Creating an integrated web-based geographic information renewable energy assessment toolkit

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1. Introduction

There is a continual demand for investment into and development of the renewable energy market, as pressures and drivers on the energy production industry remain abundant: from providing energy security to meeting CO_2 emission targets. In the UK, the 2020 renewables target aims to deliver 15% of our energy demand from renewable sources (DECC, 2011). Furthermore, applying a sustainable development approach is paramount to providing holistic and practical solutions to decision-makers. This research highlights the opportunities that geographic information approaches and spatial decision support can offer when addressing sustainability challenges surrounding renewable energy installations.

The project aimed to develop a renewable energy land suitability assessment tool that considers: onshore wind, solar, and biomass energy scenarios in the UK. Each scenario considers an array of ecological, environmental and infrastructure constraints. The system designed incorporates a data catalogue; Geographic Information System (GIS) desktop model with integrated spatial decision support using ArcGIS 10.1 and Placeway's CommunityViz Scenario 360 suitability analysis tool; and a web user interface design for retrieving system attributes. The Isle of Wight was used as a case study region.

This project was supported by WSP Group; as a result, the toolkit was designed to have both external and internal applications within the organisation's GIS, Development, Environment & Energy teams, ranging from: a complementary desk survey tool to assist WSP Group professionals performing site investigations, through to the strategic planning level, in identifying future locations for renewable energy development opportunities.

2. Aims and Objectives

2.1 Scope

This research project aimed to develop a renewable energy land suitability assessment tool that contained:

- onshore wind, solar, and biomass energy scenarios in the UK. To provide an integrated and sustainable development approach, each scenario considers an array of ecological, environmental and infrastructure constraints.
- renewable energy site suitability indicator, searchable by location.
- web-based user interface.

The scope was restricted to consider:

- commercial-scale installation sites and energy demands, using existing infrastructure, and within a rural setting; and
- the Isle of Wight as a prototype region, with capabilities for UK-wide model expansion incorporated into the model design.

2.2 Target audience and applications

The prototype toolkit was designed to have both external and internal applications within WSP Group's GIS, Development, Environment & Energy teams. The tool's purpose is to assist potential clients, such as a facilities manager or land owner, with limited planning and development knowledge, by providing an initial online assessment that identifies the planning constraints and suitability of their land prior to receiving consultation.

The desktop model components not only power the web tool, but provide their own set of services to assist WSP Group professionals, as a complementary desk survey tool. Such applications include: responding to site enquiries efficiently and effectively; as a reference tool prior to site visits and proposal stages; preparing Environmental Impact or Sustainability Assessments; and, at the strategic planning level, identifying future locations for renewable energy development opportunities.

2.3 Purpose for the research

The following drivers for the research were identified: first, the need to identify broad locational factors for renewable energy installation, prior to detailed micrositing and layout; second, no similar web tool was identified and current web tools typically provide resource potential and projection calculators, focus on a single renewable technology and contain installation or planning application guidance notes; and, finally, the lack of clear checklists or suitability indicators for a landowner’s plot.

2.4 Providing an ‘integrated’ solution?

To provide an integrated solution, the toolkit must feature:

- multi-component architecture
- web-integrated - cross-platform solution (web and desktop)
- integrated assessment - multi-disciplinary, suitability assessment, across all three sustainability domains
- integrated participation - non-expert and expert audiences
- integrated renewable system solutions - multiple renewable installation consideration at a site
- countrywide integrated solution - a toolkit that has a resilient architecture for expansion across Great Britain

3. Stages of Model Development

3.1 System Architecture

The system design (Figure 1) was developed from the Densham, P. (1991) SDS system architecture model. Here, the model has been adapted for cross platform use in order to reach different target audiences, whereas traditionally a single platform and/or decision making process is depicted. The architecture incorporates: a data catalogue (the Database Management System); Geographic Information System (GIS) desktop model with integrated spatial decision support, using ArcGIS 10.1 and Placeway's CommunityViz Scenario 360 suitability analysis tool (the Model Base Management System); and web and desktop user interfaces for retrieving system attributes, and generating reports from each platform.

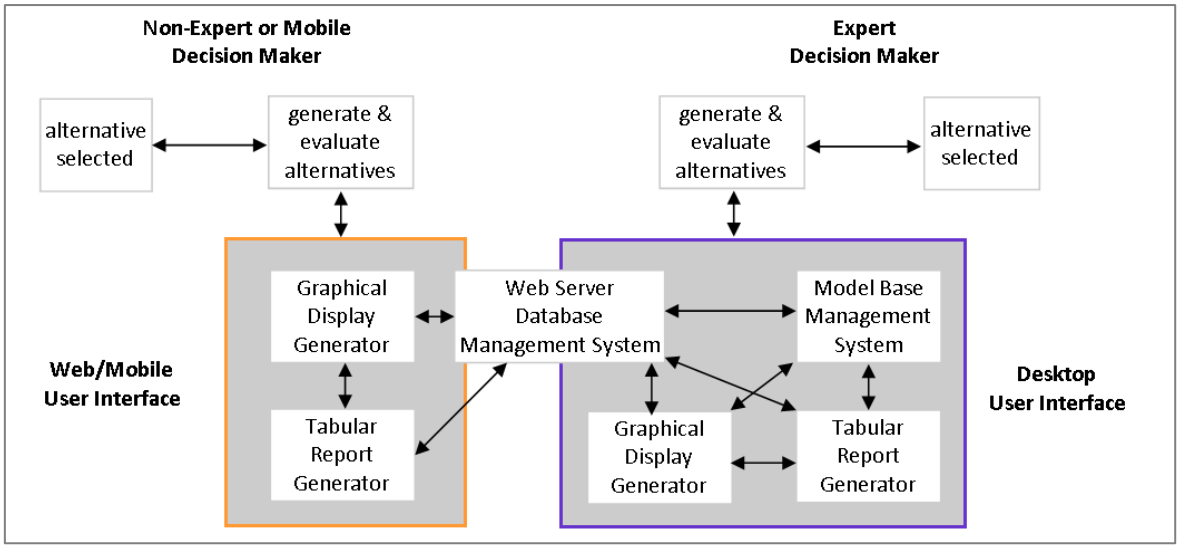


Figure 1. The proposed Spatial Decision Support System architecture (Wood, P., 2013; after Densham, P., 1991).

3.2 Renewable Energy Siting Criteria

An integrated assessment approach was adopted, considering built and natural environment impacts and planning restrictions. Criteria were assembled from a literature review, followed by review and discussion with WSP Group. The following adapted sources were used: Perpina, C. et al, (2013); Ownergy (2011); Sánchez-Lozano et al, J. (2013); Palmer, D. et al (2011); Baban & Parry, (2001); Isle of Wight AONB Partnership, (2008), and (2010); DECC, 2013.

Siting Factors were grouped as follows for all scenarios and criteria set for performing the analysis:

- Resource Potential
- Land Roughness & Interference
- Ecological Protection
- Land Use
- Population Impacts
- Proximity to National Grid
- Transport Infrastructure
- Height and Depth restrictions

3.3 Compiling the Data

All the datasets used were subject to open data license agreements, allowing the model to be commercially viable on completion, except the Ordnance Survey Postcode Polygon Data. These data were obtained under an academic Edina Digimap license while conducting the research but, in a commercial setting, would have costs associated with its use.

For each siting criterion a suitable dataset was identified, downloaded and formatted to create the geo-database management system. A selection of siting factor data and visualisations in ArcGIS for the Isle of Wight case study region are illustrated in Figure 2.

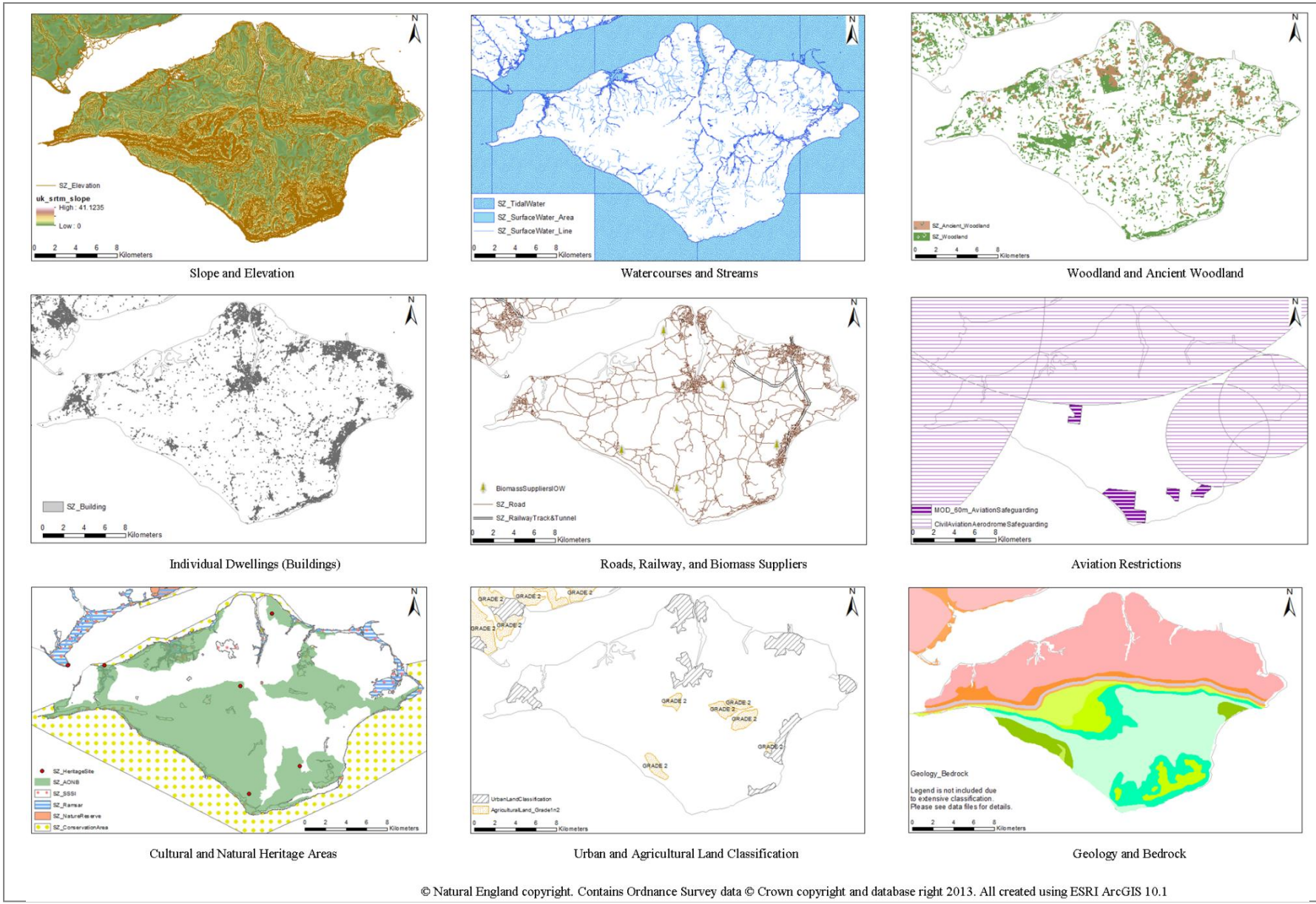


Figure 2. Siting factor original data layers for Isle of Wight

3.4 Desktop Model Development - Isle of Wight Spatial and Suitability Analysis

3.4.1 Overlay analysis

The siting criteria dictated the buffers to be performed on each corresponding data set for each scenario. The layers from this overlay analysis were organised using CommunityViz Scenario Management tools and the suitability indicator assessment was performed for the three renewable energy scenarios using CommunityViz's Suitability Indicator wizard.

The symbolisation and classification of each scenario's results were customised using a three level colour ramp and equal interval classification. The outputs (Figure 3) illustrate clearly areas of good, fair and poor suitability per scenario and, when combined with the spatial analysis layers, specific factor coverage and interference can be checked and examined (Figure 4). This suggests that when dealing with many analysis factors, spatial decision support tools can aid the interpretation process and help prioritise results for decision-makers. This is particularly appropriate when a consultant or manager is looking for an indication prior to a detailed assessment or site survey.

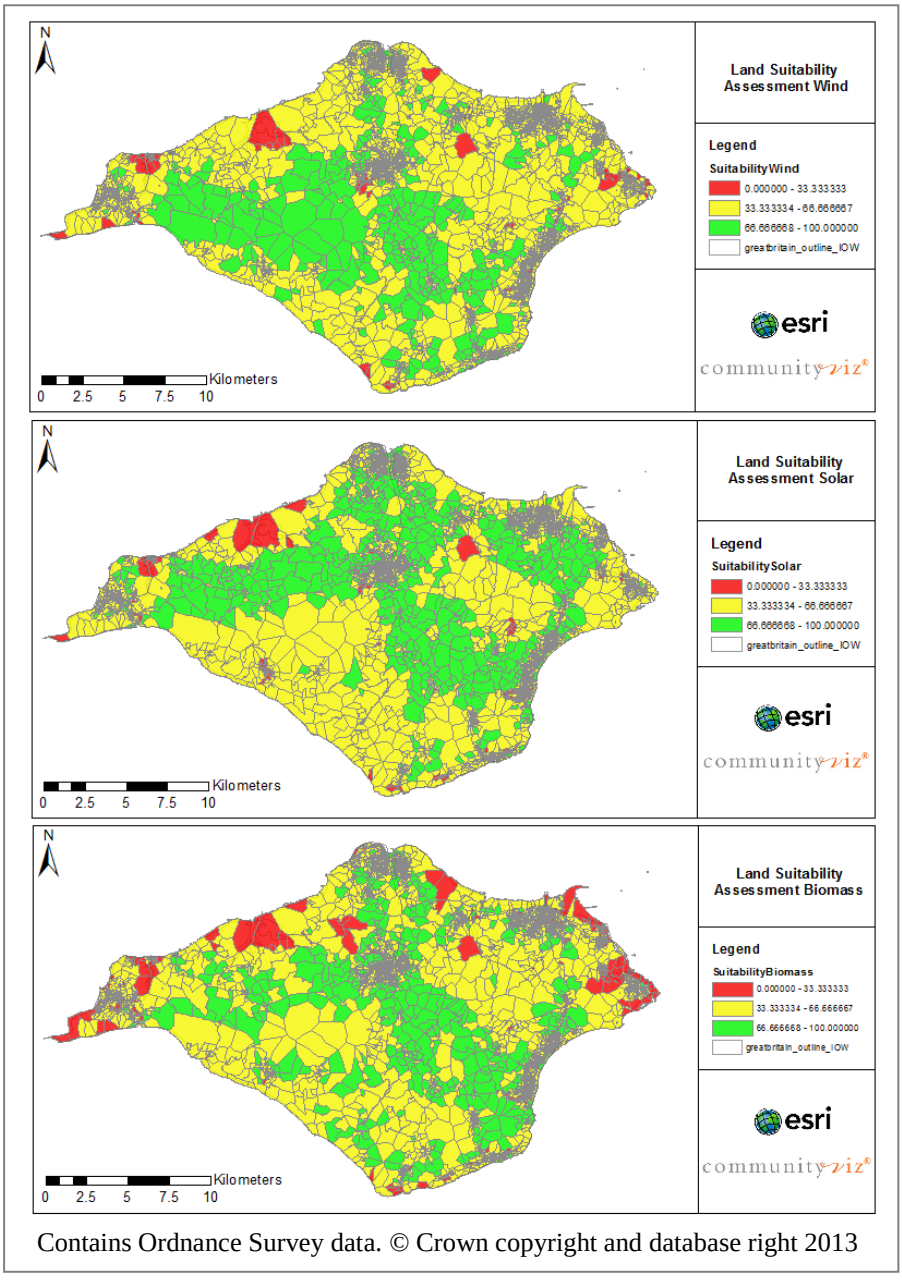
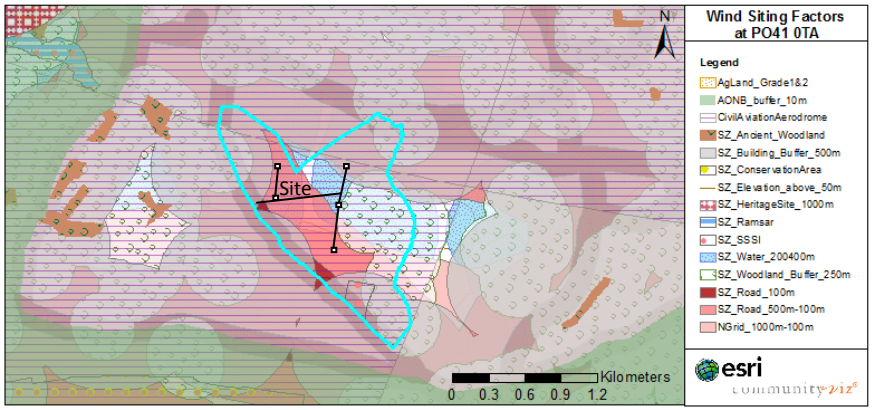
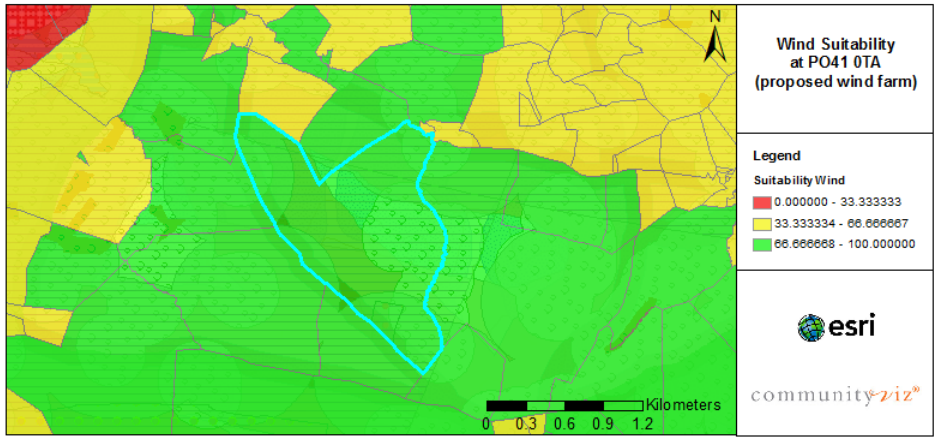


Figure 3.
Suitability Comparison for Wind, Solar and Biomass scenarios

3.4.2 Case Study Sample Desktop Model Report - Wind

Figure 4. *Wind Scenario* - Comparison between desktop model overlay analysis and suitability prediction at a proposed wind farm at Broad Lane, Isle of Wight





SITE DESCRIPTION	Land south of Wellow, off Broad Lane Shalcombe, Yarmouth Isle Of Wight PO41	
SCENARIO	**Wind**	
SITE POSTCODE	**PO41 0TA**	
PC_AREA	PO	
LOCATION (LAT/LONG)	1°27'47.362"W 50°41'3.232"N	
OBJECTID	4813	
Shape	Polygon	
Shape_Area (m²)	1680544.87	
Shape_Length (m)	6765.19	
SITING FACTOR	**SUITABILITY VALUE**	**INDICATOR**
CivilAerodromeBuffer	0.000664	✗
AgriculturalLandGrade1n2	100	✓
AncientWoodland	100	✓
AONB	100	✓
BuildingBuffer500m	67.128448	?
ConservationArea	100	✓
Elevation_above50m	100	✓
HeritageSite_1000m	100	✓
MinistryofDefence60m	100	✓
NationalGridProximity	23.369521	✗
Railway50m	100	✓
Ramsar	100	✓
RoadAccess500m	59.671581	?
RoadSafety100m	82.464465	?
SSSI	97.247256	?
UrbanArea600m	100	✓
WaterProximity200/400m	23.929293	✗
WoodlandProximity250m	58.565633	?
Suitability Wind	80.276887	**Good**

✓	No Constraint (score 100)
?	Possible Constraint (score 99-50)
✗	Definite Constraint (score under 50)

3.5 Web User Interface Development

The web interface provides the following advantages over a desktop or stand-alone system:

- essential information, and attributes of the desktop model, can be communicated to the user, providing a quick indication or initial assessment prior to detailed review;
- a comparative checklist for multiple renewable suitability, so hybrid installations maybe considered for a location;
- a tool that is not reliant on training, specialist software and the need for multi-seat licenses; and
- ease of access for employees and clients in a mobile solution.

Figure 5 illustrates the user-completed web form while Figure 6 depicts the web interface of the site suitability assessment results as a tabular report with a suitability indicator across all the renewable energy scenarios, (the location is the same as the wind case study site - Figure 4).

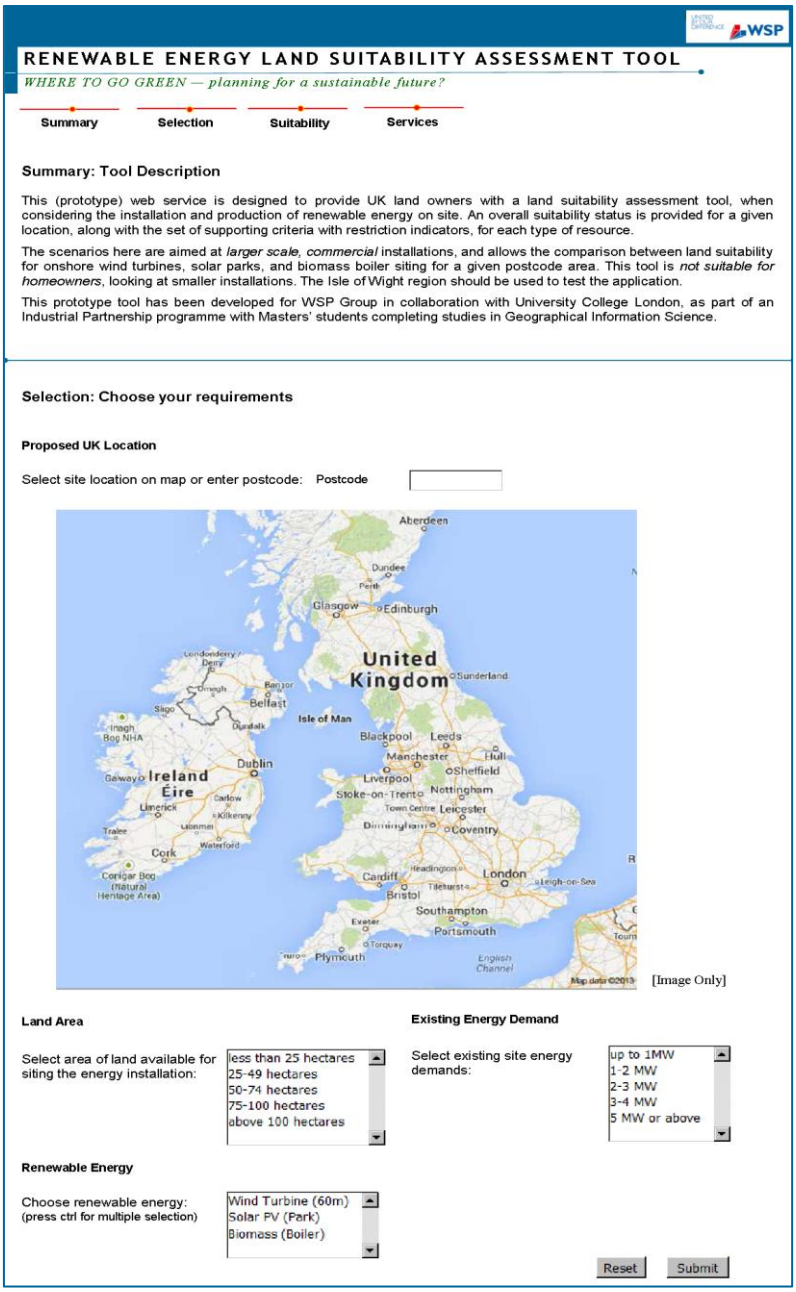


Figure 5. Prototype web user interface and form.

RENEWABLE ENERGY LAND SUITABILITY ASSESSMENT TOOL

WHERE TO GO GREEN — planning for a sustainable future?

Summary | Selection | Suitability | Services

Suitability: Renewable Energy Assessment Results

No Restriction/ within criteria	✓	Restriction/ not within criteria	✗
Possible Restriction	?	Not Applicable No Data	n/a —

	Wind (60m)	Solar PV (Park)	Biomass (Boiler)
Renewable Potential/Supply			
Wind Speed (NOABL)	✓	n/a	n/a
Optimal Solar Irradiation (Solar PVGIS)	n/a	✓	n/a
Biofuel Suppliers	n/a	n/a	?
Land Roughness/Interference			
Slope	✓	✓	✓
Aspect/Orientation	—	—	—
Elevation	✓	n/a	n/a
Woodland Proximity	?	?	?
Water Proximity	✗	?	?
Ecological Protection			
Ancient Woodland Restriction	✓	✓	✓
AONB Restriction	✓	✓	n/a
Conservation Area	✓	✓	✓
Ramsar (Protected Wetland) Area	✓	✓	✓
SSSI Restriction	?	?	?
Land Use			
Grade 1 and 2 Agricultural Land	✓	✓	✓
Urban Area Proximity	✓	n/a	n/a
Green Belt Area	✓	✓	n/a
Cultural Heritage Site	✓	✓	n/a
Population Impacts			
Building Proximity	?	?	n/a
Air Quality Management Areas	n/a	n/a	✓
Transport Infrastructure			
Road Proximity (Access)	?	?	?
Road Proximity (Safety)	?	?	?
Railway Proximity	✓	✓	✓
National Grid Proximity			
Cable Proximity	✗	✗	✗
Height and Depth Restrictions			
Civil Aviation Safeguarding Restrictions	✗	n/a	n/a
Military of Defence Aviation Restrictions	✓	n/a	n/a
N. Grid Overhead Cable Proximity	—	n/a	n/a
N. Grid Pipeline Proximity	—	n/a	n/a
Proximity to other RE sites *(existing and approved)*	—	—	—
Land Suitability at PO410TA	Good	Good	Fair

Save | Share/Email | Print to PDF

. **Figure 6. Sample tabular web report: site suitability at PO410TA**

4. Improvements

Case studies for different renewable energy scenarios were developed to test the model at sites undergoing planning applications. This helped to identify areas for improvement:

- Weighting factors and creating a hierarchy within the multi-criteria assessment (especially for wind with over 20 siting criteria).
- Manual interval classification, instead of equal interval, for suitability data and visualisations.
- Incorporating asymmetric buffering techniques to represent obstacles affected by orientation, e.g. shadowing in solar siting; downhill water feature buffers.

5. Conclusions

The research highlighted:

- the importance of multidisciplinary, sustainable approaches in planning and development;
- integrating spatial decision support with GIS to assist decision-makers, especially in a commercial setting; and
- ensuring the toolkit is 'fit for purpose', through intuitive interfaces, indicators, and reports with expert and non-expert user alternatives.

6. Outcomes

The resulting prototype tool fulfilled the research requirements, and since the completion of this research, WSP agree the tool is suitable for the target audiences and the applications identified in section 2.2. The research also provided the opportunity to showcase CommunityViz and the latest developments in Spatial Decision Support software.

WSP have subsequently used the desktop spatial analysis principles to create a desktop reference tool when reviewing 172 sites during renewable energy analyses. Agreed, subject to funding, the tool will be developed for strategic level applications to identify renewable energy potential at a local authority level, UK wide. This would involve simplifying and reducing the siting criteria factors per scenario, and enlarging the SDS analysis geography, allowing for a simplified web report and wider, non-site specific appraisal.

7. Acknowledgments

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9. Biography

Philippa Wood recently completed her MSc in Geographical Information Science at University College London and works at WSP Group as the GIS Analyst within their Development team.

Philippa is an Associate member of IEMA and holds a PgDip in Corporate Environmental Management and BSc (Hons) in Geography.