

Site selection for secondary schools

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Abstract: This case study explores site selection options for secondary school locations, based on the use of Geographic Information Science (GIS) and decision-making models. It reviews relevant literature, presents a workflow for data organization and analysis, and discusses an alternative method for importing spatial data. The document also covers database creation on Amazon Web Services (AWS) and the use of GIS technology for community engagement. In conclusion, it highlights the versatility of GIS tools in various projects and decision-making processes.

Key word: Decision-Making Models. Data Analysis. GIS Technology.

Resumo: Este estudo de caso explora opções de seleção de locais para escolas secundárias, com base no uso da Ciência da Informação Geográfica (GIS) e de modelos de tomada de decisão. Revisa a literatura relevante, apresenta um fluxo de trabalho para organização e análise de dados e discute um método alternativo para importar dados espaciais. O documento também aborda a criação de banco de dados na Amazon Web Services (AWS) e o uso da tecnologia GIS para envolvimento da comunidade. Concluindo, destaca a versatilidade das ferramentas GIS em diversos projetos e processos de tomada de decisão.

Palavras-chave: Modelo de Tomada de Decisão, Análise de Dados. Tecnologia GIS.

Resumen: Este estudio de caso explora opciones de selección de sitios para escuelas secundarias, basándose en el uso de Ciencias de la Información Geográfica (SIG) y modelos de toma de decisiones. Revisa la literatura relevante, presenta un flujo de trabajo para organizar y analizar datos y analiza un método alternativo para importar datos espaciales. El documento también cubre la creación de una base de datos en Amazon Web Services (AWS) y el uso de tecnología SIG para la participación de la comunidad. En conclusión, se destaca la versatilidad de las herramientas SIG en diversos proyectos y procesos de toma de decisiones.

Palabras clave: Modelo de Toma de Decisiones, Análisis de Datos. Tecnología SIG.

1 Part: site selection for potential secondary school location

1.1 Literature review

The science of collecting spatial data has been in use since the early 1840 with information collected remotely using aerial photographs (Miç and Antmen, 2021). Geographic Information Science (GIS) started to be developed during the 1960s developing the statistical and computing concepts needed to work with the data (Miç and Antmen, 2021). Remote Science and GIS technology has grown rapidly in the decades since, improving the analytical capabilities and providing important data and decision-making tools applied in various areas such as environmental science, public politics, sustainable socioeconomics, and conservation (Bukhari, Mahmud and Ahmad, 2010; Moussa, Mostafa and Elwafa, 2017). Site selection is a complex process that requires different considerations of various sectors and a multidisciplinary methodology.

In this project, the objective is to find suitable areas for school site selection sites. The literature review consists in five different articles, Biswas and Pamucar (2020), Bukhari, Mahmud and Ahmad (2010), Miç and Antmen (2021), Moussa, Mostafa and Elwafa (2017). The methodology was applied in different countries, which are Libya, Egypt, India, Turkey and Pakistan.

Biswas and Pamucar (2020) conducted a study to figure out the best locations for schools in using a multi-criteria group decision analysis. The authors considered six criteria including accessibility, land cost, public transportation, availability of parking space, availability of public amenities, and green space. The study found that the best locations were those that had good accessibility, affordable land costs, and were close to public transportation and public amenities.

Bukhari, Mahmud and Ahmad (2010) used a spatial multi-criteria decision analysis (MCDA) model to select safe sites for schools in Lahore, Pakistan. They identified seven criteria, including proximity to major roads, distance from industrial areas, slope, distance from rivers and canals, distance from hazardous sites, distance from built-up areas, and land-use. The study found that the safest sites were those located away from major roads, industrial areas, and hazardous sites, and had low slopes.

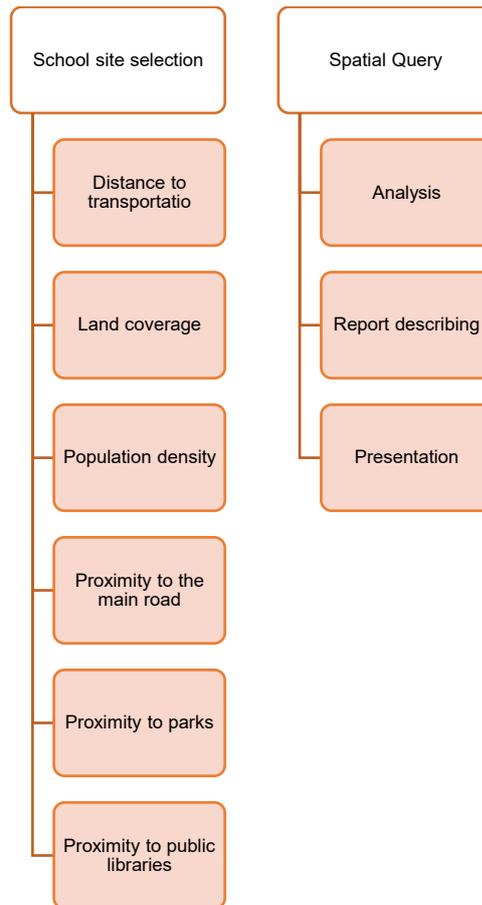
Miç and Antmen (2021) proposed a decision-making model based on three different methods to select suitable locations for universities in Turkey. They considered nine criteria, including accessibility, transportation, proximity to urban centres, land cost, public amenities, security, environmental quality, social and cultural opportunities, and qualified human resources. The study found that the most suitable locations were those that had good accessibility, affordable land costs, and were close to urban centres, public amenities, and cultural opportunities (Biswas and Pamucar, 2020).

Finally, Moussa, Mostafa and Elwafa (2017), describe in two site selection. In Egypt they identified six criteria, including accessibility, public amenities, environmental quality, land cost, public transportation, and proximity to urban centres, whereas in Libya, they identified five criteria, including accessibility, public amenities, environmental quality, land cost, and proximity to urban centres. The study found that the most suitable locations were those that had good accessibility, affordable land costs, and were close to public amenities and urban centres. The reviewed articles identified various criteria for school site selection, including accessibility, land cost, availability of public amenities, environmental quality, proximity to urban centres, and safety. The studies also highlighted the importance of using different methods to rank potential sites based on the criteria (Moussa, Mostafa and Elwafa, 2017).

In conclusion, school site selection is a complex process that involves several criteria, including accessibility, safety, infrastructure, economic, environmental, and community involvement. The literature review highlighted the importance of using GIS and decision-making models to analyse and evaluate potential school sites based on these criteria. The selection process should also involve community input to ensure that the selected location meets the needs and preferences of the local community. Based on this literature review, it will be considered for the purpose of this project the following six criteria: distance to transportation, population density, proximity to the main road, proximity to parks, proximity to public libraries in order to identify the best locations for schools in Wicklow, Ireland.

Furthermore, integrating real-time traffic data and demographic trends into the GIS analysis can provide a more dynamic and accurate assessment of school site suitability. Additionally, ongoing community engagement throughout the decision-making process is crucial for fostering a sense of ownership and ensuring the long-term success of the selected school locations.

1.2 Workflow



1.3 Spatial Queries

Firstly it was necessary to create a data base in PGAdmin in order to organise it. Some of the data needed to be manually cleaned up in Excel and some others clipped in ArcGIS pro. The spatial dataset selected for this project are transportation lines, population density, road data, public parks and public libraries.

The first action was to creat buffer zones in the data in order to identify common areas. All buffer numbers are in meters.

1.3.1 Road buffer

```

CREATE TABLE major_buffer AS
SELECT gid,class,ST_Buffer(geom,500)AS geom
FROM major;
  
```

1.3.2 Spacial Proteced Area buffer

```
CREATE TABLE special_protected_area_buffer AS
SELECT gid,site_name,ST_Buffer(geom,500)AS geom
FROM special_protected_area;
```

1.3.3 Transportation line buffer

```
CREATE TABLE wicklow_transportation AS
SELECT gid,lineefa ,ST_Buffer(geom,100)AS geom
FROM wicklow_transportation;
```

1.3.4 Libraries buffer

```
CREATE TABLE libraries_buffer2 AS
SELECT gid, branchname ,ST_Buffer(geom,2000)AS geom
FROM libraries;
```

1.3.5 Population density

The population density was filtered by age between 10 and 18 years old, and areas where there were more than 50 registers at least.

```
CREATE TABLE population_filtered AS
SELECT gid, edname, c10_18, geom
FROM saswithpopulation
WHERE c10_18 > 50;
```

Study area & Buffer zones

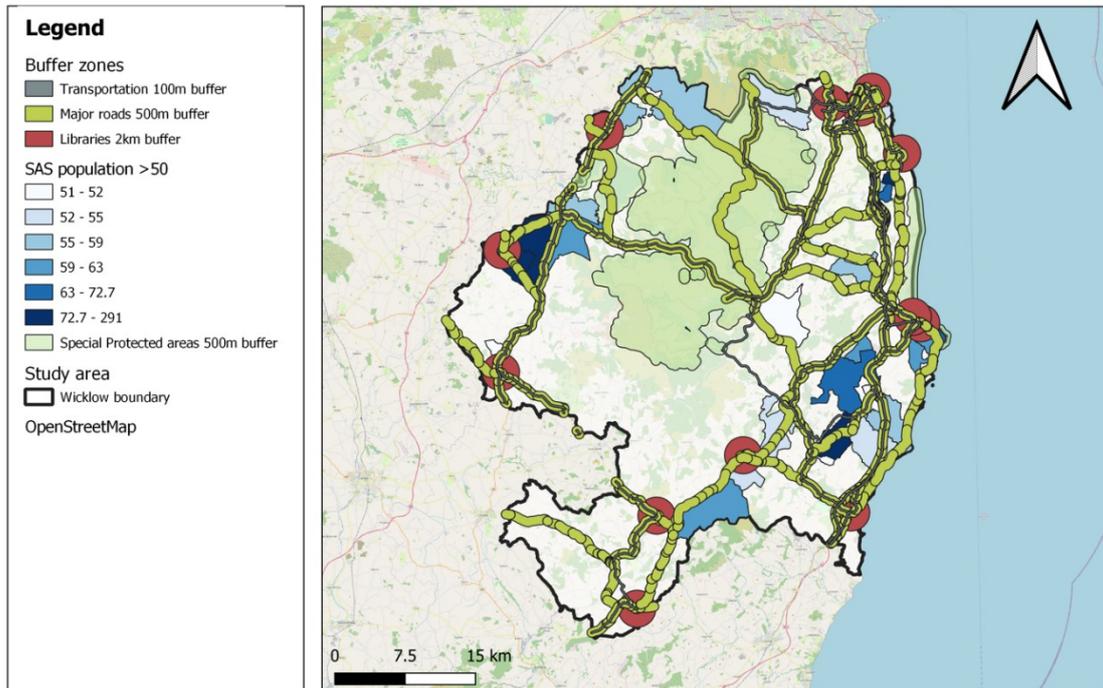


Figure 1: Buffer zones of the criteria's: transportation, major roads, library, population and special protected areas.

1.3.6 Selecting the suitable sites

In order to select suitable sites, the data set was re-organised and consolidated utilizing ST_Union function in PGAdmin4. First major roads and transportation got united:

```
CREATE TABLE UNION_1 AS
SELECT mj.GID, ST_UNION(mj.GEOM, tb.GEOM) AS GEOM
FROM major_buffer mj, wicklow_transportation_buffer tb
Then, the other buffers where joined into the file following:
CREATE TABLE UNION_2 AS
SELECT a.GID, ST_UNION(a.GEOM, b.GEOM) AS GEOM
FROM union_1 a, libraries_buffer2 b;
```

And then with population density, forming 3 unions. The Special Protected areas was used as a base layer to avoid suggesting areas within the protected areas. After uniting all the data, it was necessary to organise the geom of this new layer with:

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```
ALTER TABLE union4  
ALTER COLUMN geom TYPE geometry(MultiSurface, 2157)  
USING ST_Multi(geom);
```

Once it was done, the following query was ran:

```
CREATE TABLE suitable_area AS  
SELECT ST_DIFFERENCE(union4.geom, wicklow.geom)  
FROM union4, wicklow;
```

On Figure 2 it is possible to see the suitable areas for schools in Wicklow.

Suitable areas

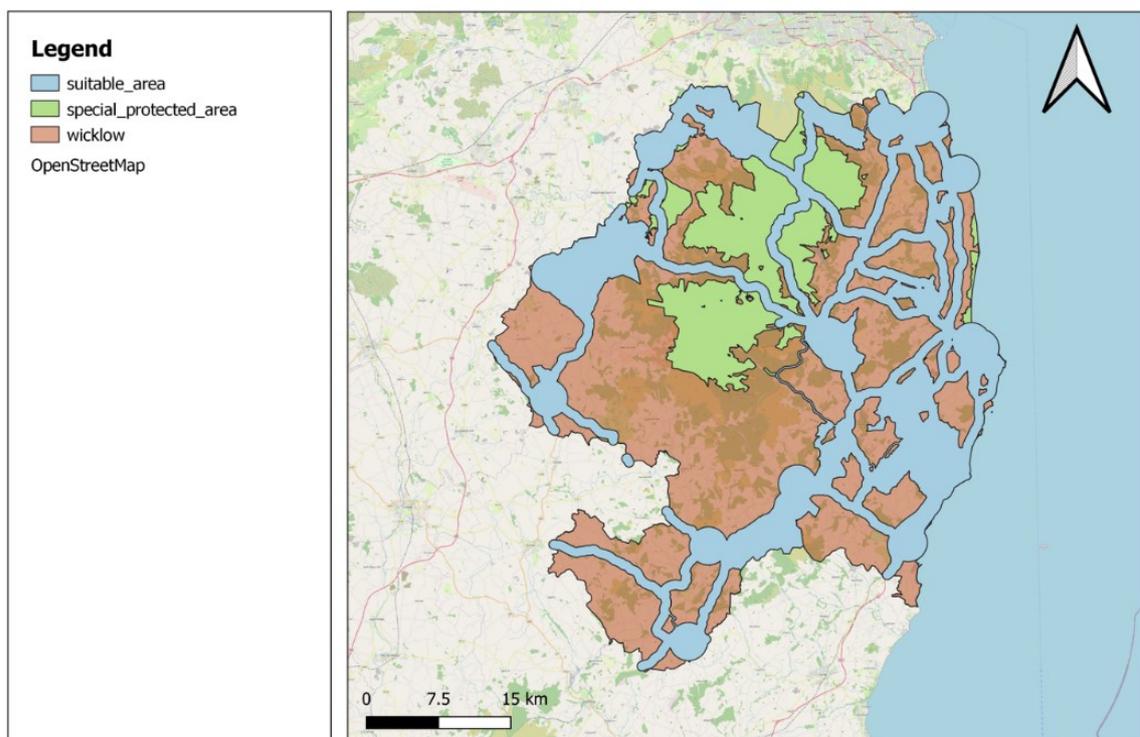


Figure 2: Suitable areas generated from criteria's and buffer zones.
In blue is shown the proposed suggested areas for development of schools.

2 Part: Database creation and uploading of relevant data

In this section, we will cover the steps for setting up a new PostgreSQL/PostGIS spatial database on Amazon Web Services (AWS), installing the necessary extensions for handling spatial data, OpenStreetMap data, and performing network analysis.

2.1 Setting Up Postgresql On Amazon Web Services

We followed the steps in the Web GIS module to create a new database under the Amazon RDS service. We selected PostgreSQL as the database engine, and after installing it on the database, the database became available in RDS. We then modified the database to add additional configuration settings, and copied the URL from the database identifier to add to the connections on the PostgreSQL installation on the virtual machine. The same data base used for a secondary project was used here to support the files and archives. A new schema was created and added the necessities extensions: *postgis*, *hstore* and *pgrouting*.

Once the GEOJson was exported, it was added to geojson.io in order to collect the points in the suitable areas, as seen in Figure 3, where the suitable areas is displayed along with the chosen location points.

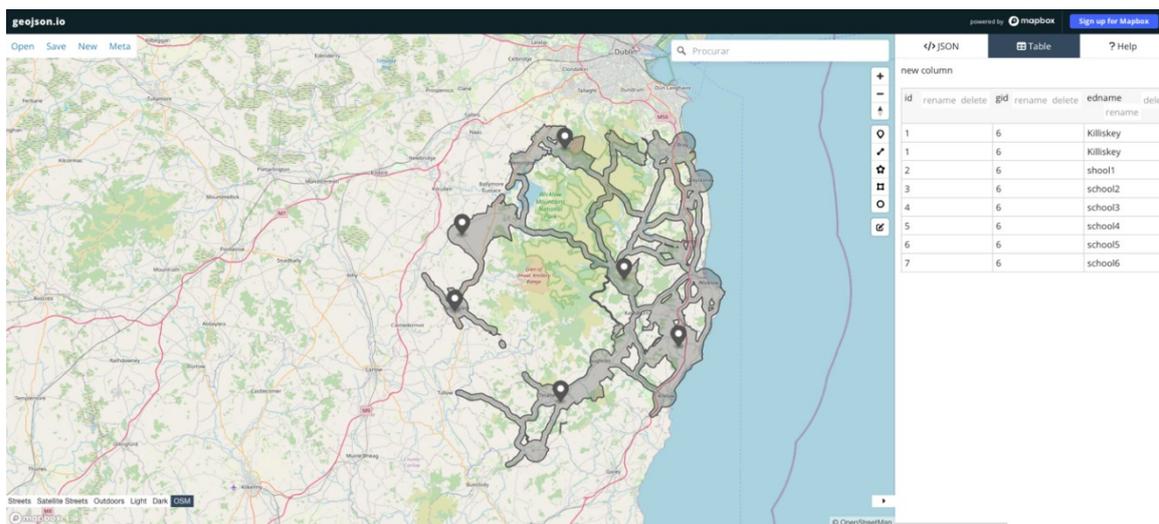


Figure 3: geojson.io website with the suitable sites displayed, as well as the proposed school locations.

Once the file was saved, it was time to add it to the main data base using Feature Manipulation Engine (FME). A workspace was set in FME with the writer and reader, moving the geojson generated file in geojson.io, to the data base in AWS.

The Feature Manipulation Engine, also known as FME, is utilized to upload data to the database. In order to do so, the geojson file must first be uploaded to the FME workspace, which is depicted in figure 12. It is crucial to carefully consider the coordinate system of both the reader and writer. Figure 4 displays the connection made to Postsql.

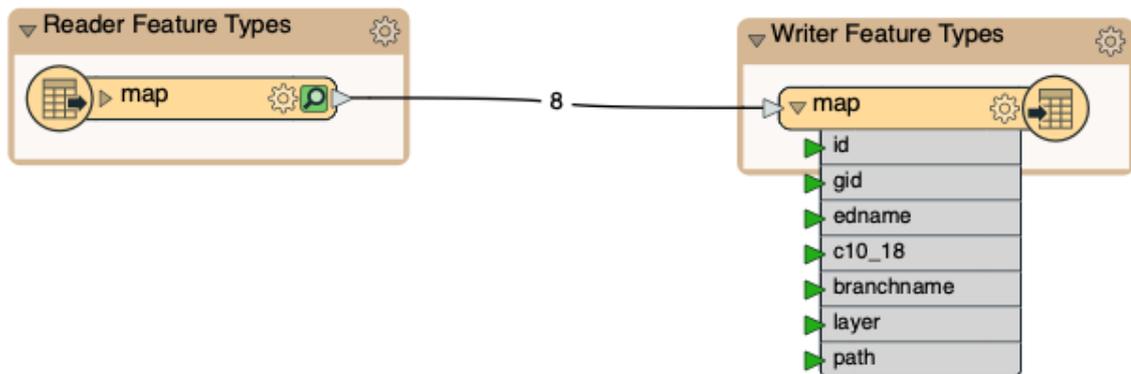


Figure 4: Connection between reader and writer in FME.

2.2 Alternative method for importing OSM files

A new layer of Wicklow County boundary was downloaded from OSM contributor's map. It was saved using sublime and imported to the data base using shp2pgsql. Also, the data base was connected to QGIS, and the importation was done by there too (using also shp2pgsql in the background).

Comparing the methodologies, FME presented to be easier and well communicative to different type of data, although it is possible to use other free resources on a daily basis, such as shp2pgsql through PGAdmin or QGIS. We intend to visually represent the comparative advantages and efficiencies of these distinct data import methods. This visualization will provide valuable insights into the best approach for specific tasks and data requirements within our geographic information system workflow.

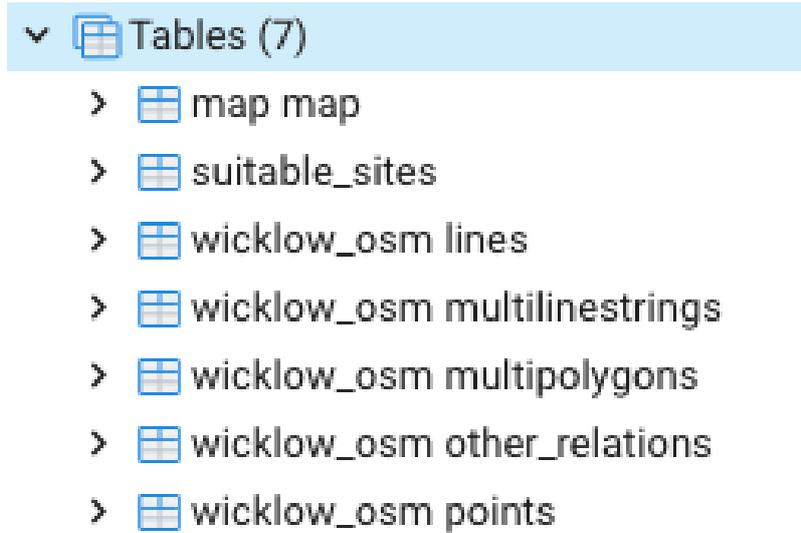


Figure 5: data base's tables, map map is the geojson file, suitable_site comes from Part 1 when it was generated by queries, all wicklows realted came from the OSM file.

3 Part: Spatial data organisation

In this section, the aim is to use relevant hstore to key and pair attributes. At this time, the local host data base used in Part 1, will be used once more. The design of a database can have a significant impact on the speed and efficiency of queries, and a poorly designed database may result in queries that do not run properly. However, there are various techniques available to improve the organization and functionality of a database, such as indexes, constraints, inheritance, and hstore.

One method for organizing databases into logical groups and facilitating their management is through the use of schemas. By grouping related tables together within a schema, database administrators can more easily control access, security, and maintenance of the database.

The OpenStreetMap project is an example of a database that was organized using the inheritance technique. Inheritance allows a table to inherit the attributes and behavior of a parent table, which can simplify the management of related tables and make queries more efficient.

Firstly, an osm schema was created, followed by the serial primary key and a parent table, and then, a child table will be added to hold the osm line data.

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```
CREATE SCHEMA osm;
```

```
CREATE TABLE osm.parent(  
gid SERIAL PRIMARY KEY,  
osm_id bigint,  
ed_id integer,  
name varchar(200),  
tags hstore,  
geom geometry(geometry,2157)  
);
```

```
CREATE TABLE osm.child_point(  
Address varchar(400),  
CONSTRAINT child_point_pk  
PRIMARY KEY (gid)  
)  
INHERITS (osm.parent);
```

```
CREATE TABLE osm.child_lines(  
CONSTRAINT child_line_pk  
PRIMARY KEY (gid)  
)  
INHERITS (osm.parent);
```

Adding a line data, and a osm polygon data created as a result:

```
CREATE TABLE osm.child_polygons(  
CONSTRAINT child_polygons_pk  
PRIMARY KEY (gid)  
)  
INHERITS (osm.parent);
```

Creating a child polygon:

```
ALTER TABLE osm.child_point NO INHERIT osm.parent;
```

3.1 Creating an example with specific numbers and administrative area.

```
CREATE TABLE administrative_areas (  
  id SERIAL PRIMARY KEY,  
  name VARCHAR(255),  
  geom geometry(Polygon, 2157)  
);
```

After that some data will be inserted. The data from Wicklow county is inserted:

```
INSERT INTO administrative_areas (name, geom)  
VALUES  
('Wicklow County', ST_Transform(ST_GeomFromText('POLYGON((-  
6.3299560546875      53.25177555492524,      -6.0333251953125  
53.25177555492524,  -6.0333251953125      52.97272320061959,  -  
6.3299560546875      52.97272320061959,      -6.3299560546875  
53.25177555492524))', 4326), 2157));
```

Points were taken from the internet and OSM map coordinate.

```
CREATE TABLE cities (  
  id SERIAL PRIMARY KEY,  
  name VARCHAR(255),  
  geom geometry(Point, 2157)  
);
```

The child level will be cities, as it was an easier data to find.

```
INSERT INTO cities (name, geom)  
VALUES  
('Wicklow', ST_Transform(ST_GeomFromText('POINT(-6.236877  
52.975301)', 4326), 2157)),  
('Bray', ST_Transform(ST_GeomFromText('POINT(-6.102123  
53.202781)', 4326), 2157)),  
('Greystones', ST_Transform(ST_GeomFromText('POINT(-6.063034  
53.145334)', 4326), 2157));
```

4 Difficulties encountered during the process

From the tools point of view, I found myself a bit lost when using AWS but I believe it is just because I was afraid of ruining what I created for another module. I am proud that I was able to progress further into analysis using SQL and other methods and solutions such as FME, creating hstore, and using more OSM contributors to collect data. I did have some trouble to download the correct data from OSM.

Conclusions and recommendations

This project had the main aim to find site selection areas for potential secondary school locations, and the use of new technologies on the studies based, such as FME, OSM data, GEOJson and AWS connection. Furthermore, this essay shows the possibilities in using GIS and how the technology can assist in engaging the community in decision making in order to bring other perspectives and how it may impact directly on interactivity from citizens in government decisions.

In closing, the use of GIS technology and tools are mutable and can be adapted depending on the objective or the project. Within politics, the type of project, data collection and analyses can involve multiple departments and can gather people's knowledge in order to define problems, and therefore the ways in which these problems can be solved.

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