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Institute of Computer Science Databases and Information Systems Special Aspects of Data Management: Geospatial Databases - Assignment Project WiSe 2024/25

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Assignment A.P

Assignment: – Deadline: January 30, 2025, 2pm
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1 Genutzte Materialien und Tools

Web Application Development

- **Leaflet.js**: A lightweight, open-source JavaScript library for mobile-friendly interactive maps. It's easy to use and can be integrated with other web technologies.
- **Bootstrap**: A front-end framework for developing responsive and mobile-first websites. It's easy to use with pre-designed components, which can help in quickly setting up the layout and design of the application.
- **Vue.js**: Modern JavaScript frameworks for building user interfaces. They are well-suited for single-page applications and can be combined with map libraries like Leaflet.

Additional Tools and Libraries

- **GitHub Pages**: For hosting web applications easily and for free.

DBMS

- PostgreSQL, PostGIS, QGIS.

Code from the official documentation of the above-mentioned tools was integrated into our source code.

Dataset and Information

[1] Wikipedia contributors. *Green belt (United Kingdom)*. Accessed: 2025-01-25. n.d. URL: https://en.wikipedia.org/wiki/Green_belt_(United_Kingdom).

[2] UK Government. *English Local Authority Green Belt Dataset*. Accessed: 2025-01-25. n.d. URL: https://www.data.gov.uk/dataset/ccb505e0-67a8-4ace-b294-19a3cbff4861/english-local-authority-green-belt-dataset10.

[3] UK Government. *National Planning Policy Framework - December 2024*. Accessed: 2025-01-25. 2024. URL: https://assets.publishing.service.gov.uk/media/675abd214cbda57cacd3476e/NPPF-December-2024.pdf.

[4] UK Government. *National Planning Policy Framework: Protecting Green Belt Land*. Accessed: 2025-01-25. n.d. URL: https://www.gov.uk/guidance/national-planning-policy-framework/13-protecting-green-belt-land.

[5] Campaign to Protect Rural England (CPRE). *State of the Green Belt 2018*. Accessed: 2025-01-25. 2018. URL: https://www.cpre.org.uk/wp-content/uploads/2019/11/State_of_the_Green_Belt_2018.pdf.

2 Documentation

2.1 Project Idee

Project Idea: Evolution of Green Areas in London and Birmingham

This project aims to develop an **interactive visualization and analysis tool** to study the changes in green spaces in **London** and **Birmingham** over the past decades. The tool will combine geospatial data to offer a dynamic, visual understanding of green area trends in these two cities.

The platform will include:

- **Geographical Mapping**: Overlay of green area changes on a city map using historical and current data.
- **Timeline Analysis**: Interactive timelines to observe the growth or reduction of green areas in different neighborhoods.

Research Question

Main Question: *"How have green spaces in London and Birmingham evolved over the years, and to what extent have environmental protection laws preserved or restored these areas?"*

Sub-questions:

1. What trends can be observed in the total green area coverage in London and Birmingham over the past 25 years?
2. Are there neighborhoods or districts in either city that have experienced significant green space loss or growth?
3. How effective have environmental laws been in preventing the loss of green spaces?

Data Sources

The following data sources will be utilized for the project:

- **Geospatial Data**: English local authority Green Belt dataset. Published by: Ministry of Housing, Communities and Local Government. Last updated: 05 December 2024 Topic: Not added Licence: Creative Commons Attribution. [2]

Real-World Applications

This project provides valuable insights for:

- **Policy Evaluation**: Assess the effectiveness of current legal frameworks in preserving green areas.
- **Urban Planning**: Support urban planners in identifying areas requiring more robust protective measures.
- **Public Awareness**: Engage residents in understanding the importance and current state of their city's green spaces.

Conclusion

The proposed project will create an actionable resource for policymakers, urban planners, and local communities to better understand and preserve urban green spaces, balancing the needs of development with environmental conservation.

2.2 Database Setup

Objective: To set up a PostgreSQL database with spatial data support using the PostGIS extension.

Step 1: Database Creation

We created a PostgreSQL database named `SDB2425`. This was achieved using the following SQL command:

```
CREATE DATABASE SDB2425;
```

The database was successfully created and made available for further configuration.

Step 2: Connecting to the Database

After creating the database, we established a connection to it via the command line interface. This was done using:

```
\c SDB2425
```

Once connected, we verified that the database was ready for extension installation.

Step 3: Installing the PostGIS Extension

To enable spatial data functionality, we installed the PostGIS extension within the `SDB2425` database. The following SQL command was executed:

```
CREATE EXTENSION postgis;
```

After the installation, we verified the successful setup by checking the installed version of PostGIS:

```
SELECT PostGIS_Full_Version();
```

This query returned the full version of PostGIS, confirming that the extension was active and ready for use.

Notes (what we learned):

- Ensure you have sufficient privileges (e.g., superuser) to create extensions in the database.
- If the `CREATE EXTENSION` command fails, it might indicate that PostGIS is not installed on the server. In such cases:
  1. Install PostGIS using your package manager. For example, on Ubuntu:
     ```
     sudo apt-get install postgis postgresql-postgis
     ```
  2. Restart the PostgreSQL server and retry the `CREATE EXTENSION` command.

Outcome

At the end of this setup process:

- The database `SDB2425` was successfully created.
- The PostGIS extension was installed, enabling the database to handle spatial data.
- Verification of the setup ensured that the database was ready for spatial data processing.

2.3 Data Import

Objective: To import geospatial data of at least two cities with appropriate attributes, preprocess it, and include additional datasets according to the project idea.

Step 1: Selecting and Downloading Data

For this task, we selected the geospatial data for **London** and **Birmingham**. The corresponding datasets were sourced from the following platforms:

- **OpenStreetMap (OSM)**: Data was downloaded from https://download.geofabrik.de/.
- **English Local Authority Green Belt Dataset**: Additional data was retrieved from data.gov.uk.

Step 2: Preprocessing the Data

To ensure the data was ready for import, the following preprocessing steps were performed:

- The downloaded shapefiles from the Green Belt dataset were reviewed to confirm attribute consistency, specifically focusing on fields such as `id`, `geom`, `lad_nm` (Local Authority District Name), `lad_cd` (Local Authority District Code), `gb_name` (Green Belt Name), and `area_ha` (Area in Hectares).
- Any unnecessary attributes were removed, and data types were validated for compatibility with the PostgreSQL/PostGIS database.
- Geometries were validated to ensure no invalid or duplicate entries existed.

Step 3: Importing Data into PostgreSQL

The preprocessed data was imported into the `SDB2425` PostgreSQL database using the PostGIS extension.

The following SQL queries were used to create tables for **London** and **Birmingham** for the year 2024 based on the Green Belt dataset:

Listing 1: SQL Query for Importing Green Belt Data

```sql
CREATE TABLE London2024 AS
SELECT id, geom, lad_nm, lad_cd, gb_name, area_ha
FROM public."Green_Belt_2024"
WHERE gb_name = 'London';

CREATE TABLE Birmingham2024 AS
SELECT id, geom, lad_nm, lad_cd, gb_name, area_ha
FROM public."Green_Belt_2024"
WHERE gb_name = 'Birmingham';
```

Step 4: Importing Additional Data

Additional datasets were imported to enrich the analysis:

- **OpenStreetMap Data:** OSM data for London and Birmingham was imported to provide supplementary attributes, such as road networks, building footprints, and green spaces.
- **Attributes Integration:** The additional attributes (e.g., land use types, accessibility metrics) were linked to the Green Belt datasets using spatial joins in SQL.

Outcome

By completing the data import and preprocessing tasks:

- Two tables, `London2024` and `Birmingham2024`, were created to store green belt data for the year 2024.
- Spatial data for each city was successfully validated, cleaned, and imported into the PostgreSQL database.
- Additional datasets were integrated to enable comprehensive analysis aligned with the project objectives.

Example: Visualization of Green Belt Data

Below is an example image depicting the visualization of the imported Green Belt data using QGIS.

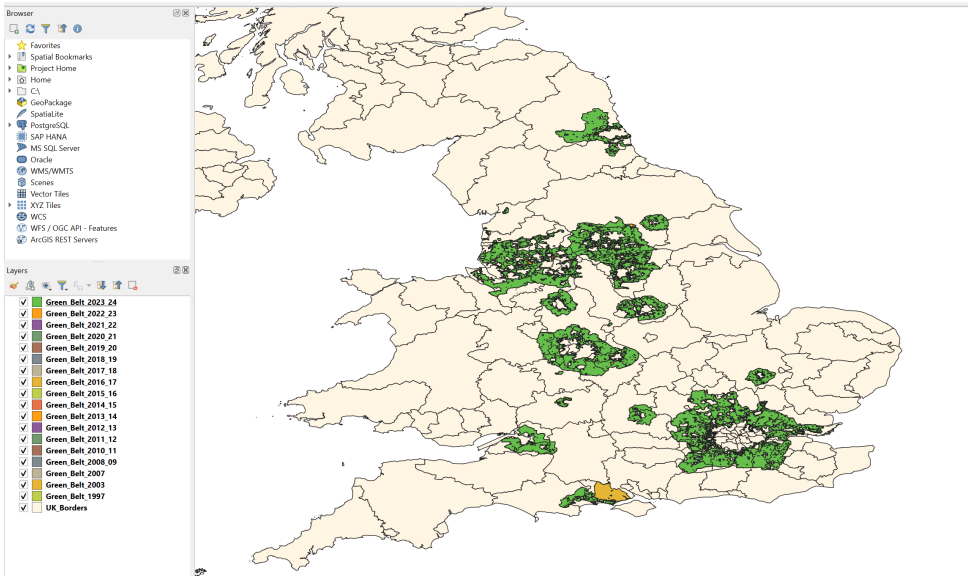

Figure 1: Green Belt Visualization in QGIS

2.4 Development of an Interactive Web Service or Mobile Application

Objective: To develop an interactive web service for visualizing geospatial data of London and Birmingham, ensuring all datasets can be visualized independently and collectively contribute to answering the research question.

1. Implementation Overview

The interactive web service was developed using modern frameworks and tools; see the the beginning of this documentation. The source code is added as an appendix to this documentation.

2. Query for Data Visualization

SQL Query for showing the areas of Birmingham for each year (London similarly) for the point plots. The plot was then created using excel, using a csv version of this query result. SQL-Schema:

```
SELECT '2024' AS year, ROUND(SUM(area_ha) / 100, 2) AS area_km2
FROM public."birmingham2024"
UNION ALL
SELECT '2023', ROUND(SUM(area_ha) / 100, 2)
FROM public."birmingham2023"
UNION ALL
SELECT '2022', ROUND(SUM(area_ha) / 100, 2)
FROM public."birmingham2022"
UNION ALL
SELECT '2021', ROUND(SUM(area_ha) / 100, 2)
FROM public."birmingham2021"
UNION ALL
```

```sql
SELECT '2020', ROUND(SUM(area_ha) / 100, 2)
FROM public."birmingham2020"
UNION ALL
SELECT '2019', ROUND(SUM(area_ha) / 100, 2)
FROM public."birmingham2019"
UNION ALL
SELECT '2018', ROUND(SUM(area_ha) / 100, 2)
FROM public."birmingham2018"
UNION ALL
SELECT '2017', ROUND(SUM(area_ha) / 100, 2)
FROM public."birmingham2017"
UNION ALL
SELECT '2016', ROUND(SUM(area_ha) / 100, 2)
FROM public."birmingham2016"
UNION ALL
SELECT '2015', ROUND(SUM(area_ha) / 100, 2)
FROM public."birmingham2015"
UNION ALL
SELECT '2014', ROUND(SUM(area_ha) / 100, 2)
FROM public."birmingham2014"
UNION ALL
SELECT '2013', ROUND(SUM(area_ha) / 100, 2)
FROM public."birmingham2013"
UNION ALL
SELECT '2012', ROUND(SUM(area_ha) / 100, 2)
FROM public."birmingham2012"
UNION ALL
SELECT '2011', ROUND(SUM(area_ha) / 100, 2)
FROM public."birmingham2011"
UNION ALL
SELECT '2009', ROUND(SUM(area_ha) / 100, 2)
FROM public."birmingham2009"
UNION ALL
SELECT '2007', ROUND(SUM(area_ha) / 100, 2)
FROM public."birmingham2007"
UNION ALL
SELECT '2003', ROUND(SUM(area_ha) / 100, 2)
FROM public."birmingham2003"
UNION ALL
SELECT '1997', ROUND(SUM(area_ha) / 100, 2)
FROM public."birmingham1997";
```

3. Interactive Web Service Description

The web service features the following components:

- A **map view** (implemented using Leaflet.js) showing the geographical distribution of green belt areas for both cities.
- Interactive controls for filtering data by year or city and toggling overlays for integrated datasets.
- Text with information about the Green Belt.

4. Example Visualization

Below is a screenshot of the interactive web service:

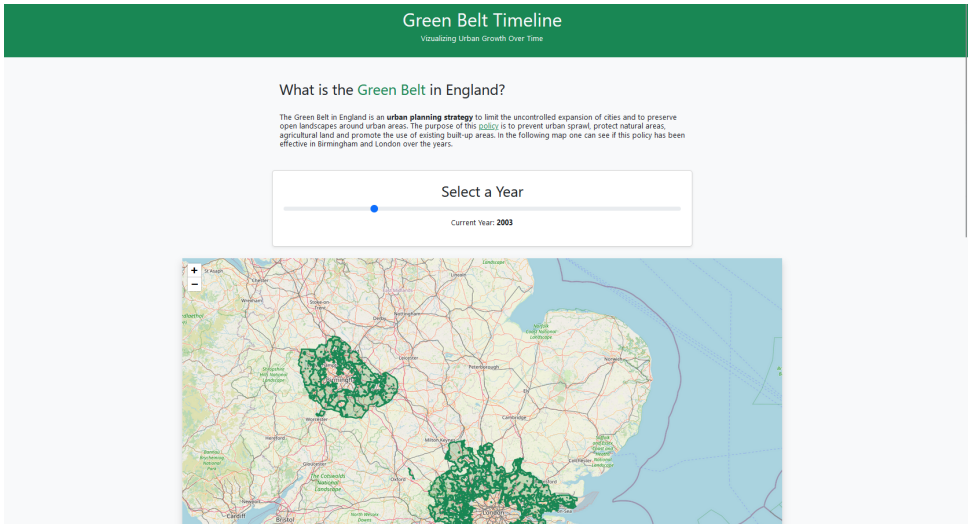

Figure 2: Screenshot of the interactive web service showing the map view and data controls.

5. Ensuring Data Visualization Meets Objectives

- Each dataset (green belt areas by year) can be visualized independently through dedicated map layers and charts.
- Data integration functionality allows users to overlay datasets, facilitating the exploration of relationships and trends.
- The service directly supports answering the research question by enabling analysis of how green spaces have changed over time and how environmental policies might have influenced these trends.

6. Commentary in Source Code

All source code includes detailed comments to ensure maintainability and clarity. For example:

Listing 2: Code with Comments in Vue.js

```
<template>
  <!-- Navigation Bar -->
  <header class="text-center py-4 bg-success text-light">
    <h1 style="font-size: 40px;">Green Belt Timeline</h1>
    <h6>Vizualizing Urban Growth Over Time</h6>
  </header>

  <!-- Main Content -->
  <div class="container my-5" style="max-width: 900px; width: 90%">
    <h2>What is the <a class="text-success text-decoration-none">Green Belt</a>
    in England?</h2>
    <br>
    <h6>
      The Green Belt in England is an <strong>urban planning strategy</strong> to
     limit the uncontrolled expansion of cities and to preserve open landscapes
    around urban areas. The purpose of this <a class="text-success" href="https:
    //assets.publishing.service.gov.uk/media/675abd214cbda57cacd3476e/NPPF-
    December-2024.pdf">policy</a> is to prevent urban sprawl, protect natural
    areas, agricultural land and promote the use of existing built-up areas. In
```

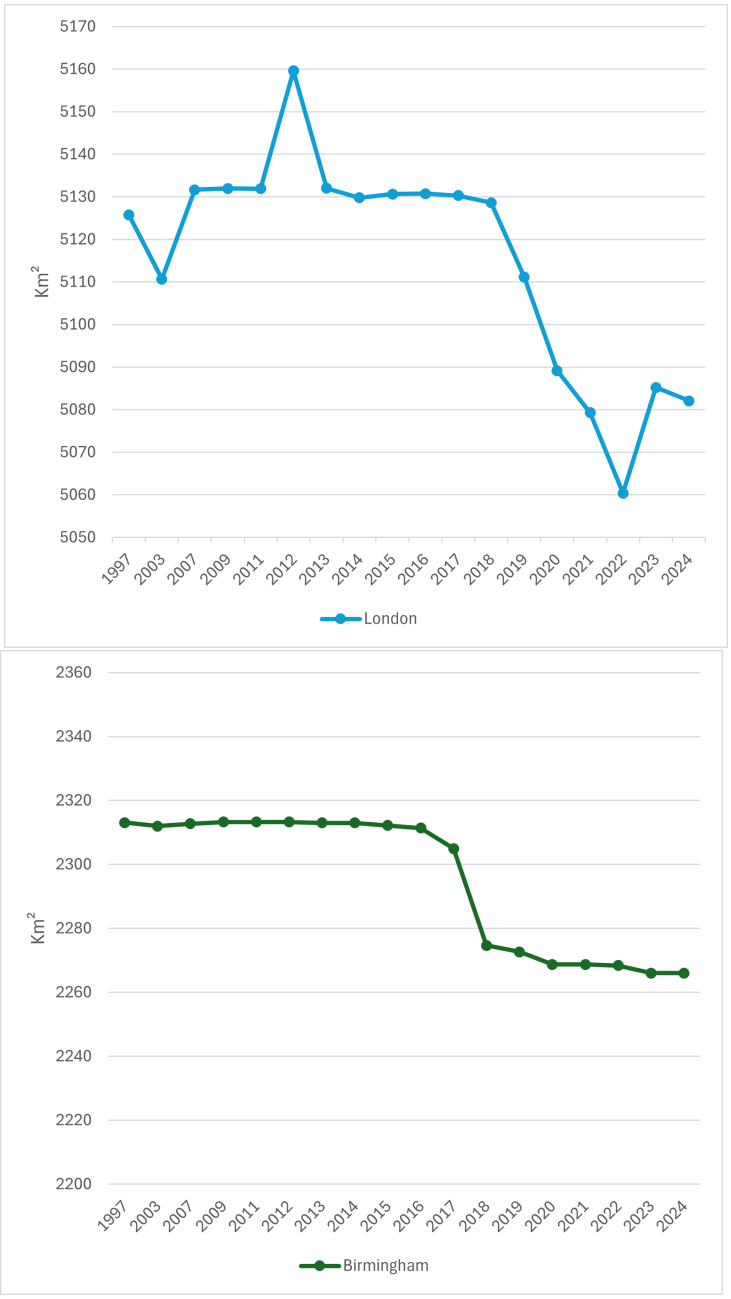

Figure 3: Plots showing green belt area trends for the 2 cities.

```
    the following map one can see if this policy has been effective in Birmingham
     and London over the years.
    </h6>
  </div>

  <!-- Slider -->
  <Slider @changeYears="loadGeoJson"></Slider>
```

```
  <!-- Map -->
  <div class="container my-4">
    <main class="shadow">
      <l-map ref="map" v-model:zoom="zoom" v-model:center="center"
    :useGlobalLeaflet="false">
        <l-tile-layer url="https://{s}.tile.openstreetmap.org/{z}/{x}/{y}.png"
                      layer-type="base"
                      name="Openstreetmap Basemap">
        </l-tile-layer>
        <l-geo-json :geojson="geojsonL"></l-geo-json>
        <l-geo-json :geojson="geojsonB"></l-geo-json>
      </l-map>
    </main>
  </div>

  <!-- Plots & Paragraph -->
  <div class="container my-5" style="max-width: 900px; width: 90%">
    <h2 class="text-center mb-4"><a class="text-success text-decoration-none">
    Green Belt</a> Area over the Years</h2>
    <Plots
      :londonImg="londonPlot"
      :birminghamImg="birminghamPlot"
    ></Plots>
    <h4 class="text-success">Urban Development Pressure</h4>
    <br>
    <h6>
      The significant reduction in Green Belt areas around London and Birmingham
    since 2018 is primarily due to <strong>urban development pressures</strong>
    of housing shortages, population growth and significant policy adjustments.
    The <strong>demand for housing</strong> in these expanding cities needed the
    development of new residential areas to provide housing and accommodate the
    growing population, often interfering with protected Green Belt zones.
    </h6>
    <br>
    <h6>
      <strong>Policy changes</strong>, especially updates to the <a class="text-
    success" href="https://assets.publishing.service.gov.uk/media/675
    abd214cbda57cacd3476e/NPPF-December-2024.pdf">National Planning Policy
    Framework (NPPF)</a>, have introduced more flexible planning policies that
    allow development within green belts under certain conditions. The effects of
     this development pressure result in <strong>environmental degradation and
    loss of biodiversity</strong>, which has a negative impact on the ecology of
    England.
    </h6>
    <br>
    <h6>
      Balancing the need for urban growth with the preservation of the green belt
     requires strategic planning and a robust policy framework. Through a
    balanced and sustainable approach, it is possible to meet the demands of
    urban growth without compromising the boundaries of the green belt.
    </h6>
  </div>

  <footer class="bg-light d-flex justify-content-center align-items-center p-3 mb
    -4">
    <img src="/favicon.ico" alt="Favicon" class="mt-2" style="width: 30px;
    height: 30px;">
  </footer>
</template>
```

```
<script>
import "leaflet/dist/leaflet.css"
import { LMap, LTileLayer, LGeoJson } from "@vue-leaflet/vue-leaflet"
import Slider from "./components/Slider.vue";
import Plots from "./components/Plots.vue";
import londonPlot from "@/assets/london.png";
import birminghamPlot from "@/assets/birmingham.png";

export default {
  components: {
    LMap,
    LTileLayer,
    LGeoJson,
    Slider,
    Plots
  },
  data(){
    return {
      // Default values
      zoom:6,
      center: [54, -3],
      londonPlot,
      birminghamPlot,
    }
  },
  created(){
    this.loadGeoJson("2003")
  },
  methods: { // Load GeoJSON data
    loadGeoJson(sliderValue){
      console.log("Changed to ".concat(sliderValue))
      fetch("./src/data/London".concat(sliderValue,".geojson"))
        .then((response) => response.json())
        .then((data) => {
          this.geojsonL = data;
        })
        .catch((error) => {
          console.error("Error loading GeoJSON:", error);
        });

      fetch("./src/data/Birmingham".concat(sliderValue,".geojson"))
        .then((response) => response.json())
        .then((data) => {
          this.geojsonB = data;
        })
        .catch((error) => {
          console.error("Error loading GeoJSON:", error);
        });
    },
  }
}

</script>

<style>
html, body {
  margin: 0;
  padding: 0;
```

```
}

main {
  height: 80vh;
  width: 100%;
}

path {
  fill: #2E7D32;
  stroke: #198754;
}
</style>
```

Conclusion

To explore our analysis further, visit our interactive website: https://worldbreaker666.github.io./

The website allows users to:

- View Green Belt areas in London and Birmingham over different years.
- Compare urban development pressures and policy impacts.
- Toggle between datasets such as population density and green belt coverage.

Green Belt Area over the Years

The Green Belt in England is an urban planning strategy to limit the uncontrolled expansion of cities and to preserve open landscapes around urban areas. The purpose of this policy is to prevent urban sprawl, protect natural areas, agricultural land, and promote the use of existing built-up areas.

The significant reduction in Green Belt areas around London and Birmingham since 2018 is primarily due to urban development pressures such as housing shortages, population growth, and significant policy adjustments.

The demand for housing in these expanding cities necessitated the development of new residential areas to provide housing and accommodate the growing population, often interfering with protected Green Belt zones.

Policy changes, especially updates to the National Planning Policy Framework (NPPF), introduced more flexible planning policies that allow development within green belts under certain conditions. The effects of this development pressure have resulted in:

- Environmental degradation.
- Loss of biodiversity.
- Negative impacts on the ecology of England.

Balancing the need for urban growth with the preservation of the Green Belt requires:

- Strategic planning.
- A robust policy framework.

Through a balanced and sustainable approach, it is possible to meet the demands of urban growth without compromising the boundaries of the Green Belt.