defra.
40 Definition of houses in multiple occupation available at: https://www.gov.uk/private-renting/houses-in-multiple-occupation
41 GLA Economics, "City ranking indices – handle with care", Current Issues Note 31.