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# Research Proposal:

# Are urban greenspaces able to provide the same level of carbon sequestration services as equivalently sized and vegetated rural greenspaces?

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# 1 Introduction

Climate change acts as a “threat multiplier”, leading to worsening global issues such as food and water shortages, health risks and economic disruption, with 2026 projected to be the hottest year on record (World Health Organisation, 2023; Luhn, 2026). Rising greenhouse emissions, particularly carbon dioxide ($CO_2$), are the primary driver of climate change, responsible for extreme weather events, biodiversity loss, and decline in environmental quality (United Nations, nd).

Governments increasingly promote Nature-based Solutions (NbS) to mitigate the effects of climate change. This is achieved by enhancing ecosystems’ ability to sequester carbon or by reversing ecosystem degradation so that these environments no longer emit harmful greenhouse gases and once again become net carbon sinks (UK Government, 2023; Climate Change Committee, 2025). NbS form part of the UK’s Nationally Determined Contributions (NDCs) under the Paris Agreement (Grantham Research Institute, 2022; Burnett, Ares and Panjwani, 2026).

Greenspaces such as forests, parks, grasslands, and urban vegetation act as carbon sinks by absorbing and storing carbon through photosynthesis. Urbanisation has significantly altered landscapes worldwide. As populations grow, cities expand and natural ecosystems are replaced with buildings, roads and infrastructure. Urban greenspaces are becoming increasingly important due to environmental, social and economic benefits (United Nations Economic Commission for Europe (UNECE), 2024). Urban parks, street trees and green corridors can improve air quality, reduce heat island effects, improve biodiversity, and contribute to carbon sequestration (UNECE, 2024; Burnett, Ares and Panjwani, 2026).

This research proposal investigates whether urban greenspaces are able to provide the same level of carbon sequestration services as equivalently sized and vegetated rural greenspaces. Although both environments may contain similar vegetation types, urban conditions such as soil compaction, pollution, altered hydrology, and increased temperatures may affect vegetation growth and carbon storage capacity (Tobiloba *et al.*, 2025). Understanding the effectiveness of different landscapes in acting as carbon sinks is important for sustainable urban planning and crucial in meeting the UK’s climate goals (UK Government, 2023).

## 1.1 Rationale

The rationale for this study is based on the increasing need for sustainable urban development, particularly as previous studies have focused on carbon sequestration services of rural greenspaces (Dan Zhao *et al.*, 2023).

As urban populations continue to rise, policymakers must maximise the environmental value of limited land. If urban greenspaces can provide sequestration services comparable to rural greenspaces, cities can play a larger role in national carbon reduction strategies (UK Government, 2023). Alternatively, if urban greenspaces are less efficient, then urban planning and management practices may need to be adapted to improve their ecological performance.

This study will contribute to existing knowledge by comparing carbon sequestration services between urban and rural greenspaces with equivalent vegetation density and area. The findings may support future urban planning policies, biodiversity strategies and climate mitigation frameworks.

## 1.2 Background

Carbon sequestration refers to the process by which $CO_2$ is removed from the atmosphere and stored in vegetation, soil and other ecological systems. Trees and plants absorb carbon during photosynthesis and store it as biomass or soil organic matter (Ontl and Schulte, 2012).

Trees are widely recognised as key NbS and can contribute significantly to the United Nations' Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), and SDG 15 (Life on Land) (UNECE, 2024).

Previous research has shown that rural greenspaces, particularly forests, play a major role in reducing atmospheric carbon concentrations (Robbins *et al.*, 2021). Rural forests generally contain healthier soil, larger uninterrupted ecosystems and lower levels of environmental stress when compared to urban areas. These factors support greater biomass accumulation and long-term carbon storage (Tobiloba *et al.*, 2025).

Recent studies show that urban greenspaces can store substantial amounts of carbon, in some cases comparable to adjacent rural greenspaces across a wide global distribution (Jiménez-Prieto *et al.*, 2026). Trees may even grow faster in urban greenspaces compared to their rural counterparts, possibly due to the urban heat island effect. However, urban areas also present adverse conditions, including limited water availability, pollution, and restricted root space, all of which may be further intensified by climate change and negatively affect plant health (Pretzsch *et al.*, 2017; Supriya, 2017). Management practices in urban greenspaces, such as irrigation and mowing, may also affect carbon sequestration performance. As a result, uncertainty remains regarding whether urban greenspaces can consistently achieve carbon sequestration levels comparable to those of rural environments (Delgado-Baquerizo *et al.*, 2023).

This research aims to address this gap by evaluating sequestration performance in comparable urban and rural greenspaces.

# 2 Research Aims

## 2.1 Aims and objectives

Aim

To determine whether urban greenspaces provide the same level of carbon sequestration services as equivalently sized and vegetated rural greenspaces.

Objectives

- Review current literature relating to carbon sequestration in urban and rural greenspaces.
- Identify the environmental factors that influence carbon sequestration rates in urban and rural greenspaces.
- Compare carbon storage estimates between selected urban and rural greenspaces.
- Examine how environmental factors contribute to carbon sequestration rates within selected urban and rural greenspaces.
- Provide recommendations for sustainable urban planning and development.
- Develop recommendations for reducing climate change and environmental management strategies.

## 2.2 Research questions

This study will address the following questions:

1. Do urban greenspaces sequester carbon at the same rate as equivalently sized and vegetated rural greenspaces?

2. What are the environmental factors that influence carbon sequestration rates within urban and equivalently sized and vegetated rural greenspaces?

3. How do soil quality, pollution and land management practices affect carbon sequestration performance?

4. What implications do the findings have for sustainable urban planning and climate policy?

### 2.2.1 Justification (literature review)

Current literature highlights the significant role that vegetation and soils play in carbon sequestration. Carbon storage within biomass and soils is increasingly recognised as an important ecosystem service within policies aimed at mitigating climate change (Davies *et al.*, 2011; Ontl and Schulte, 2012).

Although urban areas occupy only a small proportion of the world's land surface, they contribute disproportionately high levels of carbon emissions (Liu *et al.*, 2014). While urban carbon storage is relatively small compared with emissions per unit area, urban carbon reservoirs are still considered substantial (Davies *et al.*, 2011; Jiménez-Prieto *et al.*, 2026).

However, several studies have identified challenges within urban ecosystems, where environmental conditions can influence carbon sequestration capacity in different ways. Edmondson et al. (2014) suggested that human disturbance can reduce the

carbon storage capacity of urban greenspaces. In contrast, rural greenspaces often contain healthier soils, larger uninterrupted ecosystems, and lower levels of environmental stress, all of which may improve carbon sequestration efficiency (Tobiloba *et al.*, 2025).

Conversely, some researchers argue that urban environments may enhance vegetation growth due to warmer temperatures (Pretzsch *et al.*, 2017; Supriya, 2017).

Despite growing interest in urban green infrastructure, comparative studies examining equivalently sized and vegetated urban and rural greenspaces are limited (Delgado-Baquerizo *et al.*, 2023). Therefore, this research is justified because it addresses an important knowledge gap relating to sustainable urban development and climate change mitigation.

# 3 Proposed Methodology

## 3.1 Methodology outline

This study will adopt a mixed-methods approach using both quantitative and qualitative data.

- Site selection

  Two urban and two rural greenspaces will be selected within similar geographical areas to reduce climatic variation. Sites will be chosen based on:

  - Similar vegetation type
  - Similar vegetation density and age distribution
  - Similar times of year
  - Comparable land area
  - Accessibility for field observations

- Data collection

  - GIS and satellite imagery will be used to identify suitable sites.
  - Tree measurements will be obtained using a Terrestrial Laser Scanner (TLS), where available.
  - If TLS is unavailable, manual measurements will be conducted, including diameter at breast height (DBH), canopy size, and estimated tree age.

- Soil samples will be collected to determine soil organic carbon content using microBiometer.

- Environmental conditions, including levels of soil compaction and pollution, will also be recorded through field observations.

Carbon storage estimates for biomass (trees, shrubs and plants) will be calculated using established allometric equations.
Statistical Package for the Social Sciences (SPSS) software or Microsoft Excel will be used to perform statistical analyses and present data.

- Ethical considerations

The research will aim to avoid damage to vegetation and ecosystems during sampling. Permissions will be obtained where necessary before conducting fieldwork.

## 3.2 Timeline (Gant chart)

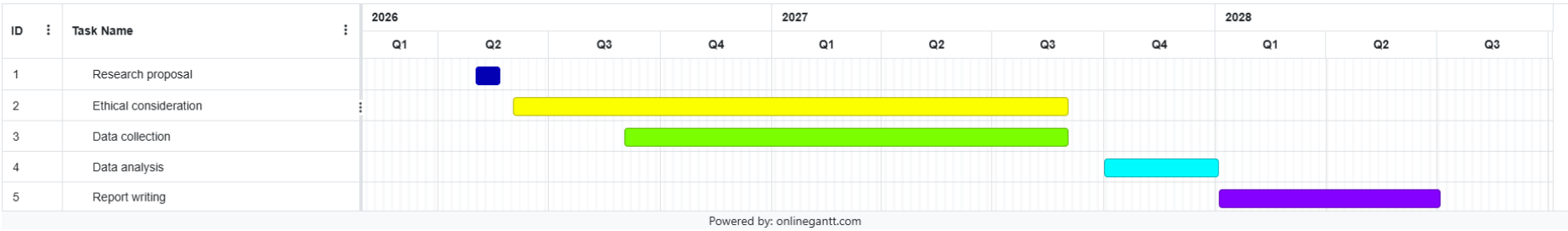


*Figure 1 Gant chart showing proposed time schedule for BSc dissertation (part-time)*

## 3.3 Evaluation

The reliability and validity of the research will be evaluated by comparing findings with established methodologies from previous ecological studies.

Limitations may include restricted access to sites, limited sample sizes and seasonal variation. These factors will be acknowledged during analysis.

## 3.4 Existing methodologies

The study will use methodologies adapted from existing scientific literature. Allometric equations developed by Forest Research will be used to estimate biomass and carbon storage (Randle, Matthews and Jenkins, 2014; Fennell, 2024).

Soil organic carbon analysis methods from environmental science literature will also be applied. Comparative analysis between urban and rural sites will follow the approaches used in previous ecological field studies (Edmondson *et al.*, 2014).

# 4 Anticipated outcomes

## 4.1 Data storage

All collected data will be securely stored using password-protected digital files and cloud storage systems. Field notes and measurements will be transferred to electronic spreadsheets following site visits.

## 4.2 Analysis

The data collected in this study will be analysed using both quantitative and qualitative methods to compare carbon sequestration performance between urban and rural greenspaces. Carbon storage estimates for vegetation will be calculated using established allometric equations based on tree measurements such as DBH, canopy size and estimated age. Soil organic carbon content will be analysed from collected soil samples to determine the amount of carbon stored within the soil at each site.

Comparative statistical analysis will be used to identify differences in carbon storage between urban and rural greenspaces of equivalent size and vegetation density. Mean carbon storage values for vegetation and soils will be compared across sites to determine whether significant differences exist between the two environments.

Qualitative observations, including evidence of soil compaction, pollution, and land management practices will also be examined to identify environmental factors that may affect carbon sequestration performance. These findings will be interpreted alongside the quantitative data to provide a broader understanding of how urban conditions affect carbon storage capacity.

Results will be presented using statistical analyses, tables and graphs to illustrate patterns and relationships between the selected urban and rural greenspaces.

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