

08/05/2026

Portfolio: Applied GIS and RS

GEOGRAPHICAL INFORMATION SYSTEMS AND REMOTE
SENSING TECHNOLOGIES

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1 Component 1: Digitisation and Visualisation (Mapping)

1.1 Introduction

In this component, the focus is on mapping and digitising a chosen site using vector data and exploring third-party datasets. The chosen site is Singleton Park, as it is large enough to contain a range of discrete features suitable for digitisation, including vegetation, pathways, recreational infrastructure and open green space. Mapping sites such as Singleton Park has practical applications in environmental monitoring, habitat management and urban green space planning. GIS can support decision-making by providing accurate spatial data on land use and environmental features (Bai et al., 2022).

Digitising is the process of converting visual spatial information into digital vector data within a GIS environment (Chang, 2019). This allows real-world features such as paths, vegetation and infrastructure to be represented as points, lines and polygons for spatial analysis and map production. Digitisation is widely used in environmental management, habitat monitoring and urban planning because it enables spatial features to be recorded, stored and analysed accurately within a digital database (Longley et al., 2015).

This component will explore the methodology used for creating the map before critically analysing several aspects of GIS theory, including the differences between vector and raster data, digital and traditional data collection methods for habitat mapping and monitoring, and the implications of these approaches for habitat management.

1.2 Methodology

The basemap chosen for the map was Google Satellite imagery. The primary reason for selecting this basemap was to digitise features independently rather than tracing already digitised features commonly displayed on basemaps such as Google Maps.

Distinct features were then identified for digitisation. Benches were represented using points, footpaths using lines and different land use types using polygons. These geometry types were selected based on the spatial characteristics of each feature and the intended purpose of the dataset.

Benches were digitised as points because they represent discrete locations where the exact area or shape was not important for the aims of the map. Representing benches as polygons would have increased digitising time and complexity without adding significant value.

Footpaths were digitised as lines because their primary characteristic is connectivity across the landscape, allowing potential future analysis such as route mapping. Land use areas were digitised as polygons because polygons allow boundaries and surface area to be measured, making them suitable for analysing the spatial extent of different landscape types.

A map scale of 1:4500 was selected to clearly display the digitised features while maintaining readability. Attribute tables were designed to store relevant information for each digitised feature. Field names were carefully labelled according to the purpose of the dataset to improve readability and support future spatial analysis. For example, the land use polygon layer included fields such as Land_Use, and Area_m2, while the amenities layer included fields relating to feature type. A legend and scale bar were also included to improve map interpretation and ensure the spatial data could be understood easily by users.

Additionally, third-party data was integrated to improve the analytical value of the map. Both vector and raster datasets were utilised for different purposes. The vector dataset used was OS Open Greenspace data from Ordnance Survey, which identifies publicly accessible green spaces such as parks, sports facilities and recreational land (Ordnance Survey, 2026). This dataset provided wider spatial context beyond the primary survey area and demonstrated the value of openly accessible national datasets for supporting local-scale GIS analysis. The inclusion of external vector data also highlights how GIS projects can combine field-collected information with authoritative secondary datasets to improve map interpretation.

A Sentinel-2 raster dataset from the Copernicus Browser was also incorporated as a virtual raster layer combining three spectral bands at 10 m resolution from May 2025 imagery. The raster layer provided recent satellite imagery which enhanced visual interpretation of land cover patterns and vegetation distribution within the study area. Unlike vector layers, which represent discrete features, raster data store information in a grid of cells and are well suited to representing continuous spatial variation across a surface. However, raster datasets can be limited by spatial resolution and image quality compared to detailed field digitisation (Mårtensson, 2011).

1.3 Results

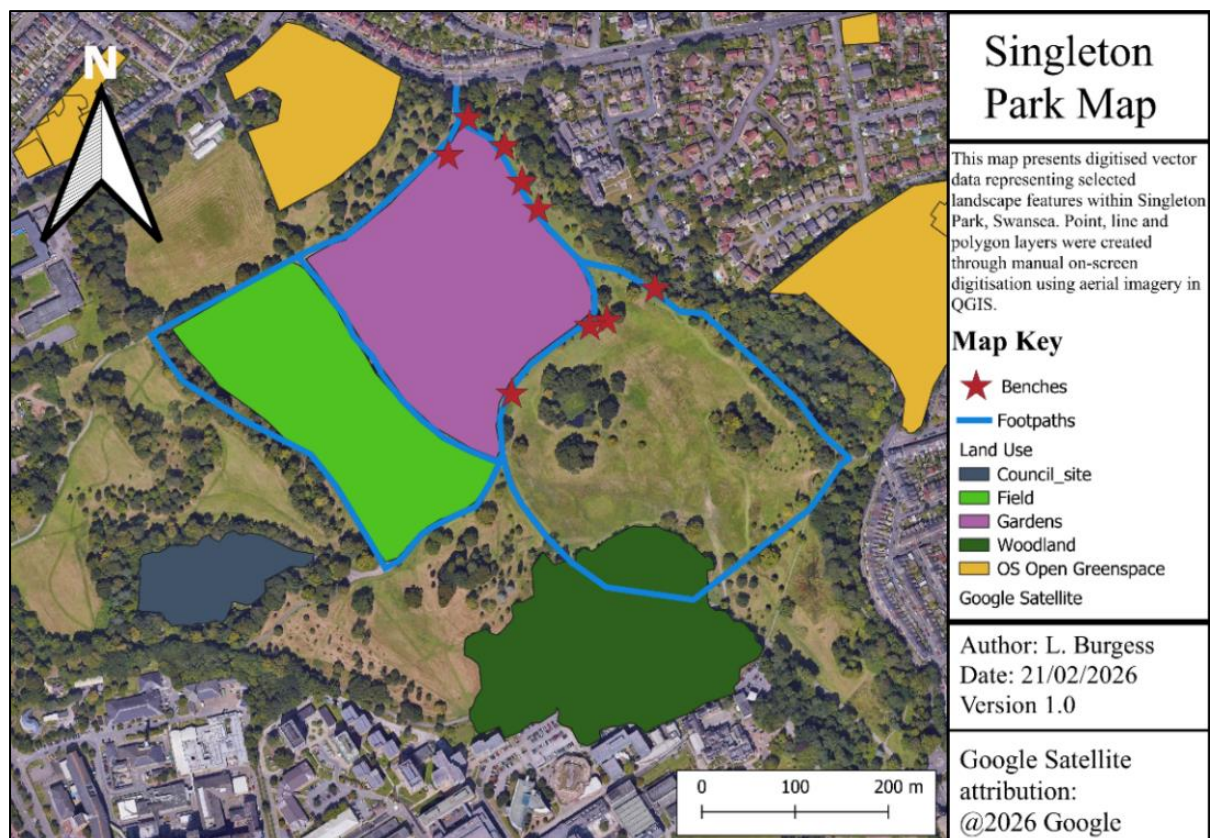


Figure 1: Digitised landscape features in Singleton Park, Swansea (Google, 2026).

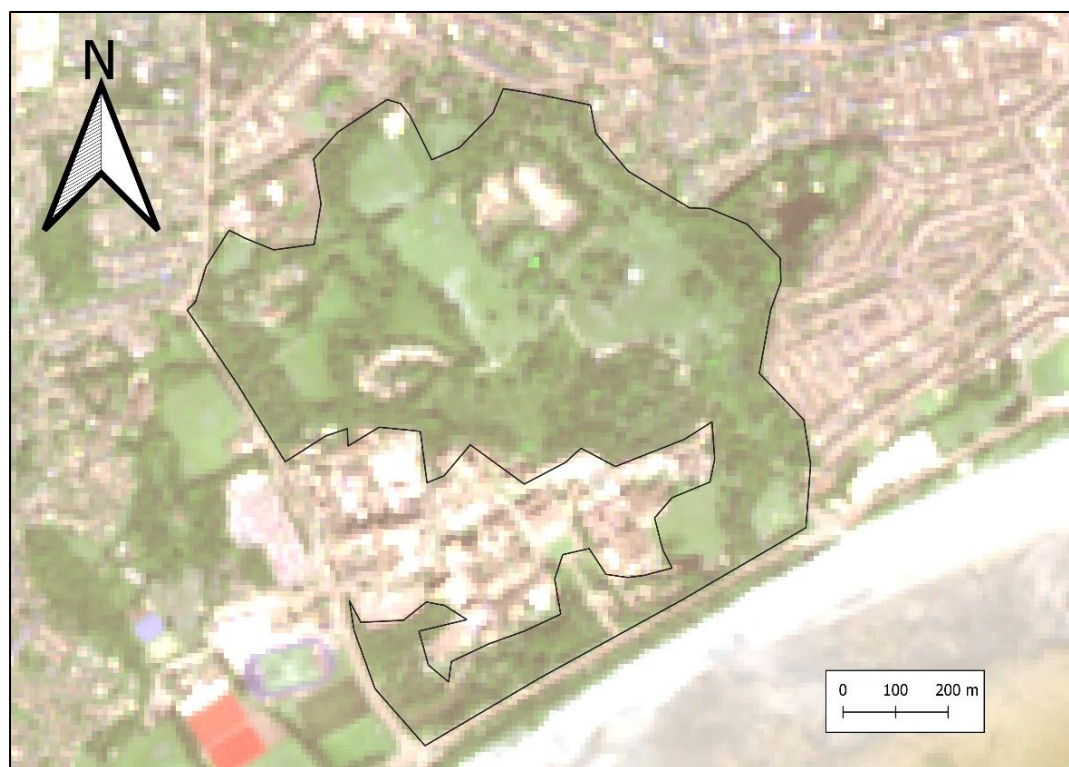


Figure 2: Sentinel-2 MSI Level-2A true-colour imagery (10 m spatial resolution) of the study area boundary (Copernicus Programme, 2025).

1.4 Discussion

Although aerial imagery allows many landscape features to be digitised efficiently, it can be difficult to accurately interpret certain features. For example, woodland, paths and open grassland, can be identified visually through differences in colour, texture and shape. However, land use classifications may involve a degree of interpretation by the digitiser because the functional use or ownership of land cannot always be directly observed from imagery alone. As an example, the category “Council_site” reflects an inferred ownership classification rather than a visually identifiable land cover type. This demonstrates how digitisation may sometimes not be totally accurate and may require additional datasets to improve classification accuracy.

This distinction reflects the wider difference between land cover and land use in GIS and remote sensing. Land cover refers to the physical material visible on the Earth’s surface, whereas land use relates to the socio-economic function or purpose of the land (Comber et al., 2005).

One limitation that was encountered during digitisation was attempting to accurately digitise footpaths under tree canopies. In several locations, footpaths were partially hidden beneath dense tree canopies, meaning their exact route could not be directly observed from the aerial imagery. In these cases, the approximate alignment of the path was estimated based on visible sections before and after canopy cover. This potentially renders the digitised path as inaccurate and demonstrates how manual digitisation can involve subjective interpretation by the operator. Such limitations are common when digitising from remotely sensed imagery, where vegetation cover can obscure underlying features (Rittger et al., 2020).

This highlights how digitisation may at times be inaccurate, as different users may interpret obscured features differently. The accuracy of manually digitised vector data is therefore influenced by image resolution, vegetation cover and the experience of the digitiser.

1.5 Conclusion

This component demonstrated how GIS digitisation can be used to map Singleton Park through the creation of vector point, line and polygon layers. It also showed the value of integrating third-party vector and raster datasets to provide wider spatial context. The process highlighted the different roles of vector and raster data, with vector layers being useful for representing discrete features and raster imagery supporting visual assessment of land cover patterns. However, the component also showed that digitisation can be limited by factors such as canopy cover and uncertainty in distinguishing land use from land cover. Overall, GIS mapping is a valuable tool for environmental habitat management, but its effectiveness is strengthened when combined with field-based observations (Álvarez-Martínez et al., 2025).

2 Component 2: Spectral Analysis

2.1 Introduction

Remote sensing relies on the measurement of electromagnetic radiation reflected or emitted from the Earth's surface (Mather & Koch, 2011). Different materials interact with radiation in distinct ways, producing unique spectral signatures based on their physical and chemical properties. Vegetation, for example, strongly absorbs red light due to chlorophyll but reflects near-infrared radiation because of internal leaf structure (Mather & Koch, 2011).

This component focuses on analysing spectral signatures from two practical investigations. The first practical involved using a spectroradiometer in a laboratory environment to measure spectral responses from physical samples. The second practical used multispectral satellite imagery of Christmas Island within QGIS to analyse different land cover types. Multispectral satellite systems such as Sentinel-2 are widely used for habitat mapping, vegetation health assessment and land cover classification. The findings are discussed in relation to spectral reflectance theory and environmental monitoring applications.

2.2 Theory Behind Spectral Signatures

Spectral signatures refer to the unique pattern of electromagnetic radiation reflected or absorbed by different materials across wavelengths of the electromagnetic spectrum. In remote sensing, these signatures allow researchers to distinguish between surface features such as vegetation, soil, water and built environments based on their reflectance characteristics (Lillesand et al., 2015). Different materials interact with incoming solar radiation in distinct ways due to their physical and chemical properties. For example, healthy vegetation typically absorbs large amounts of red light for photosynthesis while strongly reflecting near-infrared radiation because of the internal structure of leaf cells (Jensen, 2016). By measuring these variations in reflectance, spectral signatures can be used to identify, classify and monitor environmental features and changes over time. This forms the basis of many remote sensing applications, including habitat mapping, vegetation health assessment, water quality monitoring and land-use classification (Campbell & Wynne, 2011).

2.3 Physical Features Spectral Analysis

2.3.1 Methodology

Spectral signatures were extracted from physical features using a spectroradiometer in the Environment laboratory at IQ Campus on 04/02/2026. Students were instructed to collect physical objects of interest, preferably with flat surfaces to improve measurement accuracy. Samples including vegetation and rock materials were analysed using the spectroradiometer, which recorded reflectance values across visible and near-infrared wavelengths through specialist software. The analysed objects were photographed and documented to support interpretation and comparison of the resulting spectral signatures.

2.3.2 Results

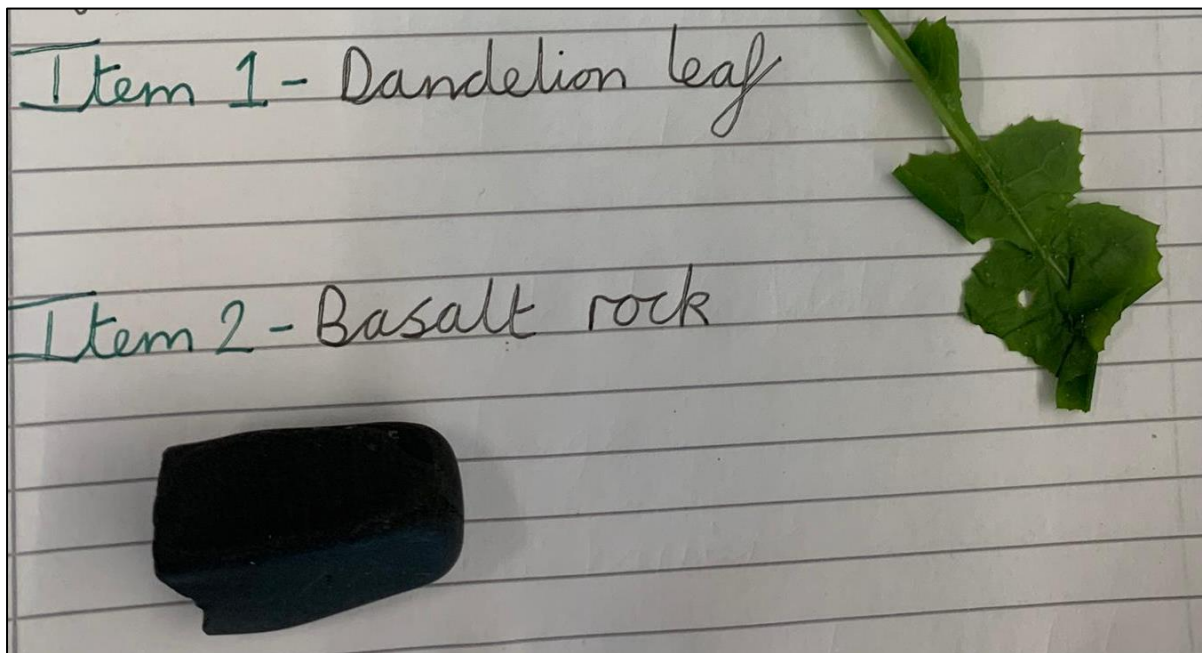


Figure 3: Samples used for analysis for Figure 4 (Author, 2026).

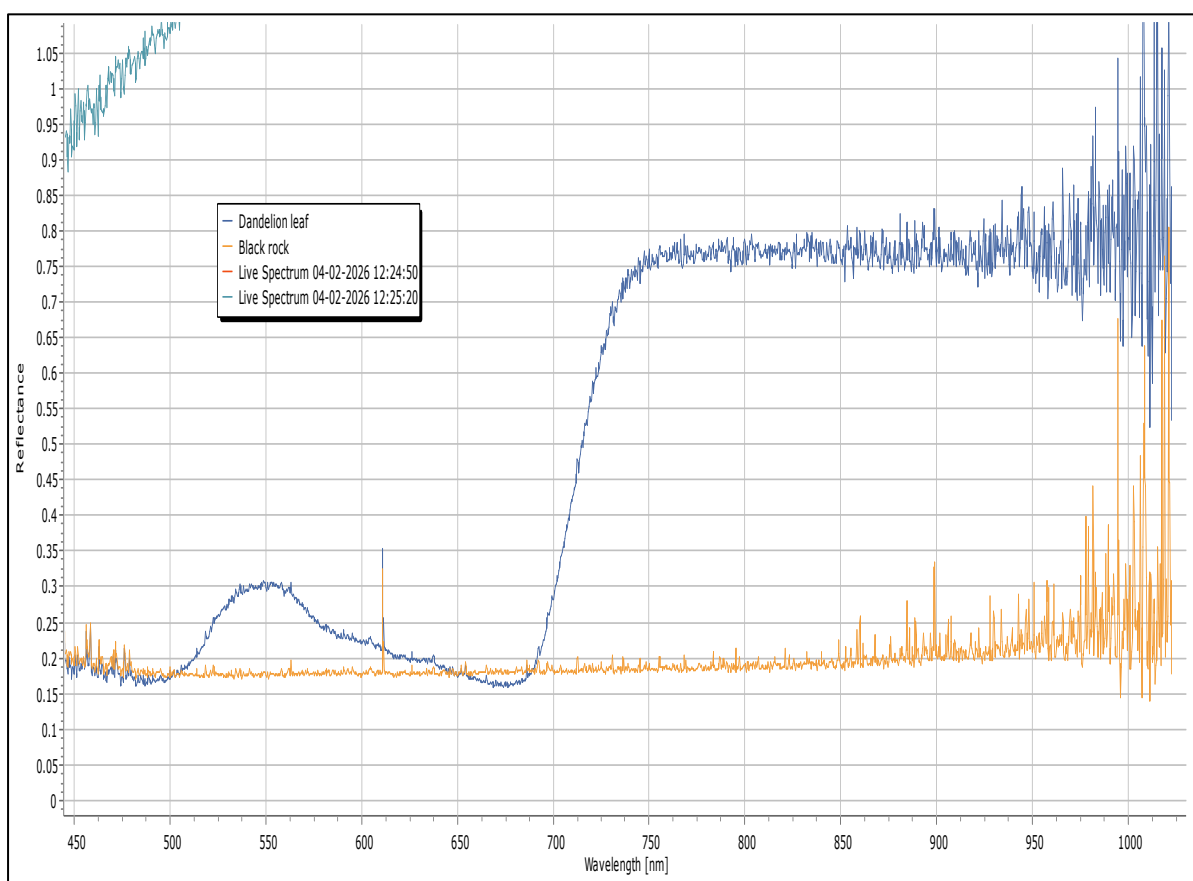


Figure 4: Spectral analysis of leaf and rock samples (Author, 2026).

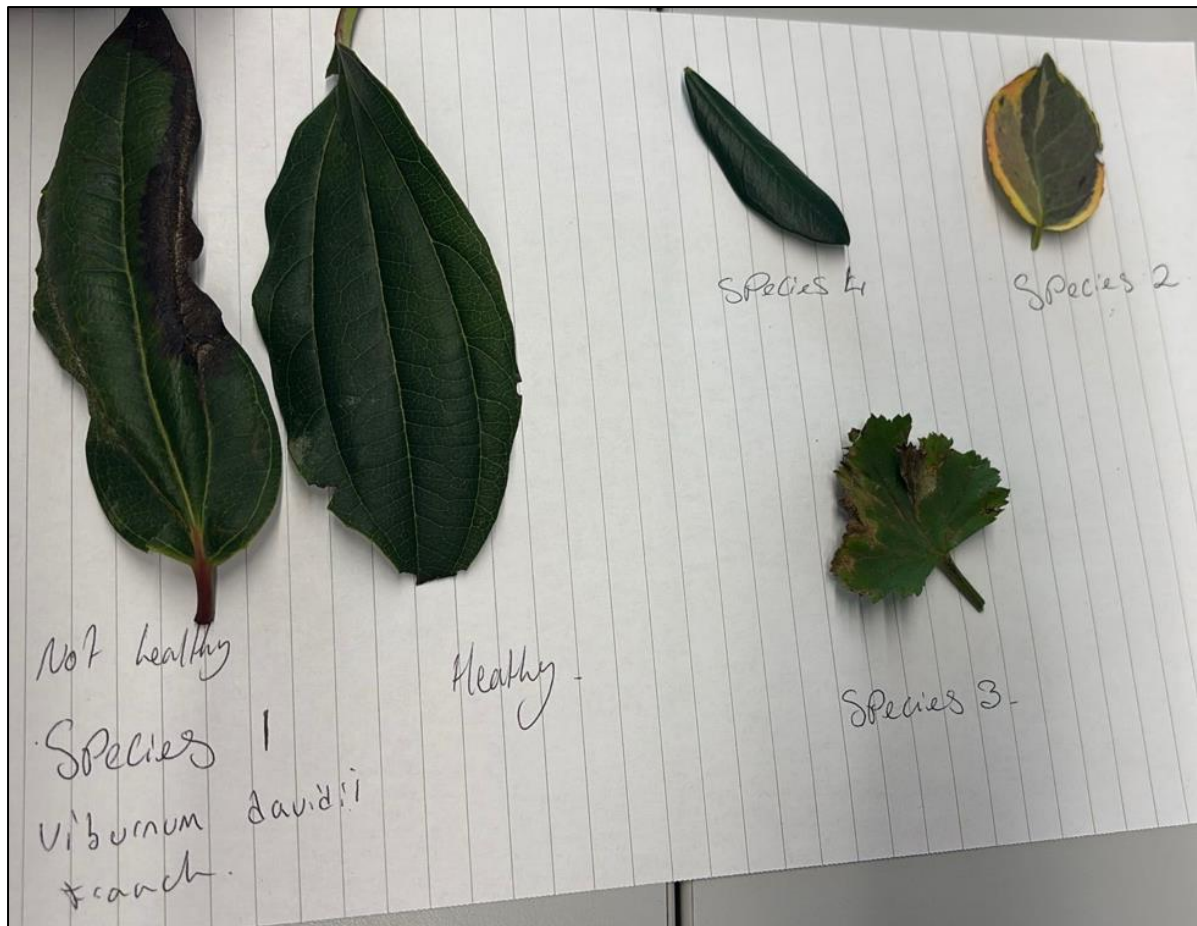


Figure 5: Samples used for analysis for Figure 6 (Tuddenham, 2026).

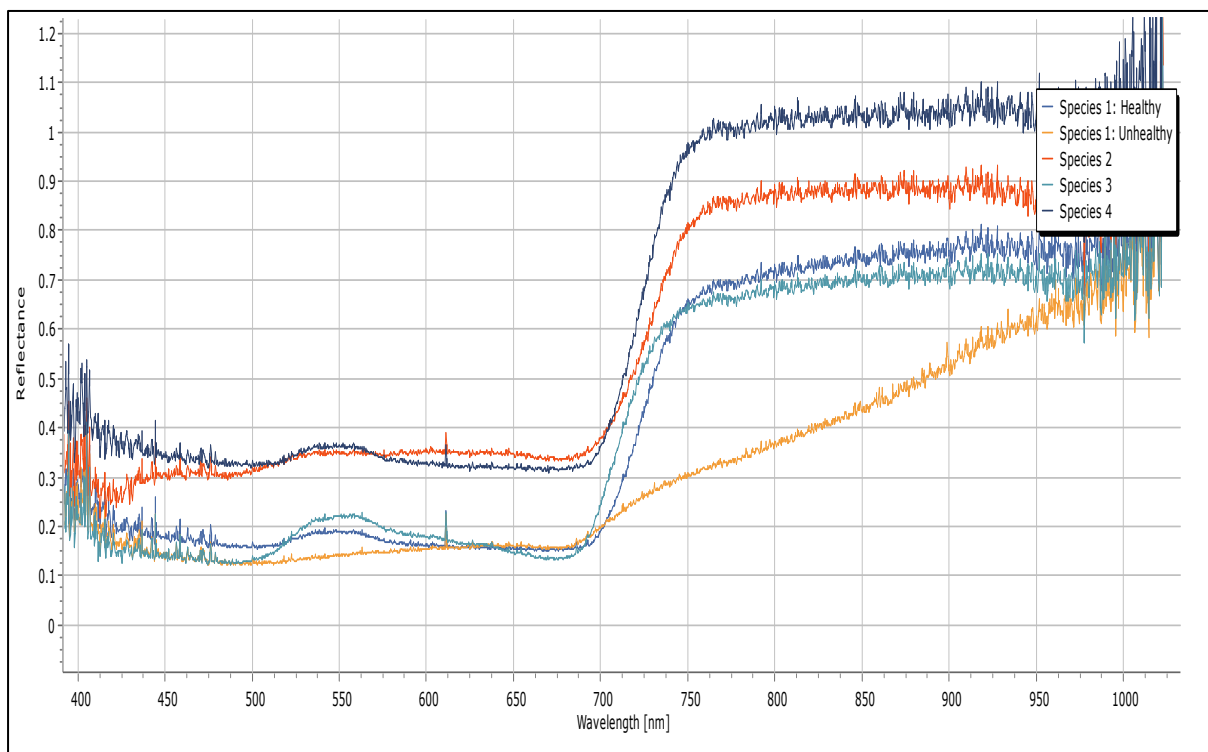


Figure 6: Spectral analysis of individual leaf samples from different plant species (Tuddenham, 2026).

2.3.3 Discussion

The sharp increase in reflectance after approximately 650–700 nm represents the “red edge”, a key characteristic of healthy vegetation. This occurs because chlorophyll strongly absorbs red wavelengths for photosynthesis, while the internal structure of the leaf reflects near-infrared radiation (Curran, 1989). The reduced reflectance observed in the unhealthy leaf suggests lower chlorophyll content and changes in leaf structure, which reduce near-infrared reflectance (NASA, 2010). This demonstrates how spectral signatures can be used to assess vegetation condition and plant stress in environmental monitoring. Remote sensing techniques using near-infrared wavelengths are commonly applied in agriculture and ecology to identify unhealthy vegetation, drought stress and disease presence across large spatial scales (Campbell & Wynne, 2011). Vegetation indices such as NDVI are derived from these spectral differences and are widely used to estimate vegetation density, biomass and ecosystem productivity from satellite imagery (Tucker, 1978).

In contrast, the basalt rock exhibited relatively stable reflectance across wavelengths. This is because non-vegetated materials lack chlorophyll and internal cellular structures, resulting in more uniform spectral responses. Variations at higher wavelengths may be due to surface roughness or mineral composition (Clark, 1999).

2.4 Christmas Island Remote Sensing Analysis

2.4.1 Methodology

Multispectral satellite imagery of Christmas Island was downloaded within a selected date range and imported into QGIS alongside a Google Satellite basemap. The downloaded imagery files were extracted and combined into a virtual raster layer using the blue, green, red and near-infrared spectral bands. This multi-band raster enhanced the visual distinction between land cover types across the island. Sampling points representing different land cover types, including beach, road, forest and runway surfaces, were then selected to extract and compare spectral signature values.

2.4.2 Results

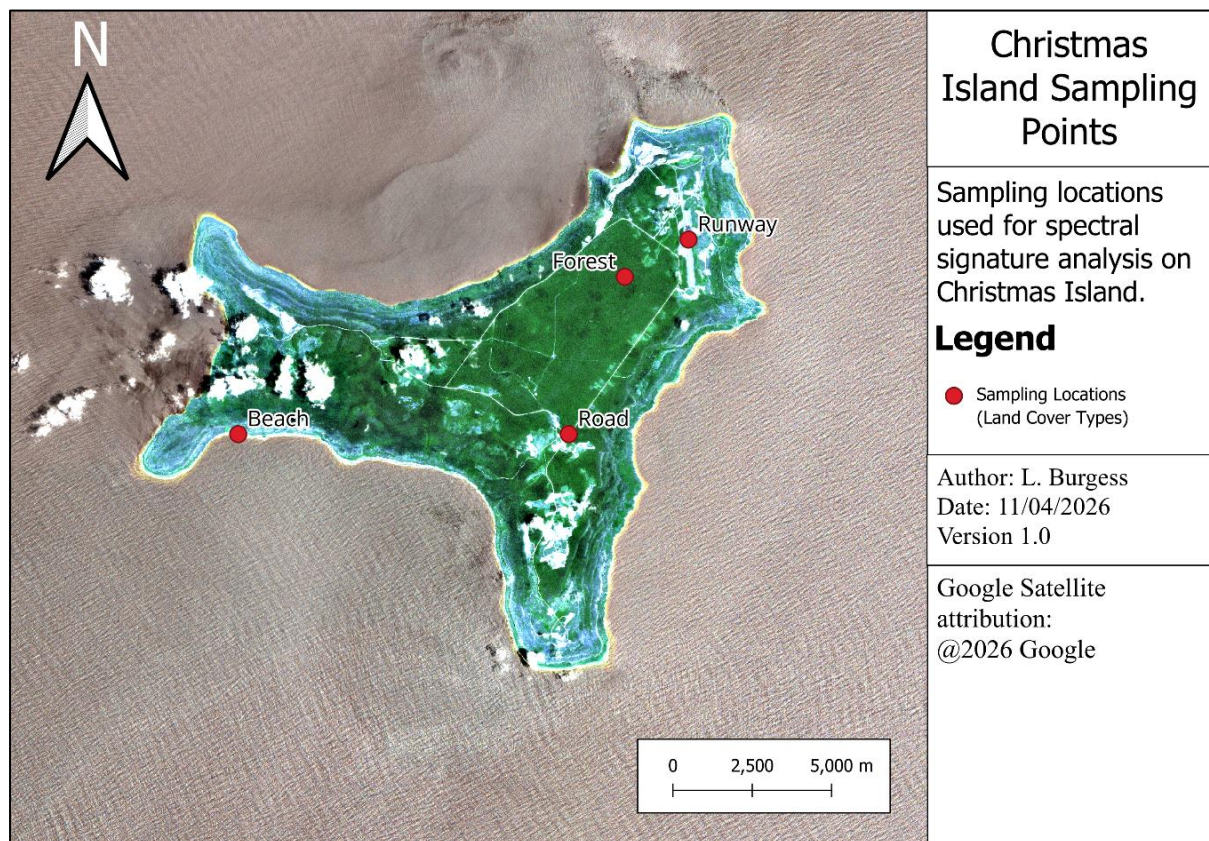


Figure 7: Sampling locations used for spectral signature analysis across different land cover types on Christmas Island.

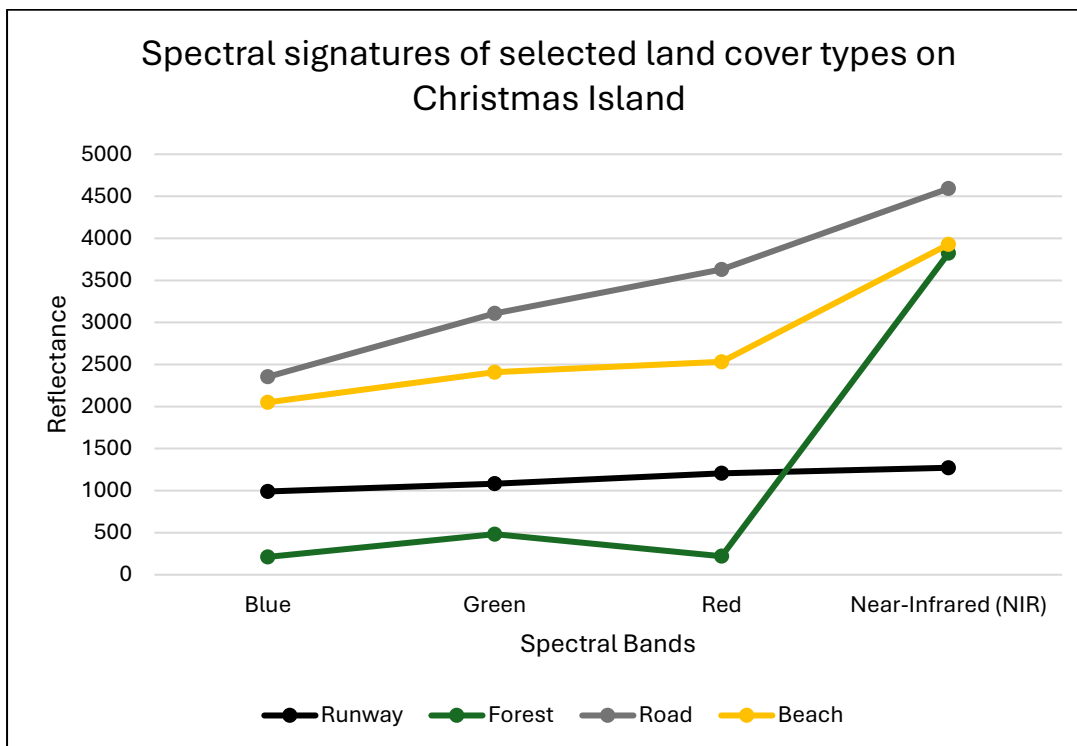


Figure 8: Spectral signatures of selected land cover types (runway, forest, road and beach) on Christmas Island, showing reflectance across visible and near-infrared bands.

2.4.3 Discussion

The significant increase in reflectance in the near-infrared band for the forest sample is consistent with vegetation spectral behaviour. Healthy vegetation reflects strongly in the near-infrared region due to leaf cellular structure, making this band particularly useful for vegetation detection and monitoring (Knipling, 1970). This principle underpins vegetation indices such as the Normalised Difference Vegetation Index (NDVI), which is widely used to assess vegetation health and density (Pettorelli et al., 2011). Similar approaches have been used in studies monitoring deforestation, agricultural productivity and ecosystem degradation, demonstrating the importance of near-infrared data in large-scale environmental management and habitat assessment (Pettorelli et al., 2011).

The relatively stable reflectance of the runway is typical of artificial surfaces such as concrete or asphalt, which lack biological properties and therefore do not exhibit strong variation across spectral bands (Herold et al., 2004).

The similarity between road and beach reflectance curves suggests that both surfaces have relatively low and gradually increasing reflectance across wavelengths. This can make them more difficult to distinguish without additional spectral bands or higher-resolution imagery, highlighting a limitation of spectral classification (Herold et al., 2004).

2.5 Wider Applications and Limitations

Spectral signatures have multiple applications for habitat monitoring and landscape mapping. For example, spectral signatures have been widely used in aquatic monitoring because water absorbs much of the near-infrared region, while algae, sediments and other constituents modify reflectance in the visible wavelengths (Klemas, 2012).

For example, satellite remote sensing has been used to detect algal blooms in lakes and coastal environments. Chlorophyll-a within algae increases reflectance in green wavelengths while reducing reflectance in blue and red wavelengths. These spectral differences allow researchers to identify algae bloom intensity and distribution to aid in habitat management without extensive field sampling (Arias et al., 2025).

However, spectral analysis should be used alongside field-based monitoring rather than as a standalone approach. Although remote sensing is valuable for synoptic and repeated water-quality assessment, on site measurements remain important for calibration, validation and the assessment of related ecological conditions such as dissolved oxygen and other water-quality variables (Lausch et al., 2024)

2.6 Conclusion

In conclusion, the spectral signature analysis demonstrated how different materials interact uniquely with electromagnetic radiation across visible and near-infrared wavelengths. Vegetation samples showed a characteristic “red edge” and strong near-infrared reflectance, while non-vegetated surfaces such as basalt and runway materials exhibited more stable spectral responses. The findings highlighted the importance of spectral data in distinguishing between land cover types and assessing vegetation condition. Both the laboratory and satellite-based practicals demonstrated the value of remote sensing for environmental monitoring, habitat mapping and land cover classification. However, similarities between some land cover types also highlighted limitations associated with spectral resolution and classification accuracy.

3 Component 3: GIS Field Data Collection

3.1 Introduction

GIS has a wide range of applications, one of which is field data collection for environmental assessment. Using mobile GIS applications such as Mergin Maps, which can be synchronised with QGIS, spatial data can be collected directly in the field and integrated into a GIS project in real time. This improves both efficiency and positional accuracy compared to manual recording methods.

This component presents a GIS-based field survey conducted at Jersey Park, Swansea. The aim of the survey is to establish a baseline assessment of biodiversity and site features, using a method that can be repeated in future to monitor ecological change and inform park management.

3.2 Site Description



Figure 9: Site Map of Jersey Park.

Jersey Park is a small urban green space located in Port Tennant, Swansea, within a predominantly residential area. The park is easily accessible and functions as a local recreational space.

The site contains a mixture of open grassland, scattered trees and a network of paved footpaths, alongside built features such as benches and entrances (Swansea Council, 2026). This variation in land cover creates multiple micro-environments within a relatively compact area.

The presence of both natural and anthropogenic features makes the site suitable for GIS-based biodiversity assessment. Urban parks such as Jersey Park play an important role in supporting biodiversity within built environments, particularly where habitat diversity is limited.

Existing biodiversity records for the site are minimal, with only one recorded species (ladybird) in 2024 (NBN Atlas, 2024). This highlights a lack of baseline ecological data.

Under Section 6 of the Environment (Wales) Act 2016, public authorities such as Swansea Council have a duty to maintain and enhance biodiversity (Welsh Government, 2016). Establishing a repeatable baseline survey of Jersey Park can therefore support future monitoring and inform management decisions aimed at improving biodiversity.

3.3 Methodology

The aim of this survey was to establish a repeatable baseline assessment of biodiversity and site characteristics at Jersey Park. Baseline biodiversity monitoring depends on consistent, repeatable methods so that ecological change can be compared over time and management outcomes can be evaluated. The methodology was designed to allow future surveys to replicate the data collection process and monitor ecological changes over time (Dalton et al., 2024).

A GIS-based field survey approach was used, combining mobile data collection with structured spatial layers. Four GeoPackage layers were created: trees (point), amenities (point), paths (line), and land use (polygon). These layers were selected to capture both ecological features and human influences on the site. Comprehensive biodiversity monitoring often requires spatial information on habitats, species, and site pressures rather than species records alone (Ecker et al., 2023).

The inclusion of land use polygons allows identification of habitat types (e.g. managed grassland, tree cover), which are important indicators of biodiversity potential and ecological condition (Harris et al., 2021). Tree data provides insight into species diversity and condition, while mapping wider site features contributes to biodiversity assessment by supporting the identification and management of habitat characteristics relevant to ecological quality (Ferris & Humphrey, 1999).

Attribute data were designed to support ecological interpretation:

- **Trees:** species, condition, notes
- **Amenities:** type, condition, notes (representing human pressure)
- **Paths:** surface, condition, width (m) (indicating accessibility and disturbance)
- **Land use:** category (e.g. grassland, tree cover, built area)

Field data was collected using Mergin Maps on a smartphone, synchronised with QGIS. This supports efficient mobile GIS data capture and integration with desktop GIS workflows.

A systematic walking survey was conducted, covering the entire park. The site was traversed multiple times, with each pass focusing on a different data layer to help improve coverage and reduce omission errors. This structured and repeatable approach strengthens the value of the dataset as a baseline for future biodiversity surveys, allowing comparisons over time to assess whether management interventions improve ecological conditions at the site (Dalton et al., 2024).

3.4 Results



Figure 10: Jersey Park Survey Results (Author, 2026)



Figure 11: Illustrates the spatial distribution of surveyed tree species across Jersey Park. Broadleaf species were the most recorded, while ornamental and willow species were more spatially isolated.

The GIS survey successfully mapped a range of spatial features within Jersey Park, including land use zones, paths, amenities and tree species distributions (Figures 10 and 11). The results show that grassland was the dominant land use type within the site, occupying most of the central and northern sections of the park. Recreational facilities including a bowls court, basketball court and playground were also identified and digitised as polygon features. Linear path features formed a connected network around the park perimeter and through central sections of the site, demonstrating accessibility across the area.

Point data collected during fieldwork identified the distribution of trees and park amenities. Tree locations were concentrated primarily along the park boundaries and near footpaths, with a variety of species recorded including broadleaf, pine, willow and silver birch. Broadleaf species were the most identified tree type across the site. Amenities such as benches and park facilities were generally located adjacent to paths and recreational areas, reflecting areas with the highest visitor use.

The integration of field-collected point data with desktop-digitised polygon and line features produced a comprehensive spatial overview of Jersey Park and demonstrated the effectiveness of combining mobile GIS field collection with GIS-based analysis and visualisation (Nowak et al., 2020).

3.5 Discussion

The survey demonstrates the effectiveness of GIS field data collection methods for recording and visualising environmental and recreational features within Jersey Park. Using Mergin Maps in the field allowed spatial data to be collected directly on site and synchronised with QGIS for map production and visual interpretation (Leaver et al., 2018). Point features such as trees and amenities were particularly suitable for field collection because their locations and characteristics could be verified directly in person. Recording tree species during fieldwork also improved data reliability compared to relying solely on aerial imagery.

Linear path features and polygon land use areas were mapped to provide a broader representation of park accessibility and land cover distribution. In QGIS, the collected features were categorised and symbolised using different colours to improve map clarity and make distinctions between feature types easier to interpret. This supported clearer visual communication of the survey results without changing the original spatial data collected in the field.

The survey also highlighted the importance of selecting appropriate geometry types for different spatial features. Points effectively represented individual trees and amenities, lines represented connected path networks, and polygons were appropriate for larger land use areas such as grassland and recreational spaces. This shows how GIS data structure influences the way spatial information can be organised, displayed and used in later analysis.

Overall, the methods used successfully produced a detailed baseline dataset for Jersey Park. The combination of field-based mobile GIS data collection and desktop visualisation demonstrates how these technologies can support biodiversity monitoring, park management and future repeat surveys to assess environmental change over time (Leaver et al., 2018).

3.6 Conclusion

In conclusion, GIS field data collection methods successfully produced a detailed spatial dataset for Jersey Park using Mergin Maps and QGIS. The combination of point, line and polygon features enabled a wide range of environmental and recreational characteristics to be mapped and presented effectively. Field collection improved the accuracy of discrete features such as trees and amenities because these could be verified directly on site. The use of QGIS for categorisation and visualisation helped communicate the data clearly through map design and symbology. Although some limitations were identified, including the challenges of representing complex landscapes through simplified geometry types, the survey demonstrated the overall value of GIS technologies for environmental monitoring. The resulting dataset could support future biodiversity assessments and park management activities.

4 Portfolio Conclusion

Across this portfolio, digitisation and visualisation, spectral analysis, and GIS field data collection have been shown to play complementary roles in habitat mapping and environmental management. Rather than functioning as isolated techniques, their greatest value lies in combination. Digitisation provides a clear and accessible way to represent spatial features such as paths, land-cover boundaries and site infrastructure, allowing a landscape to be organised into usable map layers for interpretation and decision-making. Spectral analysis adds a further layer of understanding by identifying differences in reflectance between materials, making it possible to distinguish vegetation and other land-cover types in ways that are not always visible from aerial imagery alone. Field data collection then provides the essential ground-level evidence needed to verify mapped features and record attributes that cannot be confidently inferred from imagery, such as habitat condition, species presence, or disturbance. Together, these approaches create a more complete spatial picture of a site and strengthen the evidence base for management decisions (Burke et al., 2023).

This combined value is reflected in wider conservation practice. (Fuller et al., 1997) demonstrated that integrating field surveys with satellite remote sensing in Sango Bay, Uganda, could produce biodiversity-related habitat maps suitable for longer-term conservation assessment. Similarly, (Zharikov et al., 2005) showed that aerial photography combined with GIS and ground data could map estuarine landscapes in Moreton Bay, Australia, with classification accuracies of 77–88%, highlighting the practical usefulness of geospatial techniques for wildlife conservation and management. These examples show that such technologies are especially valuable where managers need to monitor large or complex sites efficiently, identify habitat patterns, and prioritise areas for further survey or protection (Fuller et al., 1997) (Zharikov et al., 2005).

However, this portfolio also demonstrates that these methods should not be treated as fully objective or sufficient on their own. For example, digitised outputs are shaped by the interpretation of the user, including decisions about where boundaries begin and end, or how land use is inferred from imagery. Likewise, remote sensing can identify broad spatial patterns, but the level of habitat detail and condition that can be assessed remains dependent on image resolution, classification approach, and the availability of high-quality field reference data (Burke et al., 2023). Observer bias is also a recognised issue in habitat mapping; (Cherrill & Mcclean, 1999) found considerable variation between surveyors mapping the same site, showing that even standardised approaches involve subjectivity.

Overall, these technologies are best understood as decision-support tools rather than replacements for field data. Their principal strength lies in their ability to integrate visual, spectral and field-based evidence into a coherent spatial framework for conservation planning. When applied critically and supported by field verification, they can improve the efficiency, transparency and reliability of site management. Equally, their limitations mean that conservation decisions should not rely on mapped outputs alone, but on a balanced interpretation of geospatial data and more traditional field data (Aspinall, 1999).

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