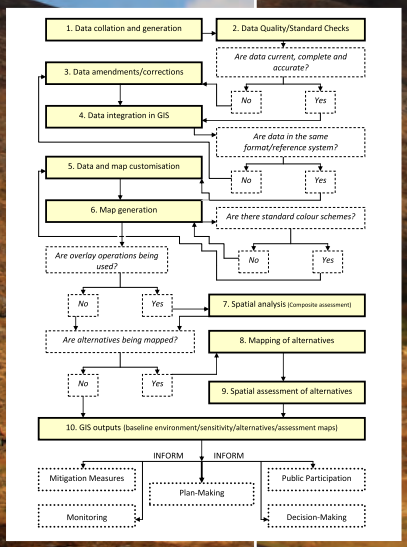
GISEA Manual

IMPROVING THE EVIDENCE BASE IN SEA



Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) is responsible for protecting and improving the environment as a valuable asset for the people of Ireland. We are committed to protecting people and the environment from the harmful effects of radiation and pollution.

The work of the EPA can be divided into three main areas:

Regulation: *We implement effective regulation and environmental compliance systems to deliver good environmental outcomes and target those who don't comply.*

Knowledge: *We provide high quality, targeted and timely environmental data, information and assessment to inform decision making at all levels.*

Advocacy: *We work with others to advocate for a clean, productive and well protected environment and for sustainable environmental behaviour.*

Our Responsibilities

Licensing

We regulate the following activities so that they do not endanger human health or harm the environment:

- waste facilities *(e.g. landfills, incinerators, waste transfer stations)*;
- large scale industrial activities (*e.g. pharmaceutical, cement manufacturing, power plants)*;
- intensive agriculture *(e.g. pigs, poultry)*;
- the contained use and controlled release of Genetically Modified Organisms *(GMOs)*;
- sources of ionising radiation *(e.g. x-ray and radiotherapy equipment, industrial sources)*;
- large petrol storage facilities;
- waste water discharges;
- dumping at sea activities.

National Environmental Enforcement

- Conducting an annual programme of audits and inspections of EPA licensed facilities.
- Overseeing local authorities' environmental protection responsibilities.
- Supervising the supply of drinking water by public water suppliers.
- Working with local authorities and other agencies to tackle environmental crime by co-ordinating a national enforcement network, targeting offenders and overseeing remediation.
- Enforcing Regulations such as Waste Electrical and Electronic Equipment (WEEE), Restriction of Hazardous Substances (RoHS) and substances that deplete the ozone layer.
- Prosecuting those who flout environmental law and damage the environment.

Water Management

- Monitoring and reporting on the quality of rivers, lakes, transitional and coastal waters of Ireland and groundwaters; measuring water levels and river flows.
- National coordination and oversight of the Water Framework Directive.
- Monitoring and reporting on Bathing Water Quality.

Monitoring, Analysing and Reporting on the Environment

- Monitoring air quality and implementing the EU Clean Air for Europe (CAFÉ) Directive.
- Independent reporting to inform decision making by national and local government *(e.g. periodic reporting on the State of Ireland's Environment and Indicator Reports)*.

Regulating Ireland's Greenhouse Gas Emissions

- Preparing Ireland's greenhouse gas inventories and projections.
- Implementing the Emissions Trading Directive, for over 100 of the largest producers of carbon dioxide in Ireland.

Environmental Research and Development

- Funding environmental research to identify pressures, inform policy and provide solutions in the areas of climate, water and sustainability.

Strategic Environmental Assessment

- Assessing the impact of proposed plans and programmes on the Irish environment *(e.g. major development plans)*.

Radiological Protection

- Monitoring radiation levels, assessing exposure of people in Ireland to ionising radiation.
- Assisting in developing national plans for emergencies arising from nuclear accidents.
- Monitoring developments abroad relating to nuclear installations and radiological safety.
- Providing, or overseeing the provision of, specialist radiation protection services.

Guidance, Accessible Information and Education

- Providing advice and guidance to industry and the public on environmental and radiological protection topics.
- Providing timely and easily accessible environmental information to encourage public participation in environmental decision-making *(e.g. My Local Environment, Radon Maps)*.
- Advising Government on matters relating to radiological safety and emergency response.
- Developing a National Hazardous Waste Management Plan to prevent and manage hazardous waste.

Awareness Raising and Behavioural Change

- Generating greater environmental awareness and influencing positive behavioural change by supporting businesses, communities and householders to become more resource efficient.
- Promoting radon testing in homes and workplaces and encouraging remediation where necessary.

Management and structure of the EPA

The EPA is managed by a full time Board, consisting of a Director General and five Directors. The work is carried out across five Offices:

- Office of Environmental Sustainability
- Office of Environmental Enforcement
- Office of Evidence and Assessment
- Office of Radiation Protection and Environmental Monitoring
- Office of Communications and Corporate Services

The EPA is assisted by an Advisory Committee of twelve members who meet regularly to discuss issues of concern and provide advice to the Board.

GISEA Manual

Improving the Evidence Base in SEA

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ABBREVIATIONS AND ACRONYMS

AA	Appropriate Assessment
CDP	County Development Plan
CEC	Commission of the European Communities
Co.Co.	County Council
CORINE	Co-ordinated Information on the European Environment
DED	District Electoral Division
DEHLG	Department of Environment, Heritage and Local Government
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
GIS	Geographic Information Systems
GPS	Global Positioning Systems
GSI	Geological Survey of Ireland
ING	Irish National Grid
INSPIRE	Infrastructure for Spatial Information in Europe
IPPC	Integrated Pollution Prevention and Control
ISDE	Irish Spatial Data Exchange
ISDI	Irish Spatial Data Infrastructure
ITM	Irish Transverse Mercator
LAP	Local Area Plan
NHA	Natural Heritage Area
NPWS	National Parks and Wildlife Service
OSI	Ordnance Survey of Ireland
SAC	Special Area of Conservation
SDZ	Strategic Development Zone
SEA	Strategic Environmental Assessment
SEO	Strategic Environmental Objective
SI No.	Statutory Instrument Number
SPA	Special Protection Area
WFD	Water Framework Directive

TECHNICAL GLOSSARY

Alternatives	In the context of spatial planning, options for accommodating the future development needs of an area within the constraints imposed by intrinsic environmental conditions.
Appropriate Assessment	Assessment of the likely significant effects of a plan, programme or project on a European site in view of its conservation objectives. The assessment is underpinned by the precautionary principle, whereby a proposal cannot be granted permission unless there are imperative reasons of overriding public interest and no alternatives, if adverse effects on the integrity of the site are anticipated or cannot be ruled out.
Attribute Table	A database or tabular file containing information about a set of geographic features, where each row represents a feature and each column represents one feature attribute. Attribute values can be used to find, query and categorise geographical features.
Cumulative Effect	In the context of impact assessment, incremental effects resulting from a combination of two or more individual effects (e.g. two or more individual plans or projects), or from an interaction between individual effects, which may lead to a synergistic effect (i.e. greater than the sum of individual effects), or any progressive effect likely to emerge over time.
Database	Structured collection of records or data, commonly stored in digital form in a computer system.
Dataset	An array of data in tabular and/or graphic form referring to a specific theme (also referred to as a 'layer' in the context of GIS).
Environmental Impact Assessment	Assessment of the effects of certain projects on the environment. It entails the preparation of an Environmental Impact Statement to inform decision-making.
Environmental Factor	Environmental aspect or parameter that contributes to determining the overall status of the environment. Environmental factors represent key considerations in SEA decision-making, and generally relate to biodiversity, population, fauna, flora, human health, soil, water, air and climatic factors, cultural heritage, landscape and material assets.
Environmental Report	Documentation containing the information associated with and derived from the Strategic Environmental Assessment.
Geographic Information Systems	Array of technological tools for the management, analysis and display of spatial data that can provide evidence-based information to support impact assessment and decision-making.
Indicators	Data that provide information about more than the data themselves (i.e. that indicate or provide a proxy for the overall status or some aspect of the status of a specific environmental parameter).

INSPIRE Directive	Establishes an infrastructure for spatial information in the EU to support Community environmental policies, and policies or activities that may have an impact on the environment.
Metadata	Information that identifies, locates and describes the characteristics of spatial datasets to facilitate cataloguing and accessing them, as well as establishing their fitness for use (i.e. quality) and their fitness for purpose (i.e. usability).
Mitigation Measures	Measures designed to prevent, reduce and, as fully as possible, offset any adverse impacts on environmental components of implementing a plan/programme or project. It should be noted that in the context of AA, offsetting adverse effects implies compensation rather than mitigation.
Modelling	In the context of GIS and SEA, a conceptual representation of environmental or planning phenomena and its simulation to better understand, define, quantify or visualise flows, trends and patterns.
Monitoring	The periodic or continuous observation of environmental indicators for any changes that may occur over time, so as to confirm predictions made with respect to likely effects and identify adverse changes that may require remedial action.
Multi-Criteria Assessment	In the context of GIS, the combined evaluation of multiple datasets with the associated multiple attribute values in a spatially specific manner.
Overlay Operations	In the context of GIS, the procedure that joins/brings together separate datasets that share all or part of the same area, which subsequently allows viewing any spatial relationship between the represented datasets.
Plan	In the context of spatial planning, the framework for land-use or sectoral actions in a particular area (e.g. regional, county, city, town or local area).
Programme	In the context of spatial planning, the overall strategy that establishes the requirements to be incorporated into plans.
Raster	Dataset where space is divided into rectangular building blocks (grid cells or pixels) each of which is filled with measured attribute values with topological relationships automatically fixed.
Reference System	Set of (spatial, temporal or attribute) rules for measurement. It provides a means to compare measurements that have been gathered using the same set of rules.
Scoping	The process of determining relevant issues to be addressed and setting out a methodology in which to address them in a structured manner appropriate to the plan/programme.
Screening	Determination of the need for an environmental assessment (under the SEA and EIA Directives).
Shapefile	Data storage formats for storing the location, shape and attributes of geographic features.
Strategic	Assessment of the effects of certain plans and programmes (and, in some

Environmental Assessment	jurisdictions, policies) on the environment. It presents a structured and participative process containing a set of tools to assist in the integration of environmental considerations and promote informed decision-making at plan/programme level.
Sensitive Environmental Factor	Environmental factor that is susceptible to or can be easily affected by external physical stimuli (e.g. land-use changes can affect ecological factors).
Strategic Environmental Objective	Methodological measures that are developed from international, national and local legislation and policies which generally govern environmental protection objectives and against which the environmental effects of the plan/programme policies and actions can be tested.
Spatial Analysis	Analytical techniques associated with the study of location, distribution and interrelationships of geographic phenomena together with their spatial dimensions and their associated attributes.
Spatial Data	Field observations/measurements linked to a location (also known as geographic information or geospatial data).
Spatial Planning	Array of methods used to influence the future distribution of activities in space entailing the geographical demarcation of economic, social, cultural and ecological policies of society directed towards a balanced development, and the physical organisation of space according to an overall strategy.
Thematic Map	Maps that display unique or group attributes according to a single topic, theme, or subject of discourse.
Vector	Dataset where the representation of spatial features is made through points, lines and polygons (or areas). Vector objects have associated attributes, and topological relationships can be built among both features and attributes.
Weighted Overlay	In the context of GIS, the procedure that enables the integration of datasets by adding their relative relevance/importance values, according to their absolute location, to obtain a new dataset. This procedure allows for the systematic aggregation of co-occurring environmental factors and their weights.

1. Purpose and Scope of the Manual

This manual is intended to be a guidance document for the application of Geographic Information Systems (GIS) as a tool to enhance the evidence base in environmental assessment. It provides recommendations for the application of GIS to support Strategic Environmental Assessment (SEA) under Directive 2001/42/EC (CEC, 2001)[1]. It may also be relevant in the context of Appropriate Assessment (AA) under the Habitats Directive 92/43/EEC (EEC, 1992)[2], the primary focus is, however on the SEA process. The SEA related legislative instruments have been transposed in Ireland through the Irish SEA Regulations (Statutory Instruments No. 435[3] and 436[4] of 2004, and 201[5] of 2011, and the Planning and Development Act 2000[6]). The manual also draws upon the requirements for spatial information established in Directive 2007/02/EC, also known as the INSPIRE Directive (CEC, 2007).[7]

Although it applies to land-use planning in particular, the recommendations and GIS applications are also transferable to other plans, programmes and assessments, such as those related to the Water Framework and Flood Risk Directives (CEC, 2000,[8] 2007[9]). They are equally transferable to offshore SEAs and to Environmental Impact Assessment (EIA) under Directive 2011/92/EU (CEC, 2011).[10] In all cases, the recommendations are not intended as an interpretation of the law and the manual does not represent a legally binding document.

It is recommended that the manual is used in conjunction with the following:

- Implementation of SEA Directive (2001/42/EC): Assessment of the Effects of Certain Plans and Programmes on the Environment – Guidelines for Regional Authorities and Planning Authorities (DEHLG, 2004);[11]
- Synthesis Report on the Development of Strategic Environmental Assessment Methodologies for Plans and Programmes in Ireland (EPA, 2003);[12]
- SEA Process Checklist (EPA, 2008);[13].
- Integrated Biodiversity Impact Assessment – Streamlining AA, SEA and EIA Processes: Practitioner's Manual (EPA, 2013);[14]

[1] Directive 2001/42/EC, of 27th June, on the assessment of the effects of certain plans and programmes on the environment. Commission of the European Communities. *Official Journal of the European Union*, L 197/30, 21.7.2001.
[2] Directive 92/43/EEC, of 21st May, on the conservation of natural habitats and of wild fauna and flora. Commission of the European Communities. *Official Journal of the European Union*, L 206, 22.7.1992.
[3] European Communities (environmental assessment of certain plans and programmes) Regulations 2004. Department of Environment, Heritage and Local Government Statutory Instrument, SI No. 435 of 2004.
[4] Planning and development (strategic environmental assessment) Regulations 2004. Department of Environment, Heritage and Local Government SI No. 436 of 2004.
[5] Planning and development (strategic environmental assessment) Regulations 2011. Department of Environment, Heritage and Local Government SI No. 201 of 2011.
[6] Planning and Development Act 2000. Department of Environment, Heritage and Local Government, No. 30 of 2000.
[7] Directive 2007/2/EC, of 14th March, establishing an infrastructure for spatial information in the European Community. European Parliament and the Council of the European Union. *Official Journal of the European Union*, L108/1, 24.5.2007.
[8] Directive 2000/60/EC, of 23rd October, establishing a framework for community action in the field of water policy. Commission of the European Communities. *Official Journal of the European Union*, L327 22.12.2000.
[9] Directive 2007/60/EC, of 23rd October, on the assessment and management of flood risks. Commission of the European Communities. *Official Journal of the European Union*, L288/27 6.11.2007.
[10] Directive 2011/92/EU, of 13th December 2011, on the assessment of the effects of certain public and private projects on the environment (codification). Commission of the European Communities. *Official Journal of the European Union*, L 26/1 28.1.2012.
[11] http://www.environ.ie/en/Publications/DevelopmentandHousing/Planning/FileDownLoad,1616,en.pdf
[12] http://www.epa.ie/pubs/advice/ea/EPA_development_methodology_SEA_synthesis_report.pdf
[13] http://www.epa.ie/pubs/advice/ea/seaprocesschecklist.html
[14] http://www.epa.ie/pubs/reports/research/biodiversity/Integrated%20Biodoversity%20Impact%20Assessment%20-%20Streamlining%20AA,%20SEA%20and%20EIA%20Processes%20-%20Practicioner's%20Manual.pdf

- Best Practice on SEA Alternatives (EPA, in press);
- The Planning System and Flood Risk Management – Guidelines for Planning Authorities (DEHLG, 2009);[15]
- Good Practice Guidance: Cumulative Effects Assessment in SEA and AA (EPA, in preparation);
- Advice Notes on Current Practice in the Preparation of EIS (EPA, 2003);[16]
- Guidelines on the Information to be Contained in EIS (EPA, 2002);[17]
- Where relevant Appropriate Assessment of Plans and Projects in Ireland: Guidance for Planning Authorities (DEHLG, 2010) should also be consulted in the context of Appropriate Assessment;[18]
- Future guidance to be issued by the relevant government departments and agencies of the State.

The manual is divided into five main sections. Sections 2 and 3 address the legislative framework, GIS techniques and their general applications. Section 4 focuses on spatial data management, establishing data requirements and examining potential limitations. Section 5 presents a methodology for applying GIS as a support tool for SEA in the context of Irish land-use planning, with Section 6 providing methodological step-by-step recommendations.

[15] http://www.environ.ie/en/Publications/DevelopmentandHousing/Planning/FileDownLoad,21709,en.pdf
[16] http://www.epa.ie/pubs/advice/ea/guidelines/epa_advice_on_eis_2003.pdf
[17] http://www.epa.ie/pubs/advice/ea/guidelines/
[18] http://www.npws.ie/publications/archive/NPWS_2009_AA_Guidance.pdf

2. Legal Framework

2.1. Strategic Environmental Assessment

The SEA Directive sets out the requirements for the environmental assessment of plans (e.g. land-use development) and programmes (e.g. waste management, renewable energy, forestry) that are likely to have significant environmental effects (Appendix A). SEA is a structured, systematic and participative procedure containing a set of tools to assist in the integration of environmental considerations and promote informed decision-making at plan/programme level.

The most widely adopted SEA methodology puts emphasis on the consideration of environmental information throughout the planning process and associated assessment stages. The procedural requirements of the SEA Directive, as set out in Articles 2 to 12, and the provision of the information required by its Annex 1 (Appendix B of this manual) are commonly fulfilled through a series of actions undertaken during plan-making, namely: screening, scoping, baseline environment, alternatives, impact assessment, mitigation and monitoring. Article 5 of the SEA Directive requires that Environmental Reports include information that may reasonably be needed taking account of current knowledge and methods of assessment. This includes collation of any relevant (spatial) information and the application of contemporary assessment methods, one of which is arguably GIS.

GIS tools can be applied and linked to the requirements of each SEA stage. However, certain SEA stages (e.g. definition of Strategic Environmental Objectives (SEOs) or mitigation measures) may entail the incorporation of non-spatial considerations (e.g. broad policies included in higher plans/programmes) which may not be easily assessed through GIS. Certain strategic policies/actions may be too broad to map or to link them to a specific location (e.g. improving the quality of life of inhabitants). Therefore, the ability of GIS to support the various SEA stages and the GIS techniques applied largely depend on the nature of the plan/programme, the requirements of each relevant stage and its reliance on spatial information.

2.2. Appropriate Assessment

Under Articles 6 and 7 of the Habitats Directive, Appropriate Assessment (AA) must be carried out to ensure that plans or projects do not significantly affect the integrity and conservation objectives of the Natura 2000 network, composed of Special Areas of Conservation (SACs - designated under the Habitats Directive) and Special Protection Areas (SPAs - designated under the Birds Directive - CEC, 2009[19]). A GIS-based spatial examination of proposed plan/project actions in the context of these designated sites, particularly in the context of their spatial proximity, can provide significant insights to the assessment. Such a spatial approach can contribute to the exploration of water and green infrastructure connectivity and linkages between the Natura 2000 network and the development site or the Natura 2000 network and other ecologically important areas such as Natural Heritage Areas (NHAs). Aspects of this Manual can be applied to Appropriate Assessment, the main focus of the Manual is, however, on SEA.

[19] Council Directive 2009/147/EC, of 30th November, on the conservation of wild birds (codified version). Commission of the European Communities. *Official Journal of the European Union*, L 20/7 26.1.2010.

2.3. INSPIRE Directive

The INSPIRE Directive aims at establishing an infrastructure for spatial information in the European Community, for the purposes of community environmental policies and activities which may have an impact on the environment. Spatial information can be defined as any data (e.g. observations, measurements) with a direct or indirect reference to a specific location or geographic area. Therefore, spatial datasets comprise geographic features (e.g. buildings, rivers) with associated attribute information (e.g. building height, water quality). GIS represent the operating systems to manage, analyse and display such information.

The INSPIRE Directive applies to a series of themes relating to environment and planning (Appendix C), for which metadata (i.e. information describing the characteristics of spatial datasets, which makes it possible to discover, inventory and use them) must be created. The INSPIRE Directive has promoted the creation of an Irish Spatial Data Infrastructure (ISDI) to acquire, process, distribute, use, maintain and preserve spatial data. The Irish Spatial Data Exchange (ISDE)[20] initiative already provides a mechanism to search metadata catalogues. INSPIRE has also advocated for the introduction of spatial data and GIS requirements into environmental legislation (e.g. Water Framework Directive – WFD). Although the SEA Directive does not formally require the use or generation of spatial datasets, the use of spatial data and GIS can significantly contribute to SEA effectiveness.

[20] www.isde.ie

3. Current Practice

3.1. Scope for Spatial Data and GIS Use in SEA and of Land-use Plans

A large number of environmental management and planning decisions are based on methodologies that utilise the spatial analysis tools provided by conventional GIS technologies (e.g. digital mapping or modelling of future changes). In the context of SEA, spatial data and GIS allow for consideration of spatio-temporal dimensions common to environmental, biodiversity and planning issues. This is of particular significance in land-use planning, where the potential significance and magnitude of an impact is largely dependent on the spatial location of proposed actions and affected receptors at a given time. The intrinsic spatial nature of land-use planning and the need to integrate environmental considerations into plan-making give GIS the potential to augment existing SEA methods and plan-making procedures. Similarly, the spatio-temporal implications of planning decisions on Natura 2000 sites make GIS a significant tool for assessing potential adverse effects on their integrity. This is achieved by incorporating spatial evidence into the process and by facilitating assessment of alternatives (or alternative ecological solutions, when necessary, in AA), definition of mitigation measures and monitoring of changes over time. In this context, data collation and analysis through GIS can support a more baseline-led approach to environmental planning and decision-making.

GIS provide the means to integrate and spatially assess multiple environmental and planning considerations in a single interface, supporting the systematic prediction and evaluation of spatially distributed and cumulative impacts, a key assessment consideration in SEA. The SEA Directive gives special consideration to the cumulative nature of potential environmental impacts. Cumulative impacts can derive from several individual aspects of a plan/programme (e.g. pollution, loss of habitats) having a combined effect. Cumulative effects also arise where each of several aspects has insignificant effects but together they have a significant additive or synergistic effect (i.e. greater than the sum of individual effects). Evaluating co-occurring environmental resources and their status or sensitivity through GIS can help address cumulative effects. This is also of relevance to AA.

3.2. GIS Applications and Techniques

GIS applications are widely used to record baseline information and for map production. Moreover, their application in performing complex analysis of impacts or scenario analysis is gaining significance. There has been a significant increase in the inclusion of GIS-based analysis and maps in Irish SEAs in recent years. GIS applications in AA remain underdeveloped but there is an increasing trend towards mapping catchments and ecological connectivity of Natura 2000 sites in relation to the proposed plan objectives and/or developments. The proprietary and open source GIS software most commonly used in Ireland includes:

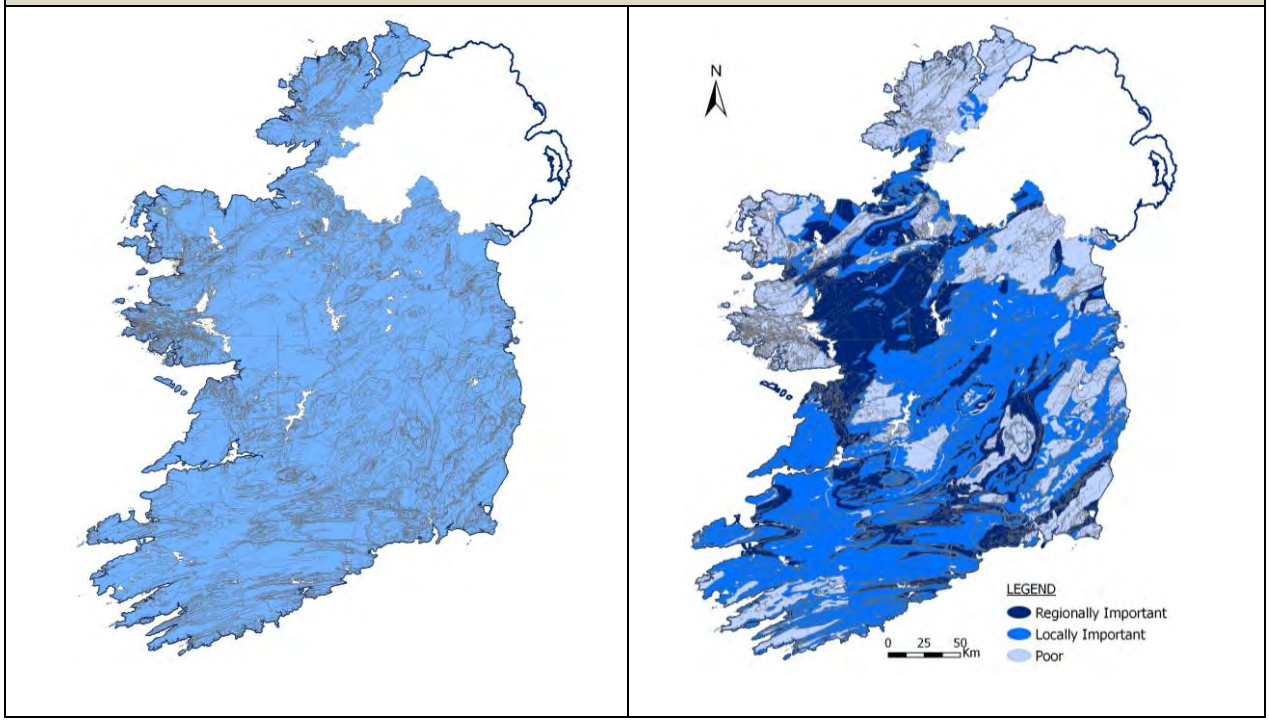
- ArcGIS (commercial software – www.esri.com)
- MapInfo (commercial – www.mapinfo.com)
- Quantum GIS (open source – www.qgis.com)

The most common methodological GIS tools and techniques used in environmental assessment and planning can be grouped according to their purpose: digital mapping, spatial analysis/assessment, and modelling. Participative GIS has also rendered a set of specific techniques and approaches.

3.2.1. Digital Mapping

GIS have been widely applied in resource mapping as the interface for storing and representing field surveys and inventories. Gathering data on-site (by means of Global Positioning Systems (GPS), aerial photography or remote sensing), transferring the information to a computer interface, and plotting the results on a digital map allow for the creation and exploration of spatial datasets. As spatial datasets have attribute information associated with each graphic feature, digital maps can illustrate the distribution of an array of features within the same layer with a unique symbol or portray them according to attribute values, thereby creating a thematic map (Figure 1). Such digital maps provide the basis for the spatial assessment of environmental and planning issues. They provide spatial and thematic illustrations of environmental aspects, facilitating the description of the baseline environment and the preparation of Environmental Reports.

Figure 1. Aquifer map of Ireland: unique symbol map (left) and thematic map colour-coded according to the simplified aquifer category (right). **Data source: GSI.**



3.2.2. Spatial Analysis: Overlays and Weighted Overlays

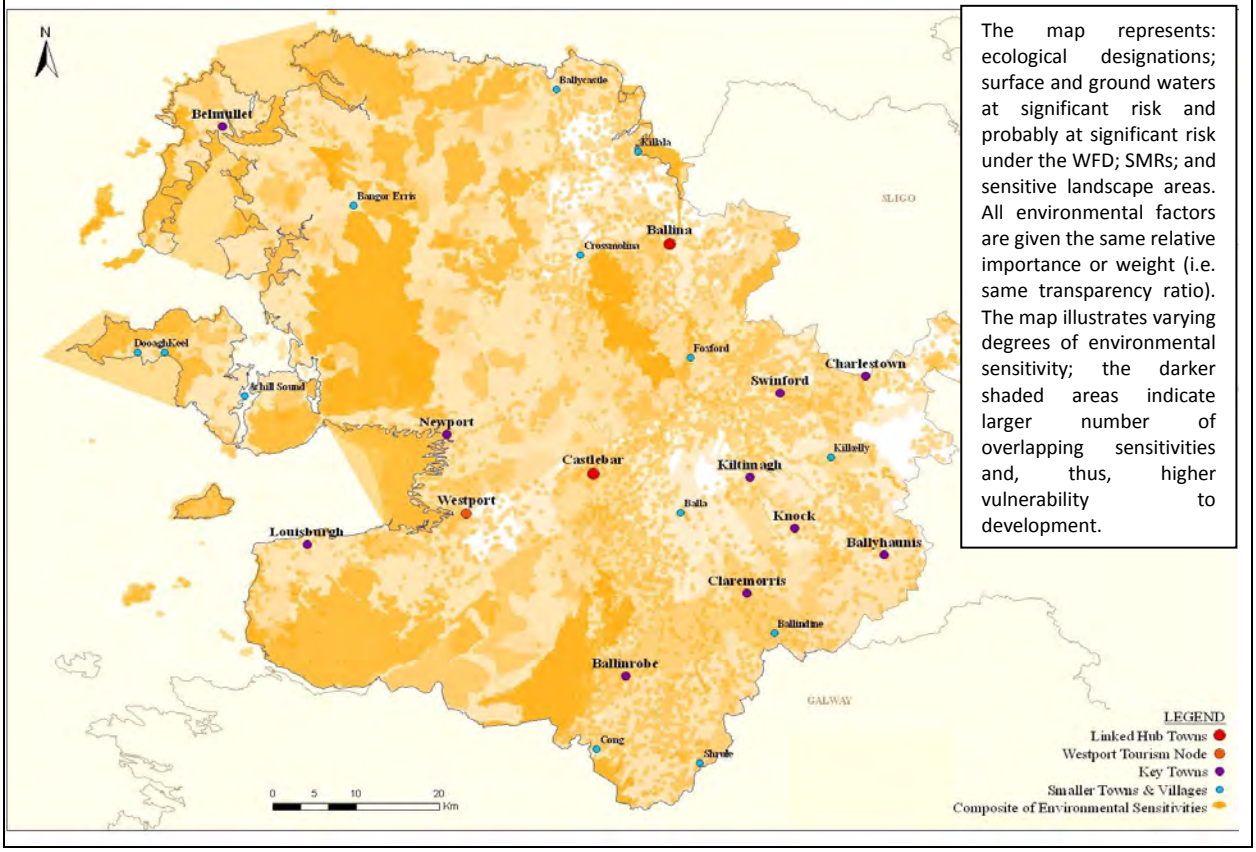
Spatial analyses typically deal with site selection or site suitability assessment of both point/polygon (e.g. landfill) and linear projects (e.g. railway). Spatial analysis for urban and rural planning and development control is one of the main practical applications of GIS in Ireland. The EPA's SEA WebGIS & Reporting tool and the GeoPortal[21] environmental data viewer, for example, facilitate a preliminary spatial assessment of environmental aspects at SEA level.

[21] http://gis.epa.ie/

Overlay and weighted-overlay techniques can play a significant role in facilitating the assessment of potential commonalities, overlaps and interactions between environmental considerations, as well as contributing to the assessment of cumulative effects. ***Overlay mapping*** techniques can be used to jointly map and spatially assess sensitive environmental areas (e.g. protected habitats, groundwater vulnerability areas). This is achieved by superimposing layers and using transparency tools (Figure 2), or by using raster calculation tools to combine them (Figure 3). The outputs illustrate the degree of interaction and overlap between co-occurring environmental factors (a larger amount of environmental sensitivities occurring at one location is illustrated as darker shaded areas in Figure 2 and as a palette of reds in Figure 3). In this way, they help identify environmentally sensitive areas as well as areas free of environmental constraints that are, therefore, suitable for development. Overlay mapping can either combine all relevant environmental aspects (as in SEA) or focus on a set of thematical aspects (such as biodiversity-related considerations for biodiversity impact assessment or AA).

Weighted-overlay mapping techniques combine multi-criteria analysis and GIS. This technique is based on the ability of GIS to combine multiple datasets, and the relative importance/significance value for each assessment criteria or dataset, in a spatially-specific manner. This technique allows for the systematic aggregation of co-occurring environmental factors and their weights. The weighted-overlay results identify areas with relative degrees of environmental sensitivity, reflecting the assigned weights as established by the assessor or gathered through public participation. These weights of subjective nature stress the relative importance of certain environmental sensitivities over others (e.g. landscape protection perceived as more important than any other environmental factors in the case of Figure 3).

Figure 2. Transparency overlay on environmental sensitivity for County Mayo. **Data source: Mayo Co.Co.**

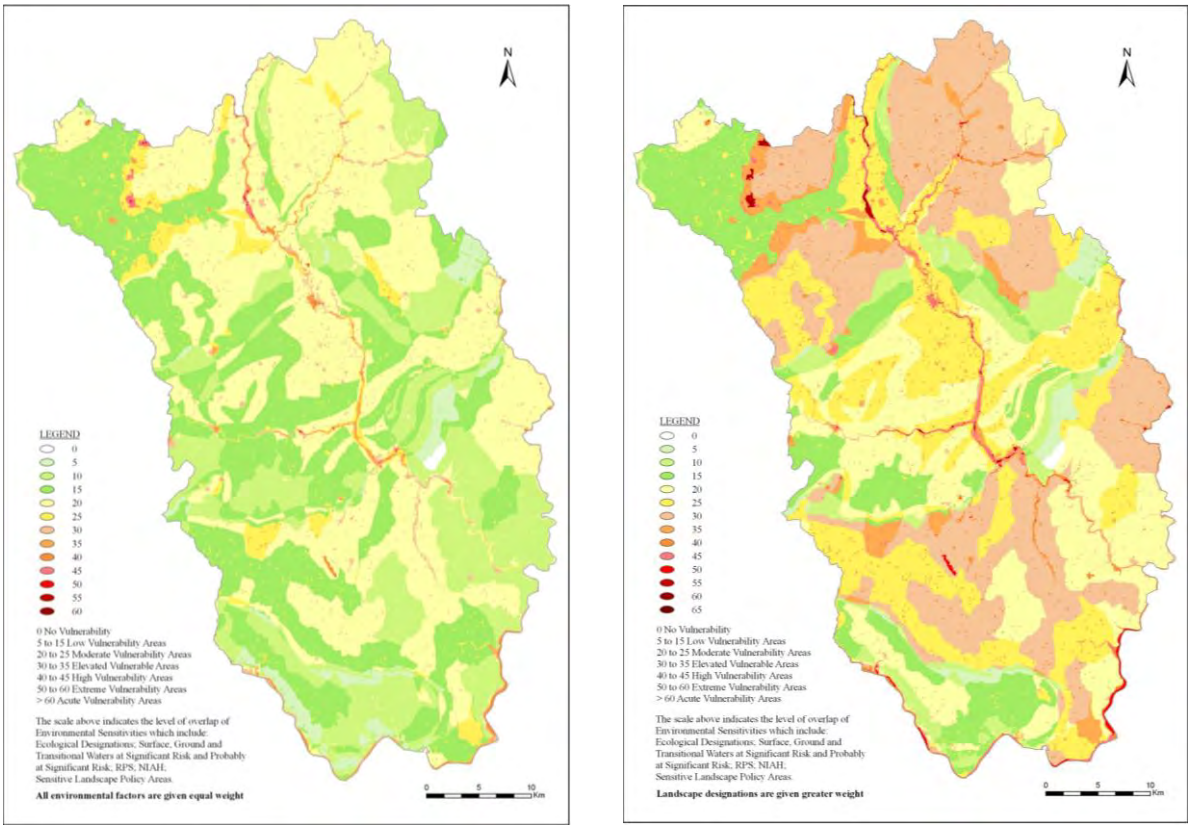


The map represents: ecological designations; surface and ground waters at significant risk and probably at significant risk under the WFD; SMRs; and sensitive landscape areas. All environmental factors are given the same relative importance or weight (i.e. same transparency ratio). The map illustrates varying degrees of environmental sensitivity; the darker shaded areas indicate larger number of overlapping sensitivities and, thus, higher vulnerability to development.

3.2.3. Modelling

Modelling attempts to replicate a real-world situation and, thereby, allow experimentation with the replica in order to gain insight into the expected behaviour of the real system under different scenarios. Modelling of hydrological processes (e.g. water quality, groundwater vulnerability, run-off, fisheries management and waste load for catchments areas) is one of the most common GIS applications. GIS approaches can also be applied to land-use modelling (e.g. EU's MOLAND[22] project on monitoring land use/cover dynamics), ecological modelling (e.g. suitability of habitats for certain species or potential for the spread of invasive species), air pollution modelling (e.g. pollutants dispersion according to wind and other climatic parameters), and risk assessment (e.g. flood risk analysis), among others. Although some of these GIS modelling approaches can be adopted in SEA to address specific environmental considerations (e.g. flooding), their broad application is limited as they cannot be systematically applied to the wide range of issues considered (i.e. each environmental factor considered may entail the application of specific models and parameters/assumptions to effectively assess its behaviour).

Figure 3. Weighted overlay on environmental sensitivity for County Kilkenny: all environmental factors are of equal importance and thus given equal weight (left), or landscape factors are perceived to be of greater importance and given greater weight (right). **Data source: Kilkenny Co.Co.**



3.2.4. Participative GIS

Public participation GIS focuses on the development of user-friendly GIS interfaces, to promote GIS use within more inclusive participatory decision-making processes. This approach typically takes two forms:

[22] http://moland.jrc.it/

a) the use of hard-copy maps to illustrate spatial issues and to, consecutively, sketch on additional public information; and b) the provision of digital maps over the Internet to convey information, as well as allowing online submission of public comments in relation to alternatives or perceptions in support of participative environmental sensitivity mapping. The application of GIS during public participation has the potential to: provide alternative (remote) means to involve and engage the public; effectively communicate potential problems and analysis results in a graphic and clear manner; and improve the understanding of the opportunities and effects of alternatives.

3.3. Benefits and Constraints of GIS-based Assessments

A GIS-based approach supports spatial and evidence-based environmental assessment. The application of a systematic method for each SEA stage that enables spatial and visual representation of environmental issues and potential planning conflicts provides a framework for enhancing plan-making processes (Table 1). Spatial data and GIS facilitate a systematic and comprehensive assessment process by:

- providing key information in a spatially specific, transparent and graphic manner;
- combining and spatially assessing multiple environmental considerations and addressing their potential commonalities, interrelationship and cumulative effects;
- facilitating the visual identification of existing environmental sensitivities and potential land-use conflicts; and
- allowing for the integration of public perceptions into the assessment.

The enhanced transparency and objectivity of assessments and the early spatial identification of environmentally sensitive areas and potential land-use conflicts (associated with the range of alternatives being considered) raise awareness and promote the incorporation of environmental considerations into the plan at the earliest stage possible. Suitably scaled maps can complement written descriptions and improve the coherency of Environmental Reports. However, these benefits are dependent on the effective application of GIS, which is influenced by technical and non-technical aspects, such as:

- GIS resources and skills of personnel operating the system;
- data sharing, availability and access;
- spatial accuracy, currency and completeness of data;
- validity of operations performed in GIS; and
- acceptance and integration of GIS outputs into decision-making.

Moreover, the overall effectiveness of GIS is commonly conditioned by the SEA context: its timing; the time-frames allocated to each SEA stage; the institutional arrangements that define the information exchange and communication channels; the target group (i.e. planners, decision-makers or the public); and the power structures, together with the environmental and spatial awareness of decision-makers, that determine the level of environmental integration into the final decision. Some of these issues, such as timing and institutional arrangements, also apply to AA processes.

Table 1. Key benefits and limitations of GIS in the various SEA stages.		
SEA Stage	**Benefits**	**Limitations**
Screening	• Rapid and spatial identification of significant environmental issues in the plan area and environs.	• Time restrictions affecting data access and gathering.
Scoping	• Systematic/replicable approach. • Rapid and spatial identification of significant environmental issues. • Better understanding of potential issues (e.g. location, extent, cumulative effects). • Time and resource optimisation.	• Time restrictions affecting data gathering. • Currency and accuracy issues in datasets affecting their usability. • Data management tasks to ensure data is fit for use.
Baseline Environment	• Visual representation of the spatial distribution of environmental information. • Improved information delivery. • Time and resource optimisation.	• Licensing/copyright impeding access to certain data. • Lack of availability of certain datasets affecting their consideration in the GIS-based assessment. • Data format/compatibility issues. Data management tasks to ensure data is fit for use. • Temporality and accuracy issues in datasets affecting their usability.
Strategic Environmental Objectives	• Provision of spatially specific targets and indicators.	• Broad and non-spatial nature of environmental objectives in other plans/programmes impeding their effective consideration and integration into the GIS analysis.
Alternatives	• Spatial definition and graphic representation of alternatives. • Improved information delivery.	• Inability to spatially interpret non-spatial strategic objectives.
Assessment of Alternatives	• Systematic, replicable and transparent spatial assessment of multiple factors. • Visual and quantitative comparison of alternatives. • Accurate identification of potential land-use conflicts for each alternative.	• Time constraints. • Currency and accuracy issues in datasets. • Inability to tackle non-spatial planning considerations (e.g. broad policies).
Mitigation Measures	• Explicit implementation of mitigation measures.	• Non-spatial nature of policy-level impact mitigation.
Monitoring Measures	• Definition of precise and spatially specific measures.	• Lack of enforcement of spatially specific monitoring.
Environmental Report	• Improved quality, accuracy and transparency of the assessment. • Enhanced information delivery. • Optimisation of time and resources required for its preparation.	• Delayed GIS incorporation in the initial SEA stages affecting spatial analysis outcomes. • Data quality issues (i.e. currency, scale, accuracy, comprehensiveness) affecting reliability of outcomes.
Public Consultation and Participation	• Complementary participative method. • Alternative means for remote participation. • Enhanced transparency. • Improved legitimacy of participation.	• Restricted public GIS knowledge/spatial literacy. • Time constraints affecting efficiency of public involvement. • Data confidentiality/copyright issues.
Decision-Making	• Evidence-informed decision-making. • Enhanced transparency, quantity and quality of the environmental information provided.	• Restricted spatial literacy among decision-makers.
Monitoring	• Rapid updating of monitored values. • Systematic spatial analysis of monitoring results by applying previously established procedures. • Visual comparison of changes over time. • Reuse of datasets in the plan/programme review and associated SEA.	• Lack of spatial context in indicators. • Lack of resources impacting on the effectiveness of monitoring.

4. Spatial Data Management

The effective use of GIS is closely tied with an understanding of the nature of spatial data and how data quality might affect the end results. The current lack of geographic data preparation and management guidelines in Ireland creates a risk of providing misleading spatial information.

4.1. Minimum Data Requirements for SEA

The SEA Directive requires that baseline environmental information (i.e. current state of the environment) be collected in relation to environmental factors, including: biodiversity, population, fauna, flora, human health, soil, water, air and climatic factors, cultural heritage, landscape, material assets and the interrelationship between these factors. In addition, relevant planning considerations may also be included in relation to proposed infrastructure (e.g. transport corridors and waste water treatment plants), population changes (i.e. census data) and planning applications (e.g. location of new housing, industrial areas) to address any socio-economic needs and development pressure areas. The type and number of data or layers necessary for each SEA varies according to the scale and hierarchy of the plan/programme, the information needs and the sector to which that SEA applies. In the context of AA, the focus is on Natura 2000 sites and species and habitats listed under the Habitats Directive. Nevertheless, for a comprehensive biodiversity impact assessment, other relevant environmental factors, such as water features, may be incorporated as necessary.

In general, relevant SEA layers can be grouped into: context data (i.e. digital maps such as raster maps and aerial photographs that provide a background to the assessment) and baseline data (i.e. vector and raster layers of environmental resources and sensitivities, as well as of planning considerations). Annexes I to III of the INSPIRE Directive list a number of thematic layers which are significantly relevant to SEA (Appendix C). Taking account of the requirements of both the SEA and INSPIRE Directives, and the commonly available datasets, the layers listed in Table 2 are essential for a workable application of spatial information in SEA of land-use plans. Additional datasets can supplement the process on the basis that the more information is available, the more informed the assessment/decision. A complementary list of datasets, sources and links is provided in Appendix D.

Table 2. Principal GIS layers for SEA of land-use plans in Ireland.
Context Data
OSI Discovery series raster maps (1:50,000) for county/regional planning
Vector maps (e.g. 1:2,500, 1:5,000, 1:10,000) for town/local area planning
District Electoral Divisions (DEDs)
Plan boundary (e.g. county/townland boundaries, small area boundary) or study area boundary
Baseline Data
Population and Human Health
Existing population and population changes (%) by DED
Towns by population
Biodiversity, Flora and Fauna
Special Areas of Conservation (SACs) and Candidate Special Areas of Conservation (cSACs)
Special Protection Areas (SPAs)
Natural Heritage Areas (NHAs)

Proposed Natural Heritage Areas (pNHAs)
Geology and Soils
Bedrock geology
Soil/subsoils classification
Landslides
Soil sealing
Water
Aquifer vulnerability
Aquifer productivity
Biological status of rivers (Q values)
Bathing quality of coastal waters
Designated salmonid waters
Ecological status of coastal/transitional/lake/surface/ground waters (WFD)
Risk status of coastal/transitional/lake/surface/ground waters (WFD)
Groundwater source protection areas
Register of protected areas (WFD)
Areas liable to flooding
Flooding events and extents
Air and Climate
Air quality monitoring locations and associated air quality data
Air quality zones
Landscape
Landscape character areas
Landscape capacity and sensitivity
Protected views and prospects
Scenic routes
CORINE land cover (sensitive land-uses and land-use changes, e.g. broad leaf forests, peatlands)
Cultural Heritage
Sites and Monuments Record (SMR)
Record of Protected Structures (RPS)
Architectural Conservation Areas (ACAs)
National Inventory of Architectural Heritage (NIAH)
Material Assets
Existing and proposed roads/railways
Waste water treatment plants and sewerage network
Drinking water infrastructure
IPPC licensed activities
Active waste licenses
Mines and quarries
Extent of urban areas

4.2. Key Considerations for Effective Data Management

Spatial datasets may, in some cases, contain errors. The lack of clear understanding of data usability and limitations may lead to inappropriate data use or incorrect GIS applications, which could render

inconsistent or inaccurate results. Therefore, data quality must be controlled to ensure that information is fit for its purpose. Similarly, data input and analysis must be monitored and any issues documented (in the Environmental Report and, where appropriate, reported back to the data owner) to ensure that results are valid and applicable. Data correction and improvement entail additional time and effort; such management tasks should be timely, and economically viable.

A number of key aspects need to be considered in spatial data management, as follows.

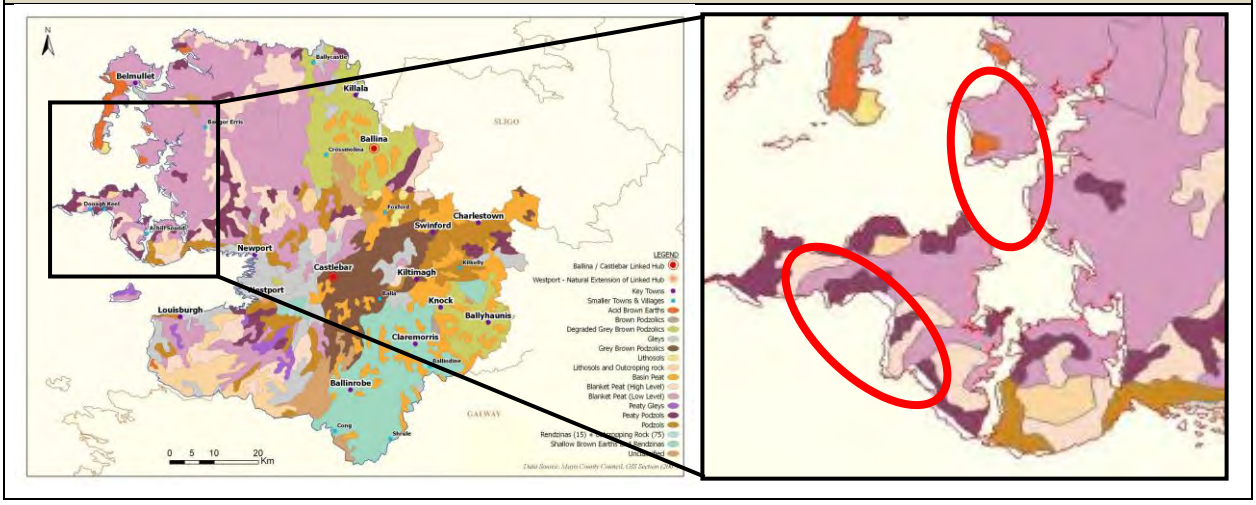
4.2.1. Availability and Accessibility

Data may be available (i.e. gathered, compiled or created) but may not be accessible. Copyright and confidentiality constraints and prohibitive costs may limit data sharing/acquisition. Copyright and accessibility issues can particularly constrain data sharing between countries, affecting GIS applications for transboundary SEAs (such as River Basin Management Plans). In cases where particular datasets are not available or readily accessible (e.g. air quality, habitat survey, coastal erosion), the relevant SEA stage shall rely on narrative information, statistics, etc. A number of datasets not currently available may be published in the short term, such as CORINE 2012 and the national flood risk mapping under preparation. The future availability of these datasets should be acknowledged in the Environmental Report so due consideration is given during plan review or at EIA level. In addition, any data gaps and accessibility issues should be accordingly reported in the Environmental Report.

4.2.2. Accuracy and Completeness

Measurements, location on a map and feature boundary definition must be precise to ensure spatial relevance. Certain datasets may not overlay properly on space, may not be spatially accurate (Figure 4) or may contain information gaps, spatial gaps or inconsistencies (Figure 5), leading to assessment inaccuracies and miscalculations.

Figure 4. Spatial location and overlap inaccuracies between the county boundary and the soils layer, probably associated with the differing scales used for data creation. **Data sources: Mayo Co.Co. and Teagasc.**



Similarly, attribute information associated with the represented features/objects must be correct and complete to ensure reliability of results. Where attribute tables contain deficient information or unexplained/undocumented categorisation codes (e.g. Table 3), these need to be completed for

comprehension and adequate use. These issues are commonly not as significant at strategic level; minor omissions and/or inaccuracies may not materially affect decisions made at higher planning tiers and, therefore, data improvement tasks may not be necessary. Nevertheless, data users should spend time getting to know the data, as poor data knowledge and understanding can lead to incorrect assessments.

Figure 5. WFD surface water risk assessment layer showing a data gap in north-west County Offaly (left), and modelled flood risk area for Lanesborough, County Longford (right) that omits the consideration of raised ground (inset). **Data sources: Offaly Co.Co.; Shannon, South Eastern and Eastern River Basin Districts; Longford Co.Co.; and OPW.**

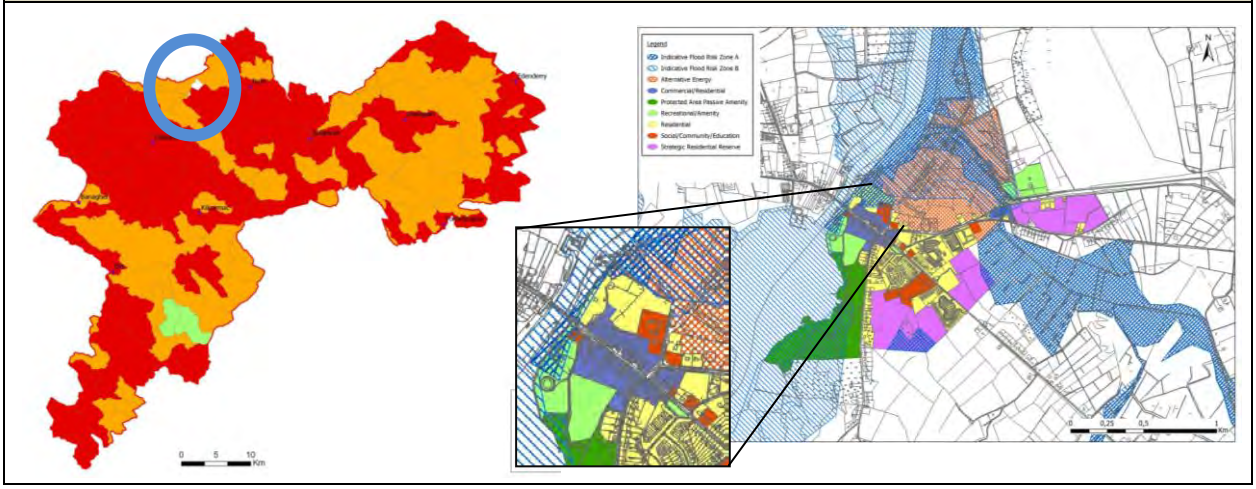


Table 3. Attribute data with WFD ground water risk assessment categories, indicating vulnerability associated with diffuse and point pollution sources and overall vulnerability. **Data source: EPA.**

		Risk Assessment Categories		
GW Name	**GW Type**	**GW Diffuse**	**GW Point**	**GW Overall**
Abbeyfeale	Poorly Productive Bedrock	2b	1a	1b
Annaghmore	Productive Fractured Bedrock	2b	2b	2b
Ardfert	Karstic	2a	2b	1b

Key to categories unexplained in the attribute table: 1a = At Significant Risk, 1b = Probably at Significant Risk, 2a = Probably Not at Significant Risk, 2b = Not at Significant Risk.

4.2.3. Temporality

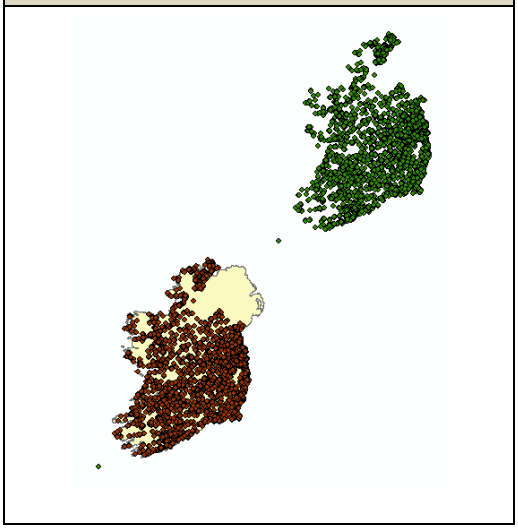
The age and currency of datasets vary and their usability depends on their purpose or on when they were updated last. Data updates largely depend on data type and responsible organisation/agency. Where datasets are not up to date, they can provide misleading information by not addressing the current state of the environment. Therefore, the most current datasets available should be acquired and applied at all times. The date of the last update must be taken into consideration for an appropriate use and interpretation. For example, although temporal variations are illustrated by CORINE datasets, where changes in land-use can be observed (e.g. from arable to urban), this dataset was updated last in 2006 (although it is anticipated that the 2012 version will be released in 2014); as a result, the depicted land-uses do not reflect current status. Also, the biological Q values that appear on the EPA GeoPortal are updated nightly, reflecting any new data or data updates imported by biologists within the past 24 hours (the date of update is provided on the GeoPortal). However, the biological Q value data available for download in the website are taken as a snapshot of the Q values throughout the year, which is carried

out on a quarterly basis. This discrepancy on the timing of updates affects the validity of the datasets downloaded from the website.

4.2.4. Projection

A common spatial reference system or projection is critical in a GIS analysis to ensure correspondence between layers. Data in different projections do not adequately overlap (Figure 6) and slight inaccuracies may occur when changing from latitude and longitude to another projection. The Ordnance Survey Ireland (OSI) has completed the transition from the Irish National Grid (ING) to the Irish Transverse Mercator (ITM). However, some national datasets are pending conversion and many of the data providers still rely on ING. As a result, layer incompatibilities remain. Nevertheless, software packages such as ArcGIS, MapInfo or QuantumGIS include conversion tools for their management. Conversion tools can also be found in the OSI website.

Figure 6. Geodirectory in ING (bottom) and ITM (top). Data sources: OSI and An Post.



4.2.5. Scale

The scale of digital data can be regarded as an indicator of both spatial detail (level of detail available for map-making) and positional accuracy (possible difference between the true real world coordinates and coordinates of the data). The 'spatial detail' determines the minimum mapping area and the number of coordinates used to describe a feature. A particular geographic feature (e.g. river) is presented in more detail (i.e. with more coordinate points and detail on width, for example) on a large-scale map (i.e. 1:1,000) than on a small-scale map (i.e. 1:50,000). The geographical scale and level of detail required for an assessment (dependent on whether SEA relates to a county, city or local area plan) should define the spatial detail of applied data (e.g. 1:50,000 for county development plans and 1:2,500 for town or local area plans). However, the level of detail is commonly conditioned by the scale of available datasets. This is the case for CORINE datasets, where the scale used for mapping existing land-uses (i.e. 25 hectares) has resulted in generic areas that lack spatial detail when applied at local level. That is, spatial data may contain much more or not enough information for a specific purpose depending on the scale. Furthermore, using data at different scales in the same GIS analysis can be problematic as measures and positional accuracy may be affected (Figure 4). Scaling considerations must be acknowledged in the assessment and documented in the Environmental Report for validity of results.

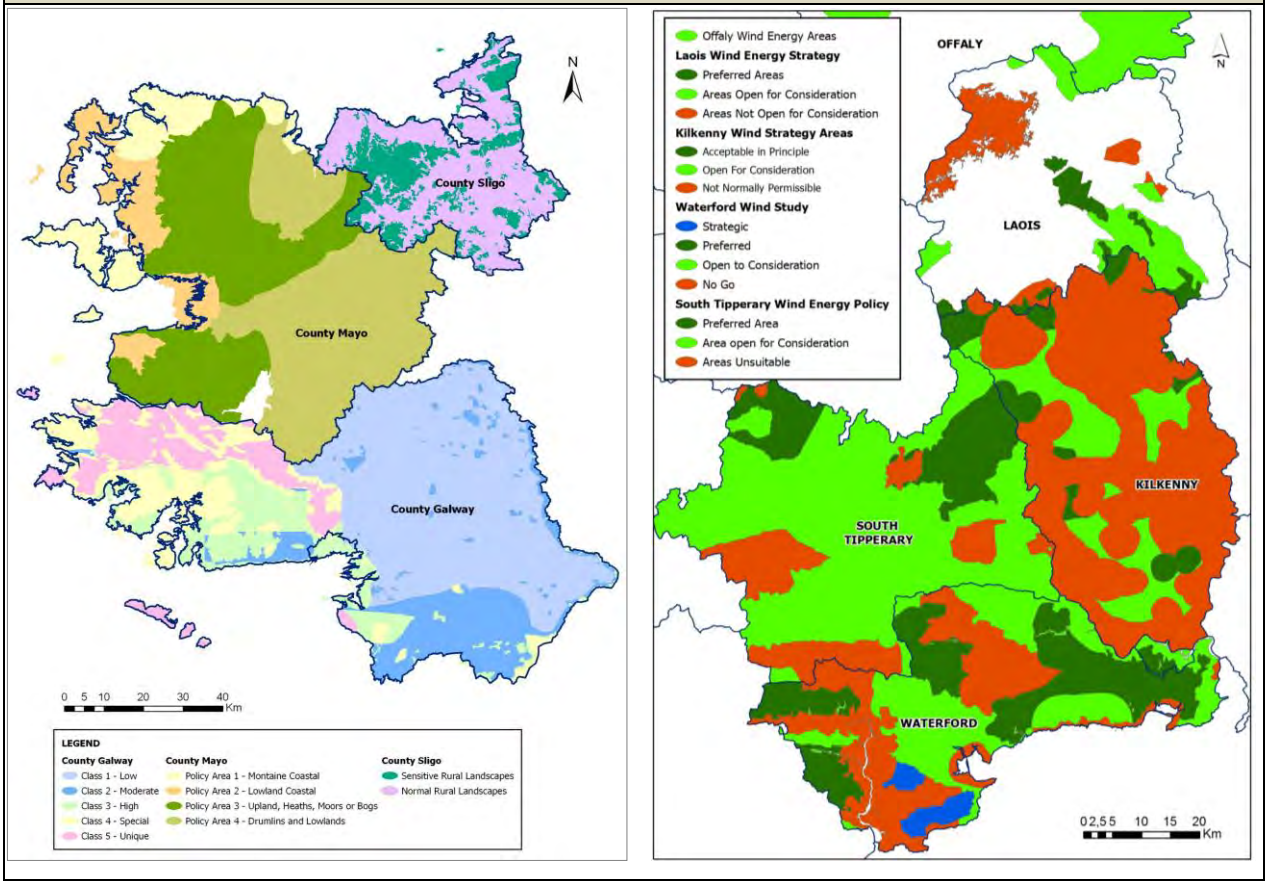
4.2.6. Data Standards

There is a general lack of standard approaches to data gathering and creation. Data sources remain inconsistent across the EU and there is a general discontinuity of information across borders and national boundaries. Data discrepancies across borders arise due to the different planning approaches (e.g. geographical and contextual discrepancies existed between the area units in the Republic of Ireland – Electoral Divisions, and those in Northern Ireland – Census Output Areas. This issue has been recently addressed through the creation of Small Area units in the Republic of Ireland which are considerably

smaller than Electoral Divisions: they comprise approximately 80–100 households per unit with an average size of 3.5 km^2). Consistency issues can also derive from varying planning approaches (e.g. differing land-use zoning types and classifications developed and applied by local authorities) or assessment methods, such as landscape character assessments or wind energy strategies. Where the methodology is county-specific, it often overlooks existing characterisations or strategies in adjacent counties (Figure 7). This highlights the opportunity for and benefits of regional approaches for certain plans/programmes.

Standards have been developed in a limited number of cases, such as the land cover types adopted within CORINE or scientifically defined categorisations such as bedrock geology or WFD status. Recent initiatives are promoting standardisation, such as MyPlan's effort to normalise land-use zoning types.

Figure 7. Discrepancies in landscape characterisation of counties Galway, Mayo and Sligo (left) and in wind energy policy areas between counties Waterford, South Tipperary, Kilkenny and Laois. **Data sources: Galway Co.Co.; Mayo Co.Co; Sligo Co.Co.; Waterford Co.Co.; South Tipperary Co.Co.; Kilkenny Co.Co.; and Laois Co.Co.**



4.2.7. Metadata

Metadata are defined as information describing the characteristics of spatial datasets, enabling their discovery and inventory, as well as establishing their fitness for use (i.e. quality) and their fitness for purpose (i.e. usability). Metadata are 'data about data', providing information on the reference system, collection methodology, scale and date, collector/creator contact details, etc. This information is of significance in SEA, where different data sources are utilised, integrated and interrogated.

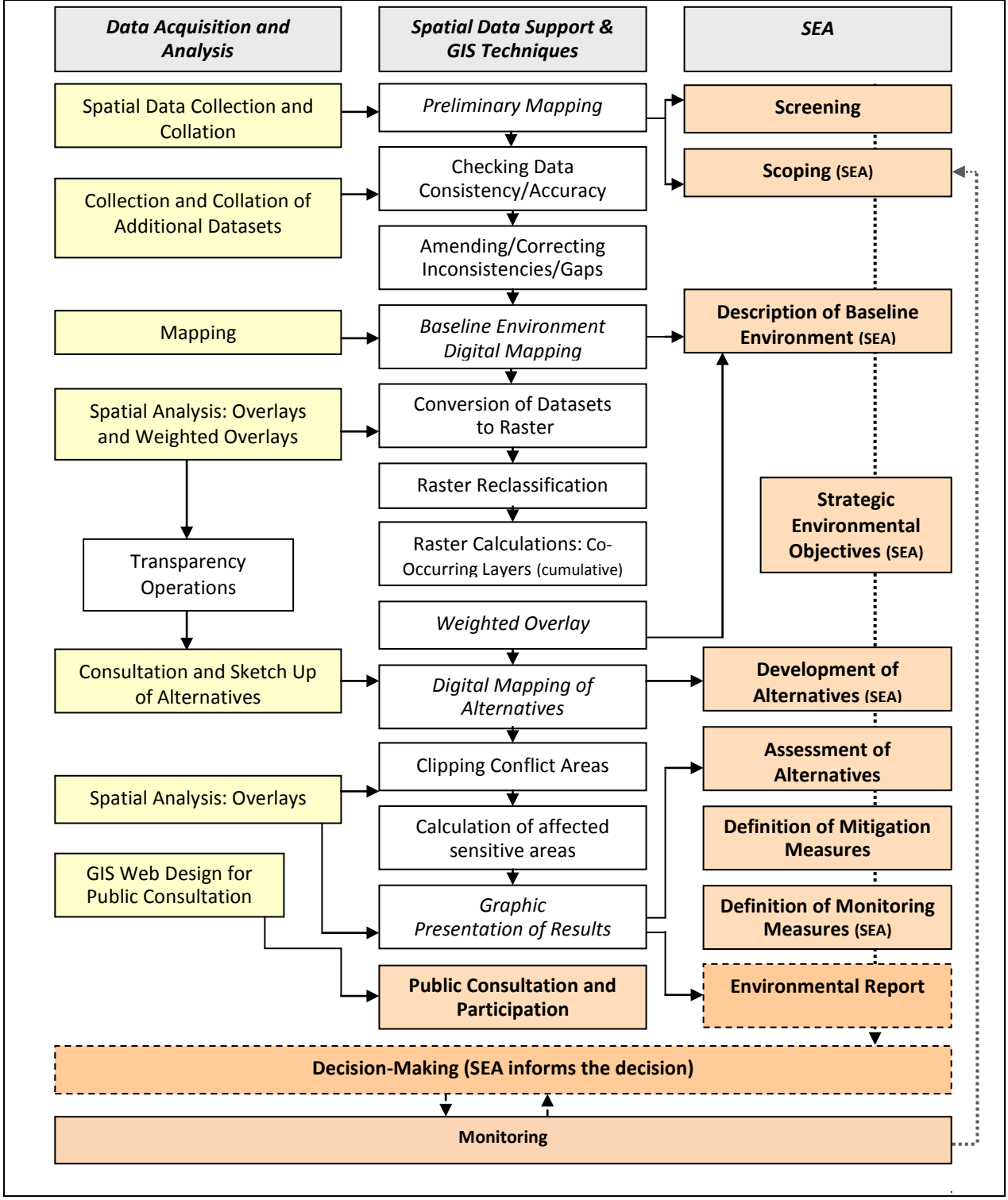
Metadata implementation regulations were prepared as part of the INSPIRE Directive (CEC, 2009).[23] They establish requirements for the creation and maintenance of metadata for the themes listed in the Annexes of the Directive (Appendix C) to ensure that the Spatial Data Infrastructures of Member States are compatible and usable in a community and transboundary context. General lack of metadata in Irish datasets continues to affect the prompt establishment of their availability, relevance, quality and usability for the purpose of any given study.

[23] http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/metadata/MD_IR_and_ISO_20090218.pdf

5. Methodological Framework to Enhance Current Practice

Effective SEA processes imply that appropriate environmental, and biodiversity, information has been taken into account throughout the plan-making process. A systematic and timely implementation of a GIS approach should ensure that the appropriate GIS outputs (e.g. digital maps and quantitative spatial information) are made available to support each SEA stage and assist in the preparation of the plan/programme. Figure 8 illustrates the tasks to be undertaken to inform each specific stage.

Figure 8. Primary (yellow) and secondary (white) tasks in the SEA stages (orange).



The steps in Figure 8 are based on a methodology for assessing environmental sensitivities and thus identify planning constraints and opportunities (González *et al.*, 2011).[24] This systematic methodology has been widely applied successfully in Ireland and elsewhere, as illustrated by the case studies.

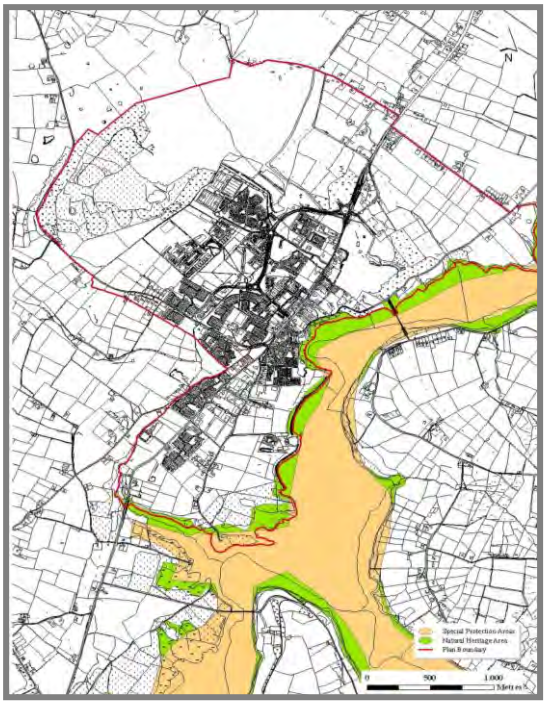
5.1. Screening

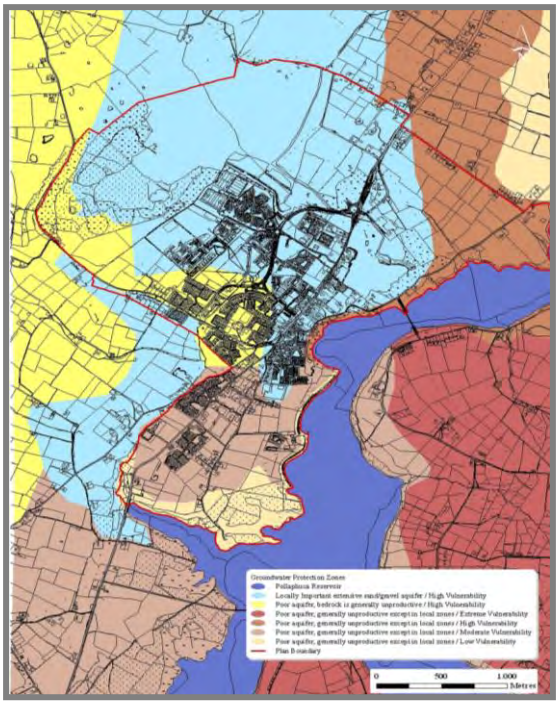
The need for SEA is determined by applying established criteria/thresholds as set out under the amendment of Part 3 of SI No. 436 of 2004 and amended by SI No. 201 of 2011 (e.g. mandatory for County Development Plans (CDPs), and for Local Area Plans (LAPs) with population above 5,000 people). In such cases, screening may not benefit directly from the capabilities of GIS. However, in case-by-case screening (e.g. LAPs with population below 5,000 people) the need for SEA is determined by the likelihood for significant environmental impacts (Box 1). In such cases, GIS can be applied in the preliminary screening assessment of potential environmental issues. Similarly, the spatial representation and assessment of Natura 2000 sites could assist screening for Appropriate Assessment.

Best Practice Tip: Outside legislative thresholds, checking ecological designations and water quality within or adjacent to the study area can provide a rapid indication of the need for SEA or AA.

Box 1. Case study: SEA of Blessington Local Area Plan 2012–2018[25]

The Blessington LAP contains a population of less than 10,000 and, therefore, SEA was not mandatory under SI No. 436 of 2004 (the amended thresholds of 5,000 inhabitants as per SI No. 201 of 2011 were not published at the time of the Blessington LAP preparation). However, SEA and AA screening revealed important environmental and planning issues within the plan area. These included Special Protection Areas and proposed Natural Heritage Areas (left) and locally important aquifers (right). As a result, it was established that the LAP should be subject to SEA.



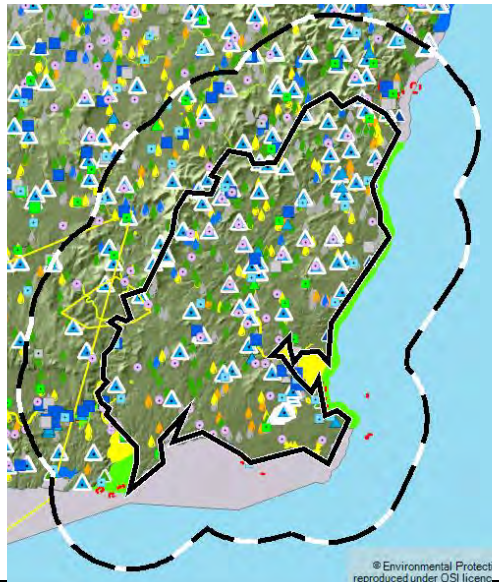


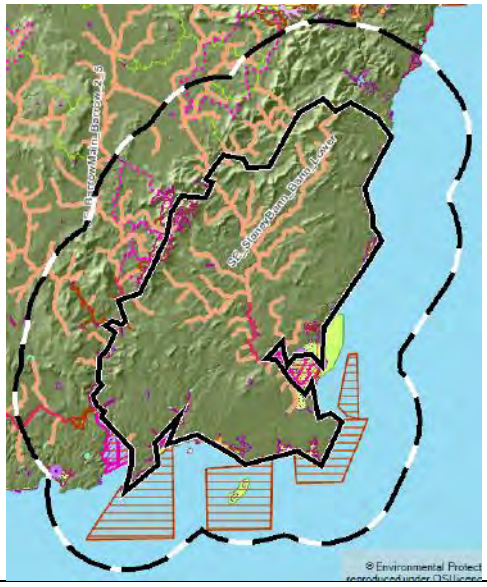
[24] A González, A Gilmer, R Foley, J Sweeney, J Fry (2011). Applying Geographic Information Systems to Support Strategic Environmental Assessment: Opportunities and Limitations in the context of Irish Land-use Plans. Environmental Impact Assessment Review, 31(3) 368–381

[25] http://www.wicklow.ie/apps/wicklowbeta/Publications/Planning/BlessingtonTP/2.%20SEA%20Env%20Report%20Appendices%20&%20NTS.pdf.

The EPA has implemented a tailored internal GIS to assist SEA screening and scoping: WebGIS & Reporting tool. The tool includes automated generation of SEA screening and scoping reports, containing a number of maps highlighting the key environmental considerations in the area together with the available quantitative and qualitative values for those environmental factors (Figure 9).

Figure 9. EPA's Search and Report sample maps and data generated for County Wexford: Water quality (left) and designated sites (right). **Data source: EPA.**





Water Quality (EPA)

Table 2.1 - Rivers (2007 - 2013)

Water Quality Range	Description	Number Of Sites
Q4-5, Q5	High Status	20
Q4	Good Status	106
Q3-4	Moderate Status	64
Q2-3, Q3	Poor Status	21
Q1, Q1-Q2, Q2	Bad Status	1

Table 2.2 - Lakes (2009)

Quality Category	Description	Number Of Sites
Oligotrohic/Mesotrophic	Unpolluted	1
Moderately Eutrophic	Moderately Polluted	-
Highly / Strongly Eutrophic	Highly Polluted	-
Hypertrophic	Seriously Polluted	-

Table 3.1 – WFD Register of Protected Areas

Type Of Protected Area	Code
Shellfish Areas	PA2_0002
Shellfish Areas	PA2_0056
Shellfish Areas	PA2_0058
Shellfish Areas	PA2_0059
Salmonid Rivers	PA5_SAC_002162
Salmonid Rivers	PA5_SAC_002162
Salmonid Rivers	PA5_SAC_002162
Salmonid Rivers	PA5_SAC_002162
Salmonid Rivers	PA5_SAC_002137
Salmonid Rivers	PA5_SAC_002137
Salmonid Rivers	PA5_SAC_002137
Salmonid Rivers	PA5_SAC_000781
Salmonid Rivers	PA5_SAC_000781

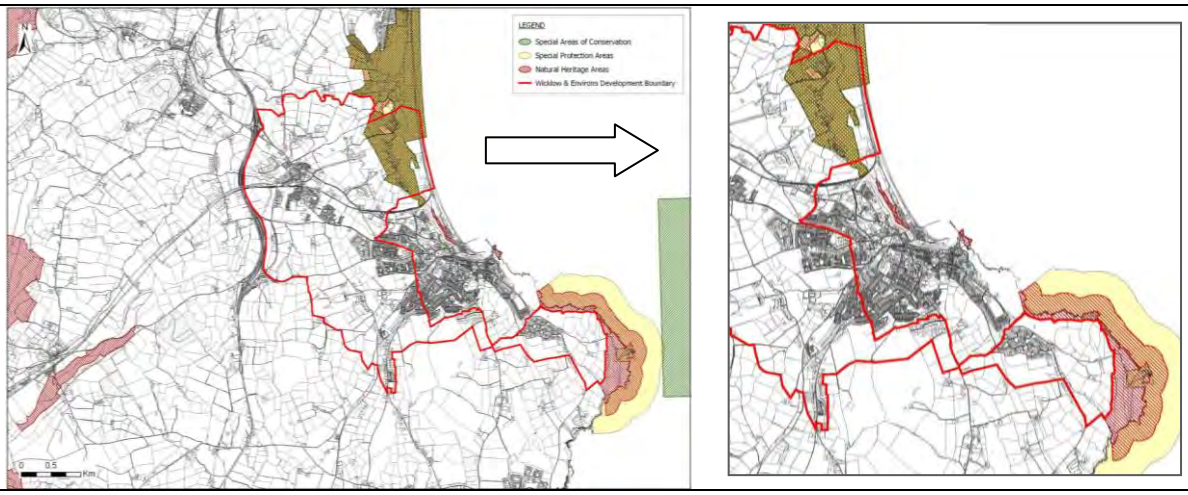
5.2. Scoping

Existing SEA screening and scoping techniques, such as checklists and matrices, involve tasks that while well structured, lack spatial and temporal dimensions. GIS have the potential to usefully augment

traditional systems by automatically checking the relevance of potential impacts by reference to spatially specific and quantifiable data. Mapping the location of environmental considerations within a plan area (e.g. SACs, surface waters with poor ecological status) allows for identification of those lands that are environmentally sensitive to zoning and associated development, and thus helps anticipate potential land-use conflicts (Box 2). It also facilitates identification of environmental factors that need further consideration (Box 3).

Box 2. Case study: SEA of Wicklow Environs and Rathnew Local Area Plan 2013–2019[26]

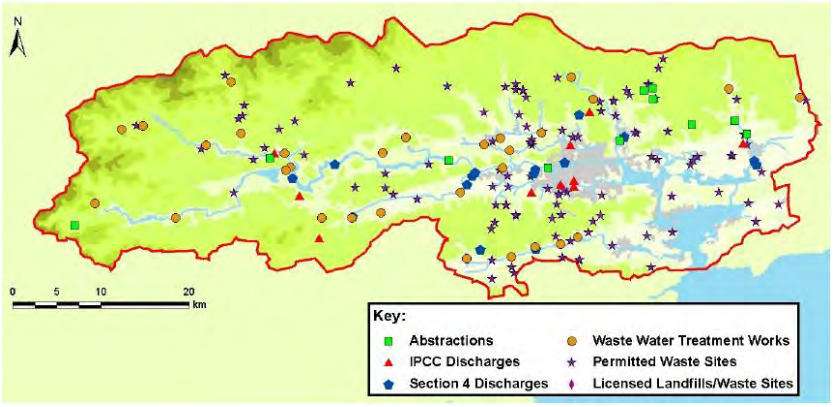
The population of Wicklow Environs and Rathnew exceeds the 5,000 people threshold set under the SI No. 201 of 2011. Since SEA was mandatory, scoping was undertaken to identify key environmental issues. The spatial analysis revealed that the implications for ecological designations (SACs, SPAs and proposed NHAs) within or in immediate proximity to the LAP needed further assessment. Moreover, in the context of AA, hydrological or green infrastructure linkages with these ecological sites were also analysed. When drafting the plan, the LAP took account of these issues, establishing compatible land-uses (e.g. open space, amenity) on or adjacent to such sensitive areas.



[26] http://www.wicklow.ie/apps/wicklowbeta/Publications/Planning/WicklowTownAndEnvirons/Adopted/Appendices/D%20-%20SEA%20Statement%20&%20Reports.pdf

Box 3. Case study: Lee Catchment Flood Risk Assessment and Management 2010[27]

The spatial approach to the scoping of issues facilitated the identification of areas that required further scrutiny during the assessment. The Scoping Report includes a set of maps highlighting key strategic issues relating to flood risk management within the catchment area, including contaminated land, floodplain infill with waste material, risk status of water bodies, concentration of point discharges within the catchment, ecological designations (i.e. SACs, SPAs, NHAs), salmon fishing areas, etc. These maps informed the focus of the SEA which, complemented with surveys, analyses and computer modelling enable detailed analysis of flood risk areas and management options.



Simple mapping tools (e.g. editing of layer properties) can be applied to create thematic maps to support the scoping of issues. A preliminary assessment of environmental sensitivities within the plan boundary (or boundaries for transboundary SEAs) can also be undertaken by overlaying the relevant thematic layers and by visually observing any spatial linkages and interrelationship. Layer transparency tools can also be used to identify the degree of overlap of concurring constraints and sensitivities. Prepared thematic maps can then be incorporated into the Scoping Report.

Best Practice Tip: Where no GIS-compatible digital datasets are available early in the process, maps and graphics can be scanned and used to illustrate the relevant environmental issues in the scoping report.

5.3. Baseline Environment

The aim at this SEA stage is to advise on environmental sensitivities (i.e. existing environmental issues and potential cumulative effects) within the plan area for consideration when drafting the plan (or its alternatives). Relevant baseline data layers include physical factors (e.g. land cover, topography, geology), fieldwork data (e.g. water quality sampling data) and statistical data (e.g. population density). These are commonly gathered from various sources (Appendix D) to form a spatial database that fits both the objective and the geographical scale of the plan/programme and the scope of the associated SEA. Modelling techniques can also be applied at this stage to obtain specific sets of information (e.g. flood risk areas, coastal erosion) which can generate valuable predictive information for SEA.

In a similar manner to the scoping stage, basic data display and mapping operations can be applied in the preparation of maps that illustrate the status of environmental aspects and enhance understanding of the spatial distribution of environmental aspects and the potential for cumulative effects. Layer

[27] http://www.leecframs.ie/downloads/documents/REP005_draftFRMP.pdf

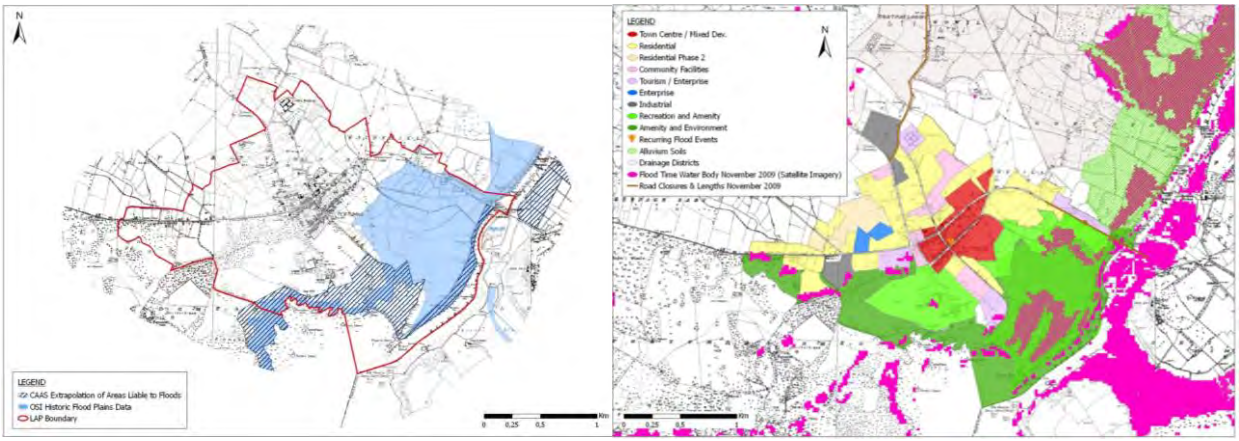
properties can be edited to enhance further information display. Careful consideration should be given to the colour schemes applied (i.e. established colour schemes should be adopted for those standardised datasets such as CORINE land cover, bedrock geology and ecological status of waters under the WFD). Any technical difficulties associated with data inconsistencies should be addressed during this stage. Editing tools can be used to complete, correct and appropriately integrate data into the GIS interface. Editing of data obtained from third-party sources should be done through consultation with the data owner to ensure that amendments are appropriate and improvements correct. Unresolved data gaps and inconsistencies, as well as any assumptions made during modelling, for example, also need to be clearly acknowledged in the Environmental Report.

Best Practice Tip: All relevant digital datasets can be simply overlaid on a single map to visualise potential (cumulative) impacts. This can be achieved by ensuring that all the layers have the same colour and subsequently applying a transparency of 50% to each layer as shown in Figure 2.

In the example illustrated in Box 2, the ecological designations can be described according to their geographic context and relative location within the study area boundary. This provides a visual and more accurate description of environmental considerations, which can assist in the appropriate/sustainable zoning of lands during plan-making. All relevant environmental considerations can be overlaid to obtain and provide additional information to SEA as part of the planning process. Overlay techniques facilitate the evaluation of spatial correlations and juxtapositions, and thereby the assessment of relative degrees of sensitivity within the plan area and the potential for cumulative, synergistic and/or secondary impacts (Section 3.2.2). Collected spatial data can be complemented with field surveys to validate the extent of environmental factors and identify any additional sensitive areas (Box 4).

Box 4. Case study: Galway Flood Risk Assessment and Management[28]

Inspection of historical maps was complemented with detailed field surveys undertaken with water services inspectors from the County Council in order to verify the data available from the Office of Public Works. These facilitated the adjustment of flood boundaries, as well as the identification of additional flood risk areas.



[28] SEA under preparation. Report to be published.

Overlay Operations to Establish the Composite Environmental Sensitivity Baseline

Overlay operations also enable the incorporation of public values in the form of weights (i.e. relative importance of the environmental layer based on stakeholder/public perception). Although this technique can lead to significant discussion on the representativeness and appropriateness of weights, as well as on their influence on the resulting mapped analysis, it enables public involvement in the assessment (Section 5.9). Moreover, it provides a strategic overview of the overall environmental sensitivity as a planning support tool. However, the potential for significant impacts of certain planning objectives or specific projects outside highly sensitive areas should not be overlooked.

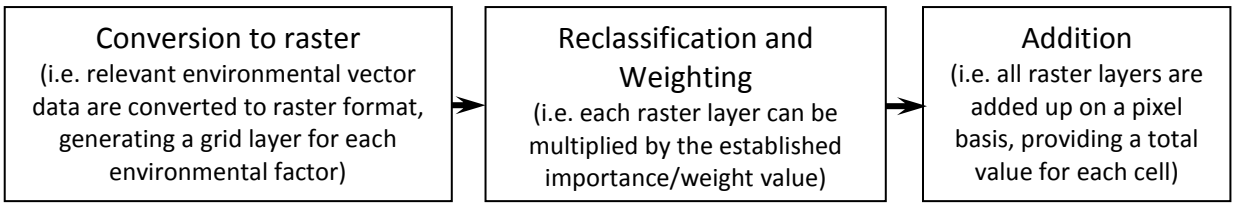
To facilitate overlay operations and allow the integration of weighted values, vector layers can be converted to raster format using conversion tools. The pixel size should respect the scale of the assessment and the properties of the datasets used, and provide sufficient and adequate detail for the assessment. The relative level of accuracy adopted must reflect the plan hierarchy and, thus, its geographical scale; however, the absolute accuracy depends on the spatial accuracy of used datasets. Where data accuracy issues are identified, it must be clearly stated that the resulting sensitivity area boundaries are indicative rather than definitive.

Best Practice Tip: A cell size of 50 m × 50 m can be applied for regional assessments; 20 m × 20 m is adequate for county-wide assessments, while this can be reduced to 10 m × 10 m at local area level. All layers in a given assessment should adopt the same pixel size to ensure their correlation.

Raster cells can also be reclassified according to their relative importance value (if stakeholders assign greater significance to one or various factors). Raster calculations can overlay and join the various raster datasets according to the absolute spatial location of features (i.e. cells/pixels), and combine importance values for each location. This is achieved by adding up all co-occurring environmental criteria (Box 5).

Box 5. Overlay methodology for calculating environmental sensitivity

Weighted Overlay Flow Diagram:



Weighted Overlay Equation: $Vn = \Sigma WjVj$

Where:

- Vn: Resultant sensitivity value for the area/pixel which relates to the total number (n) of environmental factors that overlap in that area and their associated relative importance.
- Wj: Degree of sensitivity of each factor (j) according to scientific opinion.
- Vj: Relative importance value or weight of subjective nature for each factor (j). This value represents stakeholder/public perceptions. The values or weights can be assigned to each feature on a layer or to the layer as a whole.

Best Practice Tip Wj: To standardise categorisations it can be set that highly sensitive environmental factors (e.g. surface waters with bad ecological status under the WFD or landscapes classified as highly sensitive in the County Development Plan) equate to 10, while sensitive factors (e.g. surface waters with poor ecological status or landscapes classified as sensitive) equate to 5. A value of 0 must be given to the cells that had no occurrence of environmental sensitivities.

Best Practice Tip Vj: Factors of concern or perceived as more important can be given a weight of 1.5 to increase their significance. Factors perceived as neutral still have scientific significance (e.g. relative water quality status) and must, therefore, be given a weight of 1 (i.e. a 0 value would cancel them out).

Applying the (weighted) overlay equation through the spatial analysis tools in GIS (e.g. raster calculator) provides an overall picture of environmental constraints and opportunities (relative degrees of sensitivity of lands within the plan area). Box 6 represents a form of categorisation of results of the spatial assessment. The results of the weighted overlay map can also be quantified to calculate the total amount of lands under each environmental sensitivity class, which may provide further insight into lands that need to be protected or not developed and the associated policy recommendations (Box 7). In addition, the preparation of composite environmental sensitivity maps can contribute to the identification of sustainable alternatives (Box 8).

Best Practice Tip: A traffic-light colour scheme can be adopted for clarity of visualisation, where the darker the areas, the higher their environmental sensitivity.

Box 6. Environmental sensitivity categorisation of weighted overlay results

The adoption of a standardised classification for the various degrees of environmental sensitivity facilitates transparency and comparability across assessments. A classification type may be as follows:

Overlay Results	Category
0	No sensitivity (i.e. areas without any environmentally sensitive features)
5–15	Low-sensitivity areas
20–25	Moderate-sensitivity areas
30–35	Elevated-sensitivity areas
40–45	High-sensitivity areas
50–60	Extreme-sensitivity areas
>65	Acute-sensitivity areas (i.e. severe sensitivity due to a significant number of overlapping environmental aspects and a clear likelihood of cumulative effects)

This classification assumes that the sensitivity of an area increases significantly when two or more highly sensitive environmental factors overlap. A score of 5 represents one sensitive environmental factor occurring. A score of 10 indicates two sensitive or one highly sensitive factor; a score of 20 encompasses four sensitive, two highly sensitive or one highly sensitive and two sensitive environmental factors, and so on (as per Box 5). In light of this categorisation, each pixel reflects a sensitivity score which determines the relative sensitivity to impact of those lands.

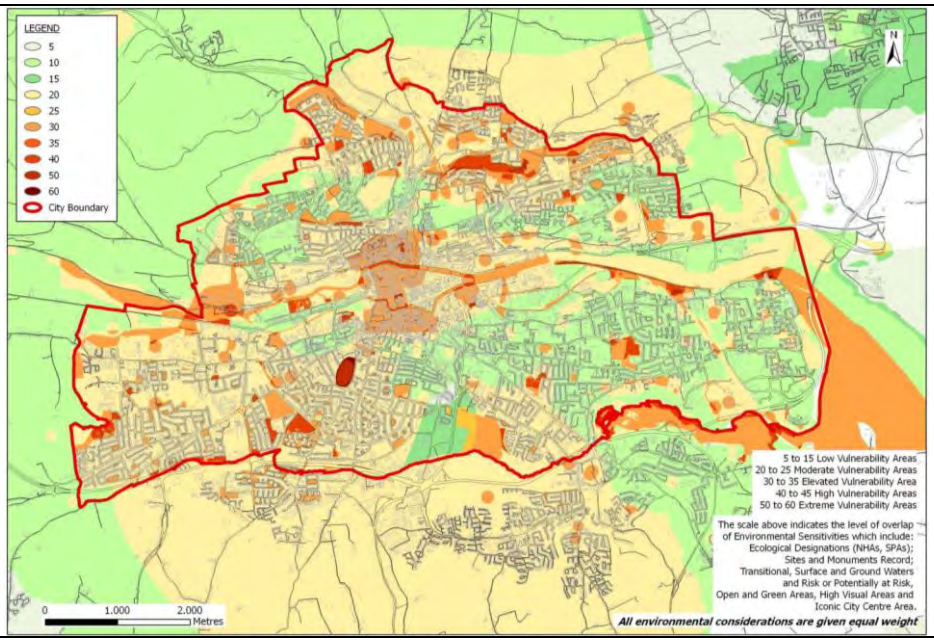
Box 7. Case study: Cork City Development Plan 2009–2015[29]

The environmental sensitivity areas for Cork City, resulting from the weighted overlay assessment, solely indicate the level of overlap between environmental factors and their scientific status (i.e. all environmental factors were given equal importance and, thereby, no subjective weightings were applied). In this context, the map may not fully portray the 'real' sensitivity of the areas. For instance, certain ecological designations alone, such as SACs or SPAs, can make an area extremely sensitive to development, while water considerations, such as aquifer vulnerability, may condition but not prevent development. Giving appropriate weights (that reflect the importance and sensitivity of each layer) to each environmental consideration can provide further insight into the assessment.

Calculating the areas under each environmental sensitivity category can be achieved by using GIS raster count tools and multiplying the number of pixels under each category by the pixel size adopted (e.g. pixel size 20 m × 20 m = 400 m^2 land area). The mapped outputs can thus be complemented with quantitative values on the extent of each environmental sensitivity type within the plan area.

Overlay Results	Area (km^2)	Percentage
No sensitivity	0	0
Low-sensitivity areas	15.80	39.9
Moderate-sensitivity areas	18.30	46.2
Elevated-sensitivity areas	4.38	11.0
High-sensitivity areas	0.98	2.5
Extreme-sensitivity areas	0.15	0.4
Acute-sensitivity areas	0	0
Total	**39.61**	**100**

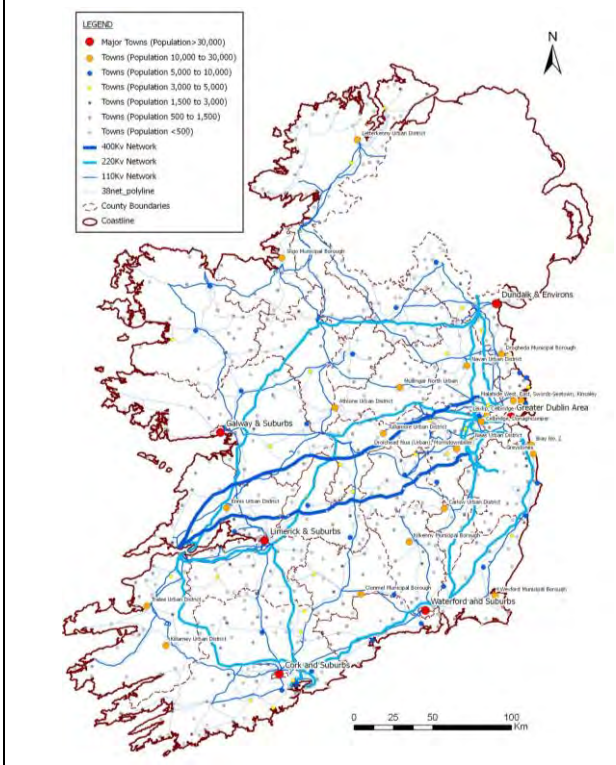
These values can be used to further understand relative sensitivities in the overall context of the plan area. In this particular example, avoiding development on only 1.13 km^2 or 2.9% of the total plan area (i.e. on high- and extreme-sensitivity areas) may help mitigate the most severe environmental effects.

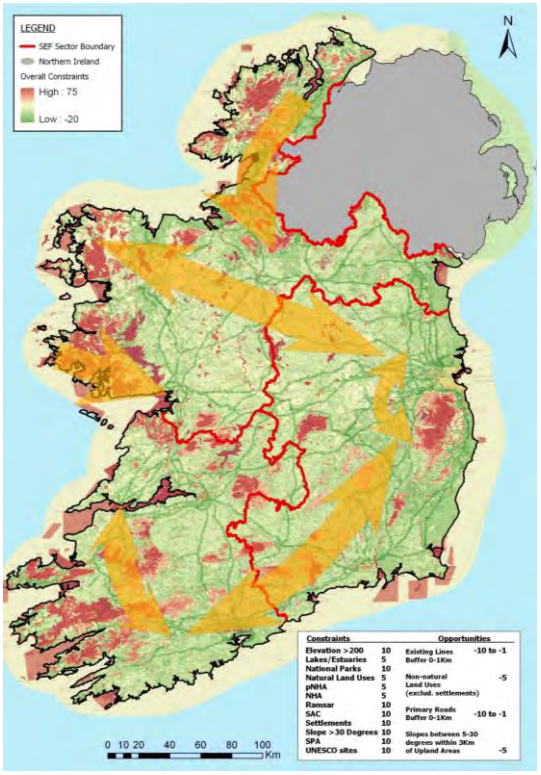


[29] http://www.corkcity.ie/newdevelopmentplan/SEA%20Statement%20%20low%20res%20version.pdf

Box 8. Case study: EirGrid – Grid 25 Analysis[30]

The planning of the national transmission grid to support onshore and offshore wind development, entailing major reinforcements to the existing network and new networks, took account of the continuing need to balance the reliability and security objective with the costs and environmental impact of developments. Therefore, the SEA undertook a nationwide analysis of the current network, and a detailed opportunities and constraints analysis for future grid development. This opportunities and constraints analysis enabled the identification of strategic corridors and can be used to support the identification of network alignments at project level.





5.4. Strategic Environmental Objectives

The formulation of SEOs is often based on regulatory requirements and existing higher-tier plans/programmes. Although the ability of GIS to directly assist this SEA stage can be limited, spatial data and GIS can contribute to the integrated formulation of SEOs. The baseline maps prepared can assist significantly by strategically informing this process. Visually assessing potential environmental issues can help identify and prioritise the measures for environmental protection. Moreover, establishing SEOs and associated targets and indicators while considering their spatial context can subsequently help in defining spatially specific mitigation and monitoring measures (Box 9).

Best Practice Tip: Identifying key environmental sensitivities within the plan area can contribute to validating and prioritising any associated environmental objectives, as well as determining associated indicators and targets in more accurate and spatial detail.

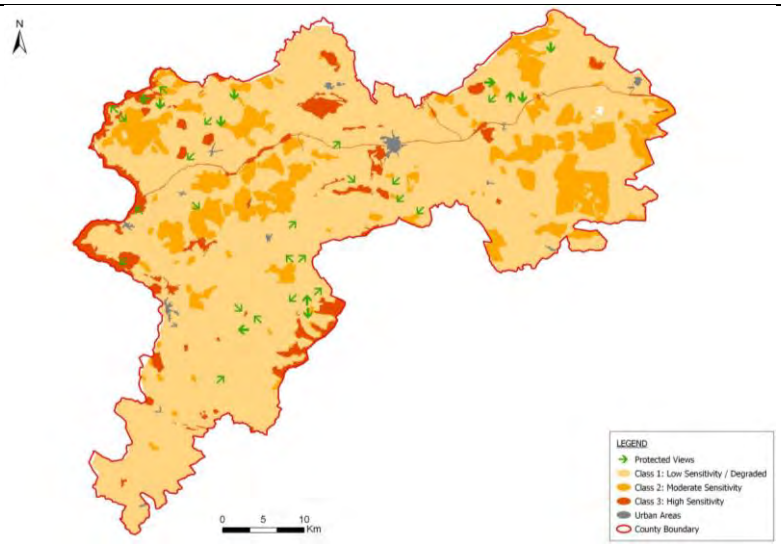
[30] http://www.eirgrid.com/media/Environmental%20Main%20Report.pdf

Box 9. Case study: SEA of Offaly County Development Plan 2009–2015[31]

Although SEOs tend to be broadly defined (e.g. to protect designated sensitive landscapes), they can be further refined by illustrating their spatial context. The landscape sensitivity categorisation in county Offaly was used to inform the definition of SEOs which facilitated a more precise formulation of associated indicators and targets.

SEO L1: To protect County Offaly's sensitive landscapes and designated scenic views

Indicator L1i: Number of unauthorised conspicuous developments located within sensitive landscapes.
Target L1i: No unauthorised developments to be conspicuously located within (high and moderate) sensitive landscapes.
Indicator L1ii: Number of unauthorised conspicuous developments adversely impacting upon views and prospects of special amenity value or special interest.
Target L1ii: No unauthorised developments to adversely impact upon views and prospects of special amenity value or special interest.



5.5. Definition of Alternatives

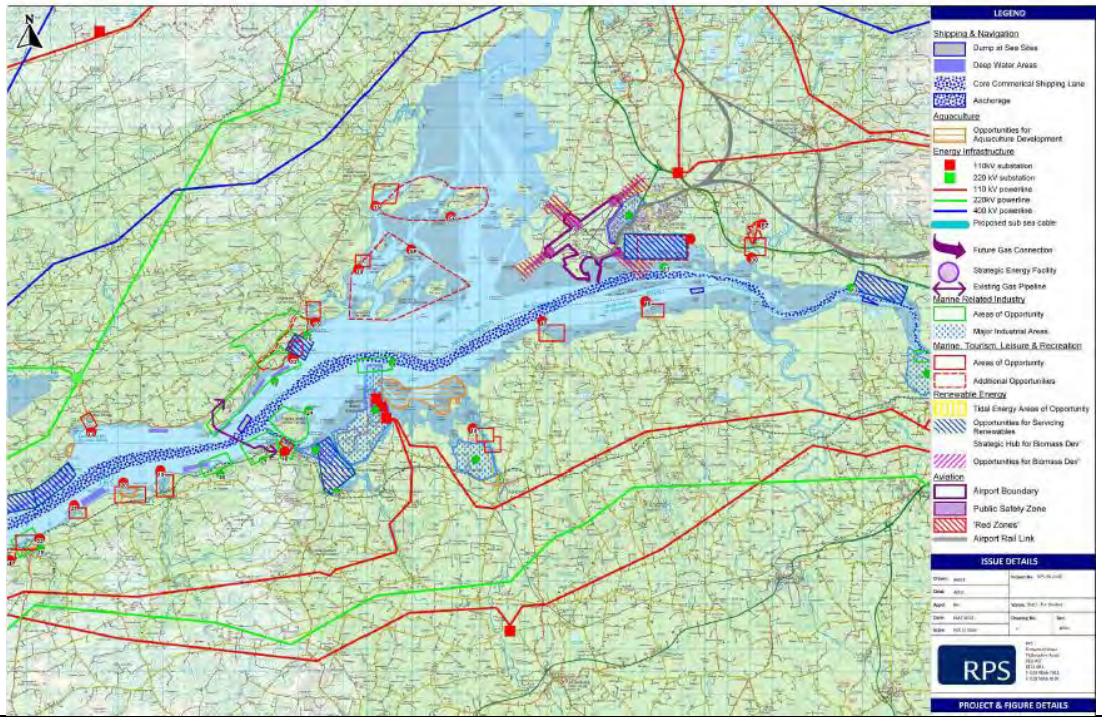
The identification, development and assessment of alternatives are essential parts of SEA. In AA, the development of alternative ecological solutions is only required when significant adverse effects have been identified. Development and illustration of reasonable and realistic planning scenarios (which in the context of spatial planning largely relate to land-use zoning options and their location) can be easily achieved using GIS. The ability of GIS to rapidly update information is crucial for modelling and generating alternatives. Moreover, the capacity of GIS to illustrate proposed alternatives against the baseline environmental data can facilitate their assessment and, thereby, the identification of the most environmentally sensitive areas and the most suitable development scenario (Box 10).

[31] http://www.offaly.ie/eng/Services/Planning/County_Development_Plan_2009-2015/Environmental_Report_.pdf

Best Practice Tip: Alternatives can be as spatially specific or as broad as appropriate, taking account of the plan/programme hierarchy. For example, at county level generic development clusters can be defined (e.g. urban areas), while at local level extent and zoning type of land parcels can be specified (Box 11).

Box 10. Case study: Strategic Integrated Framework Plan for the Shannon Estuary 2013–2020[32]

This non-statutory plan was subject to SEA and AA due to the environmental and ecological sensitivity of the estuary. The initial consideration of over 100 alternative locations for maritime, industrial, energy, tourism or leisure development was narrowed down to reasonable strategic development sites (preferred alternatives) on the basis of their preliminary assessment and comparison against the baseline environment maps. Undertaking a spatial environmental review of the proposed strategic development locations as they were identified ensured that environmental matters were incorporated at the earliest possible opportunity and avoided environmentally sensitive or otherwise important areas. The spatial overlay facilitated early identification of potential conflicts with developments on or adjacent to the Fergus Estuary and the coastal lagoons within the estuary. These sites were subsequently removed from the plan.

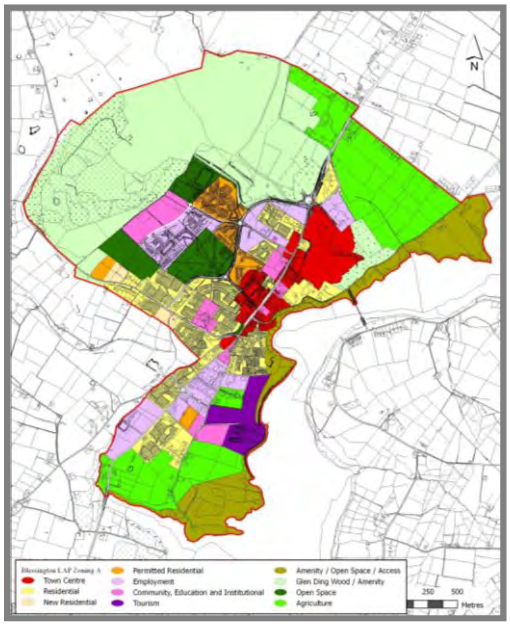


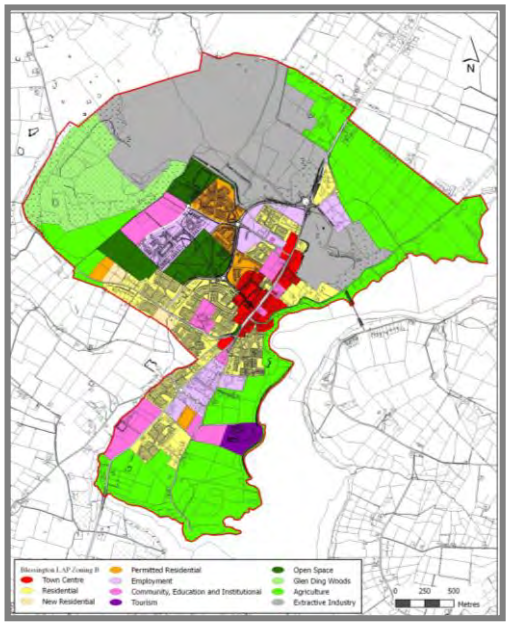
[32] http://www.shannonestuarysifp.ie/sites/default/files/sifp/Volume_3/SEA_Environmental_Report.pdf

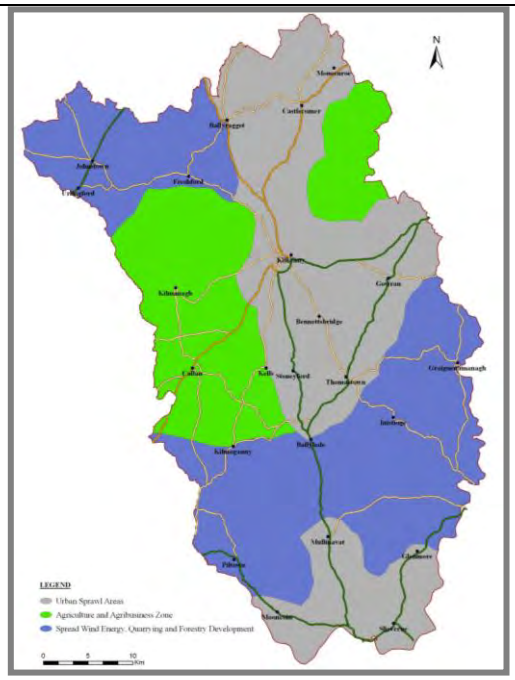
Box 11. Case studies: Blessington Local Area Plan 2012–2018[33] and Kilkenny County Development Plan 2008–2014[34]

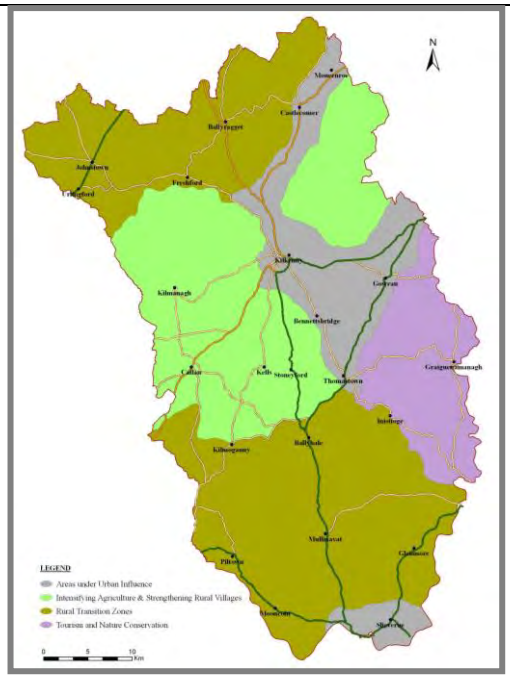
Alternatives considered when drafting a plan can be mapped, particularly at the local level. At this level, land-uses are specifically defined for each field or land parcel. The alternatives for Blessington LAP include variations on zoned lands (e.g. extractive industry or amenity to the north of the plan area).

Alternatives are often defined in broader terms at higher planning tiers (i.e. county level) due to the larger geographical extent and the more strategic policies and objectives considered. This is illustrated by the potential development scenarios considered in the Kilkenny CDP, where the indicative extent of urban sprawl areas (and the associated zoning objectives/policies) differs.









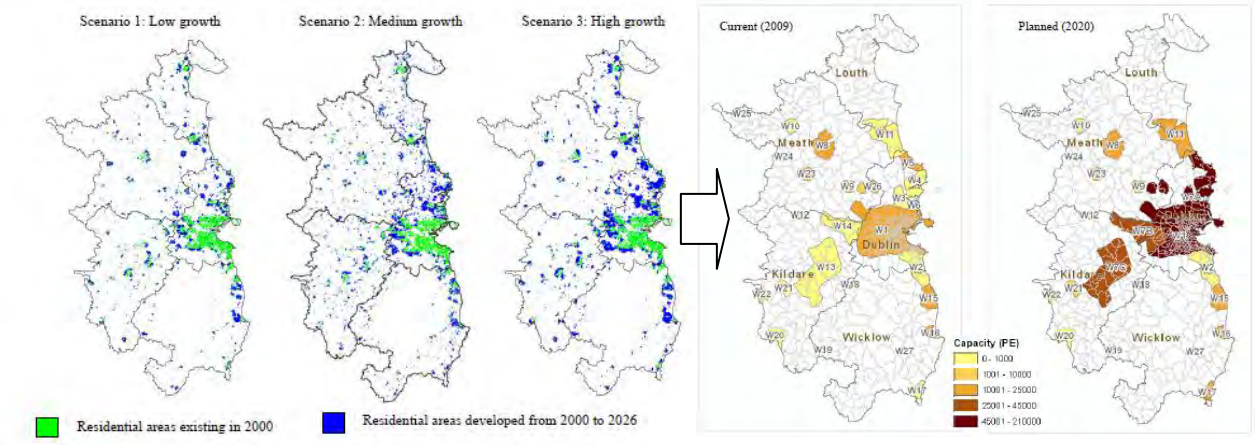
[33] http://www.wicklow.ie/apps/wicklowbeta/Publications/Planning/BlessingtonTP/2.%20SEA%20Env%20Report%20Appendices%20&%20NTS.pdf
[34] http://www.kilkennycoco.ie/resources/eng/Services/Planning/DevelopmentPlans/SEA%20Statement%20on%20County%20Dev%20Plan.pdf

Digitising tools are used for the creation of new layers that illustrate considered alternatives and specify the associated zonings/typologies in the attribute tables. Modelling techniques can also be applied at this stage to simulate scenarios, of urban development and expansion for example, and create thematic maps for alternatives (Box 12). Layer properties can then be edited to colour-code different zonings. The colour scheme adopted should be standardised and equally applied to all the scenarios to aid in their visual comprehension and comparison.

Best Practice Tip: Clustering of planning applications received and/or granted, or mapping of received pre-planning consultation submissions can be used to generate alternatives, where land-use zonings incorporate these considerations (e.g. indicative urban sprawl or clusters that require a LAP).

Box 12. Case study: Regional Planning Guidelines for the Greater Dublin Area 2010–2022 – Providing Waste Water Treatment Plant Capacity in the Dublin Region 2006–2016[35]

MOLAND land use model was adapted to determine how the spatial distribution of three population projections for the Greater Dublin Area (GDA) would impact on future capacity and defined catchment areas of waste water treatment plants. Therefore, land use modelling determined where future infrastructural limitations would necessitate the distribution of population outside of pre-determined growth areas regardless of availability or suitability of zoned development land. The results formed part of broader considerations in alternatives selection for the Regional Planning Guidelines for the GDA.



5.6. Environmental Assessment of Alternatives

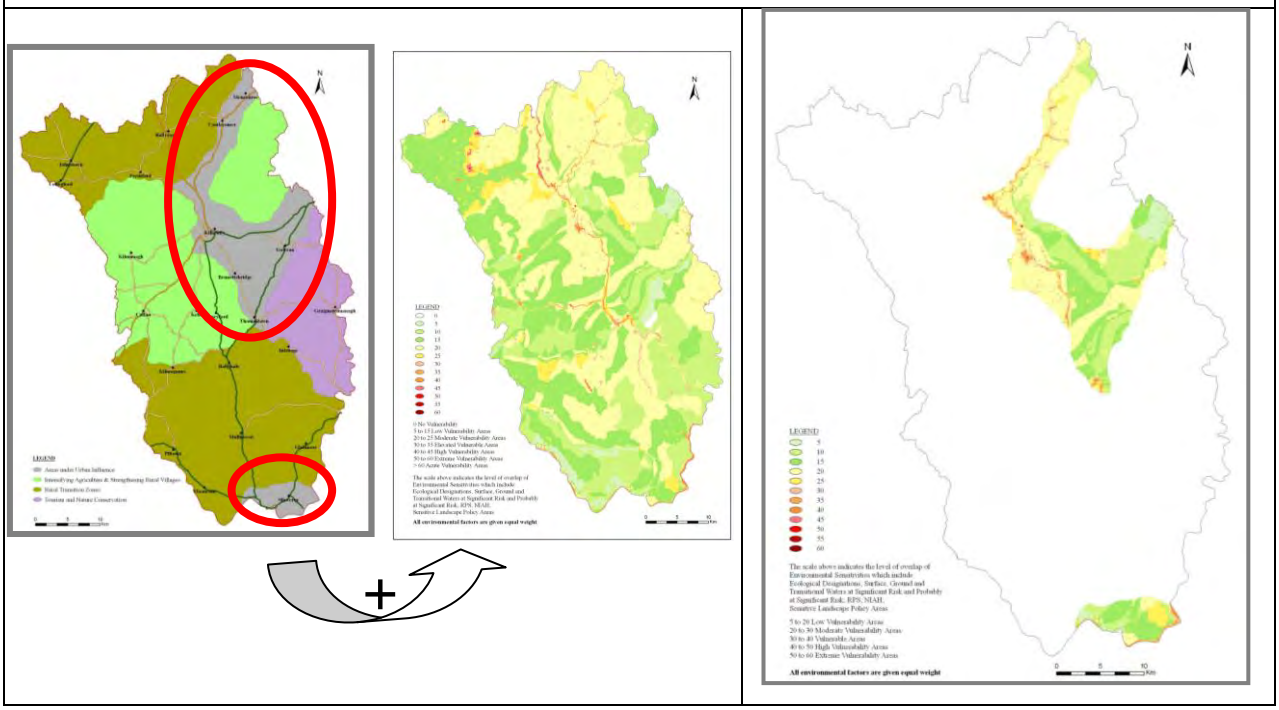
Mapping the different alternatives/scenarios considered in the plan/programme-making process facilitates understanding of the environmental implications of each alternative. Spatially correlating the areas under development pressure with the environmentally sensitive areas allows for the rapid identification of potential land-use conflicts (and, consequently, environmental protection objectives). Thus, GIS can allow for efficient prediction, quantification and comparison of potential impacts associated with the proposed alternatives (Box 13). The visual representation of such an assessment provides comprehensive and transparent results to support informed decisions (Box 14).

[35] http://www.naturaconsultants.com/derrytest/wp-content/uploads/2012/01/Greater-Dublin-Regional-Planning-Guidelines-Part-II.pdf

Box 13. Case study: Kilkenny County Development Plan 2008–2014[36]

Proposed alternatives for the Kilkenny CDP were overlaid with the previously prepared composite environmental sensitivity map, subsequently extracting (i.e. clipping) the areas under development pressure. In this particular case, the areas zoned as suitable for development are largely located within low and moderate environmental sensitivity areas. Nevertheless, this zoning affects the highly sensitive corridor of the river Nore. Quantification of affected sensitive areas for each of the alternatives as per the table below clearly showed that the strong planning scenario represented the most environmentally sustainable option. The assessment also contributed to identifying more suitable areas in environmental terms (e.g. the south- and north-western lands).

Vulnerability Area	Scenario 1 Weak Planning	Scenario 2 Normal Planning	Scenario 3 Strong Planning
Low	364.41	149.49	22.54
Moderate	383.83	140.72	34.63
Vulnerable	29.87	15.88	5.42
High	5.97	2.79	1.24
Extreme	0.18	0.11	0.09
Acute	364.41	0	0



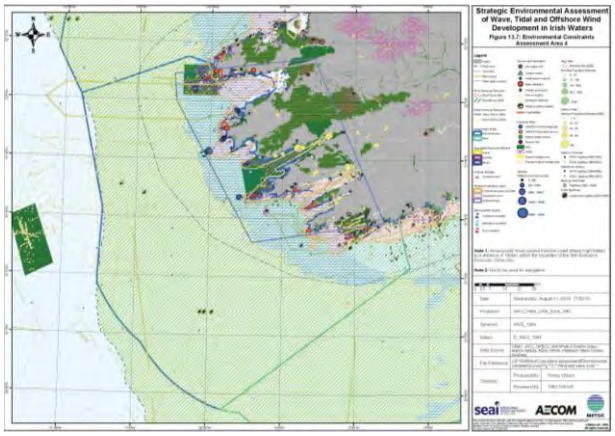
Each individual alternative can be overlaid on and evaluated against the environmental sensitivity map/s previously generated. Buffering techniques can also be applied at this point to illustrate situations where the assessment requires the identification of an 'impact area' of the alternative(s) that is larger than its footprint. Detailed assessment of the preferred alternative can also be undertaken in a similar manner. Clipping tools in GIS can be used to extract environmentally sensitive areas under development pressure associated with the preferred alternative(s) and evaluate and quantify their significance and extent. This approach facilitates rapid and clear identification of the most environmentally suitable alternative.

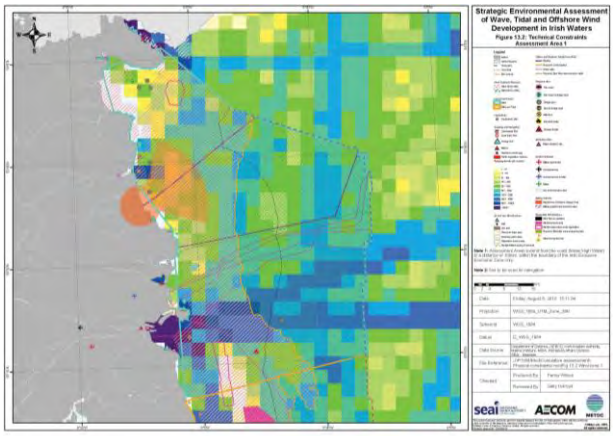
[36] http://www.kilkennycoco.ie/resources/eng/Services/Planning/DevelopmentPlans/SEA%20Statement%20on%20County%20Dev%20Plan.pdf

Best Practice Tip: Where no weighted overlay has been undertaken, alternatives can be overlaid with each of the key environmental aspects (such as ecological designations, sensitive landscape areas or flood risk areas).

Box 14. Case study: Draft Offshore Renewable Energy Development Plan (OREDP) 2010–2030[37]

The SEA aimed to identify the maximum amount of renewable energy development of different types (i.e. fixed wind, wave, tidal and floating wind) that could be accommodated in six different assessment areas without significant adverse environmental impacts. Key environmental receptors and sensitivities in each area were identified (e.g. shellfisheries, seascape, protected sites) and potential effects of the relevant technologies examined based on these constraints and assumptions about technologies. Cumulative effects assessments were also carried out, identifying the potential amount of development that could be accommodated without significant adverse environmental impacts.





5.7. Mitigation Measures

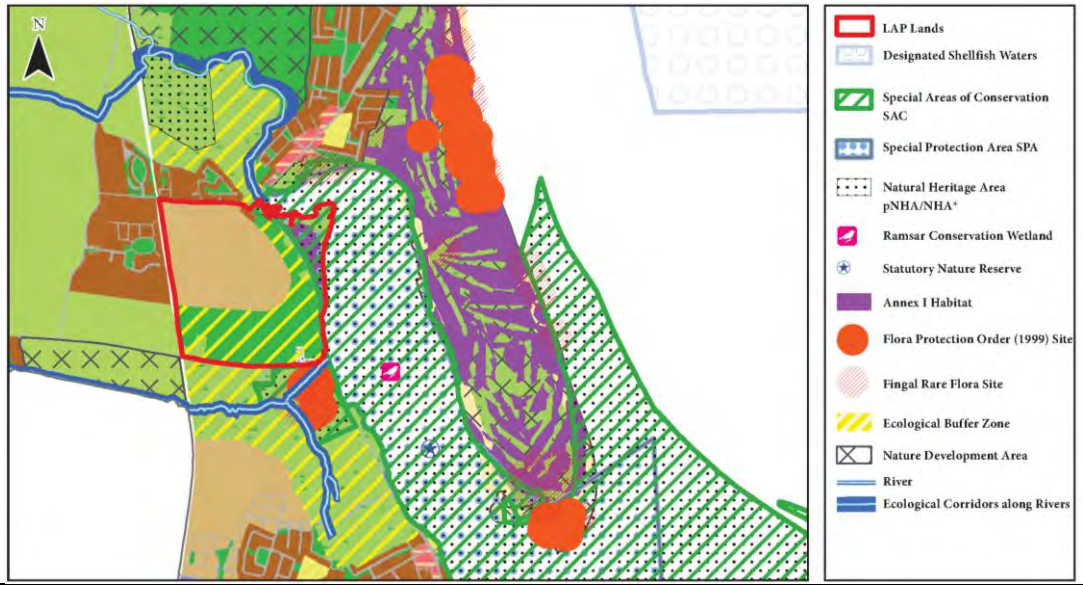
Mitigation measures are generally defined during the assessment of the preferred alternative in an effort to prevent, reduce and, as fully as possible, offset (or compensate in the case of AA) any significant adverse effects of its implementation. As a result, mitigation measures focus on environment protection, and are commonly related to resolving any conflicts and spatio-temporal correlations identified during the GIS-based assessment. Although the direct application of GIS techniques may be limited in this SEA stage, the enhanced evaluation of both baseline data and environmental impacts through GIS can help to more adequately identify quantitative and spatially precise mitigation measures (e.g. no development to occur within 50 m from the shoreline or within 200 m of a SAC). Therefore, previously prepared maps and spatial analyses undertaken can potentially support and improve the formulation of mitigation measures (Boxes 15 and 16).

Best Practice Tip: Any land-use conflicts identified during detailed assessment of the preferred alternative can be used to formulate mitigation measures that attempt to resolve the identified conflicts.

[37] http://www.dcenr.gov.ie/Energy/Sustainable+and+Renewable+Energy+Division/Natura+Impact+Statement+and+Strategic+Environmental+Assessment+on+draft+Offshore+Renewable+Energy+De.htm

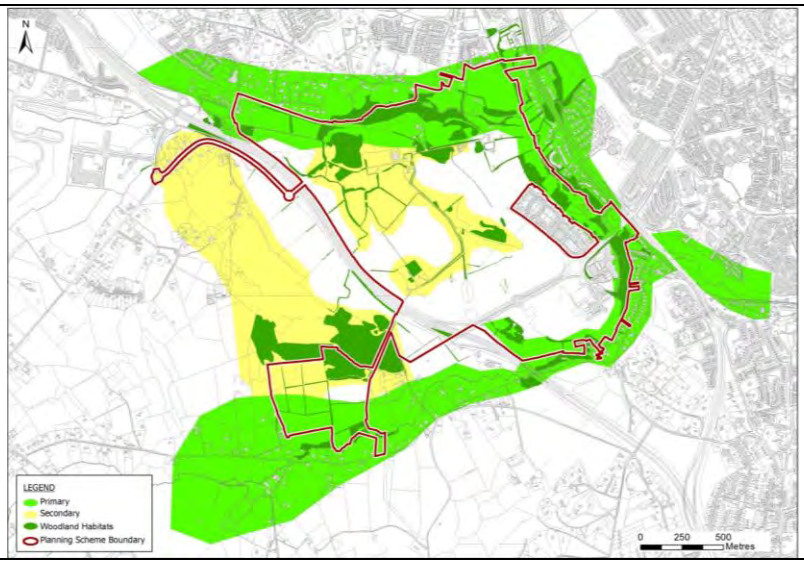
Box 15. Case study: Portmarnock South Local Area Plan 2013–2019[38]

In the context of AA, development pressure areas adjacent or in close proximity to environmentally sensitive areas (e.g. Natura 2000 sites) were mitigated by ensuring spatially specific mitigation measures. These included selection of the proposed walkway route that avoided Annex I habitats, management of defined areas for wintering birds to reduce the impact of recreational activities and loss of feeding habitat from residentially zoned lands within the LAP and retention and management of the Murragh Spit for waterbirds. Location-specific mitigation measures can be mapped (e.g. creating buffer zone along the boundary of Natura 2000 sites or mapping the management objectives), and used for development control.



Box 16. Case study: Cherrywood Strategic Development Zone (SDZ) 2012[39]

The spatial identification of urban development areas and green spaces within the Cherrywood SDZ enabled identifying ecological corridors as mitigation measures that provided environmental and, in particular, biodiversity benefits to the area, enhancing the sustainability of the plan.



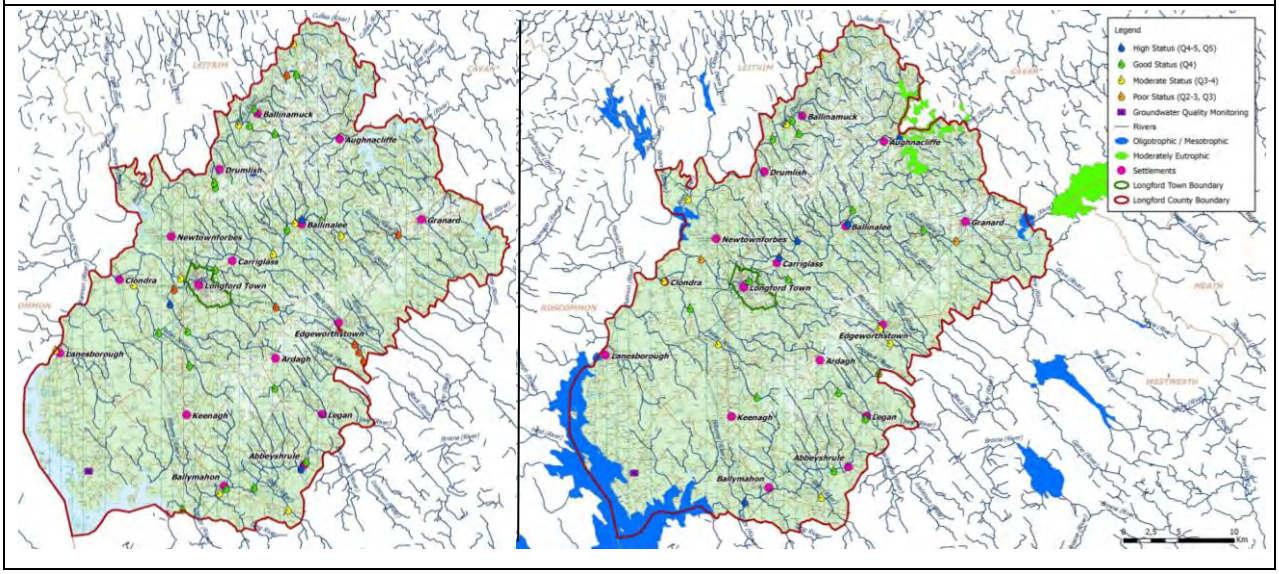
[38] http://www.fingalcoco.ie/media/Adopted%20Portmarnock%20South%20Local%20Area%20Plan%20Document.pdf
[39] http://www.dlrcoco.ie/aboutus/councildepartments/planning/findit/cherrywoodstrategicdevelopmentzonesdz/

5.8. Monitoring

GIS integration at early stages of the SEA process, such as the establishment of the environmental baseline, can provide the foundation for impact monitoring, particularly where data sources and impact assessment methods used are suitable for reuse during monitoring. In such circumstances, monitoring the accuracy of impact predictions during the life of a plan and the effectiveness of mitigation measures may only require systematic updating of baseline datasets followed by re-implementation of pre-existing impact assessment routines. Ensuring adequate access to relevant existing data sources could facilitate incorporation of data updates from existing monitoring arrangements, such as the measurement of environmental quality indicators undertaken by the EPA (e.g. monitoring of water quality and status as required by the WFD). This, in turn, would reduce monitoring resource requirements by rapidly updating the values of relevant environmental indicators in GIS, and help to avoid duplication of work among the different SEA levels – by re-using and recycling relevant datasets. Recording local issues and updating any local changes (e.g. on the boundaries of Natura 2000 areas or on river water quality) is essential and can help determine the effects of developing the zoned lands, as well as establishing any remedial actions required and informing plan review (Box 17).

Box 17. Longford County Development Plan 2015–2021[40]

A simple analysis of the river water quality values for Longford CDP overtime facilitated a rapid identification of changes in the water quality of certain rivers and streams. Moreover, mapping the sampling periods revealed that the sampling date of the most recent values differed across locations (from 2011 to 1987). Of the 28 locations which have data available for 2010/2011 (right), 18 (64%) were identified as being of either high or good status, 8 (29%) of moderate status, and 2 (7%) of poor status.



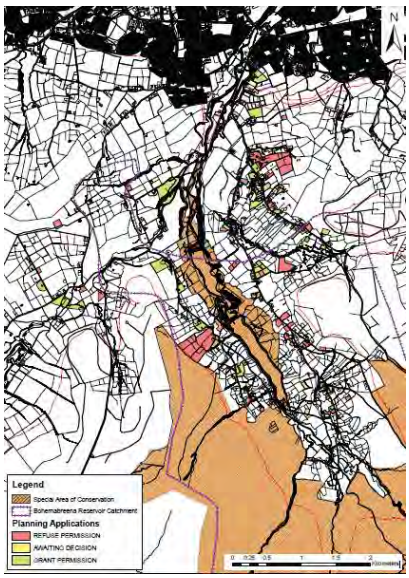
For effective and efficient GIS-based monitoring, it is important to establish a clear protocol by specifying key aspects such as spatial scale of monitored data and frequency of monitoring (Box 18). Such protocol should aim at addressing any identified data gaps and data management issues (Section 4), as well as ensuring the creation of metadata to improve spatial analysis certainty for future SEAs as well as AAs.

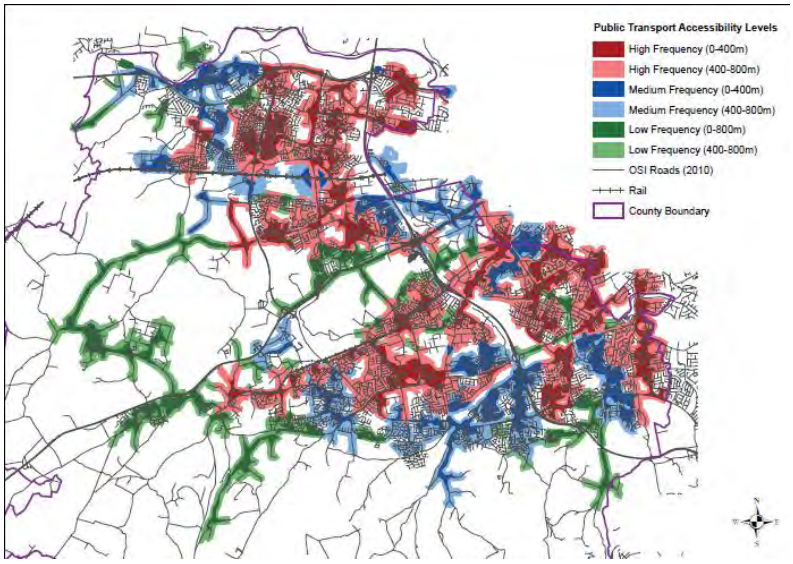
[40] http://www.longfordcoco.ie/uploadedFiles/LongfordCoCo/Our_Departments/Planning/Documents/Development_Plan_Review/Final%20SEA%20Scoping%20Report.pdf

Best Practice Tip: Update the baseline datasets with any new available spatial information and monitoring updates, and compare these to the previous values to identify any changes and trends.

Box 18. South Dublin County Council SEA Monitoring System[41]

Approximately 40% of the SEA indicators in South Dublin are being drawn from monitoring systems already in place both within and external to the Council. The remainder are being derived through a web-based SEA Monitoring System created to capture critical data at the planning application decision-making stage. These Development Derived Indicators allow a means of monitoring significant environmental impacts of implementing the policies and objectives of the County Development Plan and also, as information builds up over time, will enable evidence-based policy analysis and review. The figures below address landscape and natural heritage protection and public transport indicators (rural housing pressure monitoring on the right, and Public Transport Accessibility of areas and districts within the County on the left)





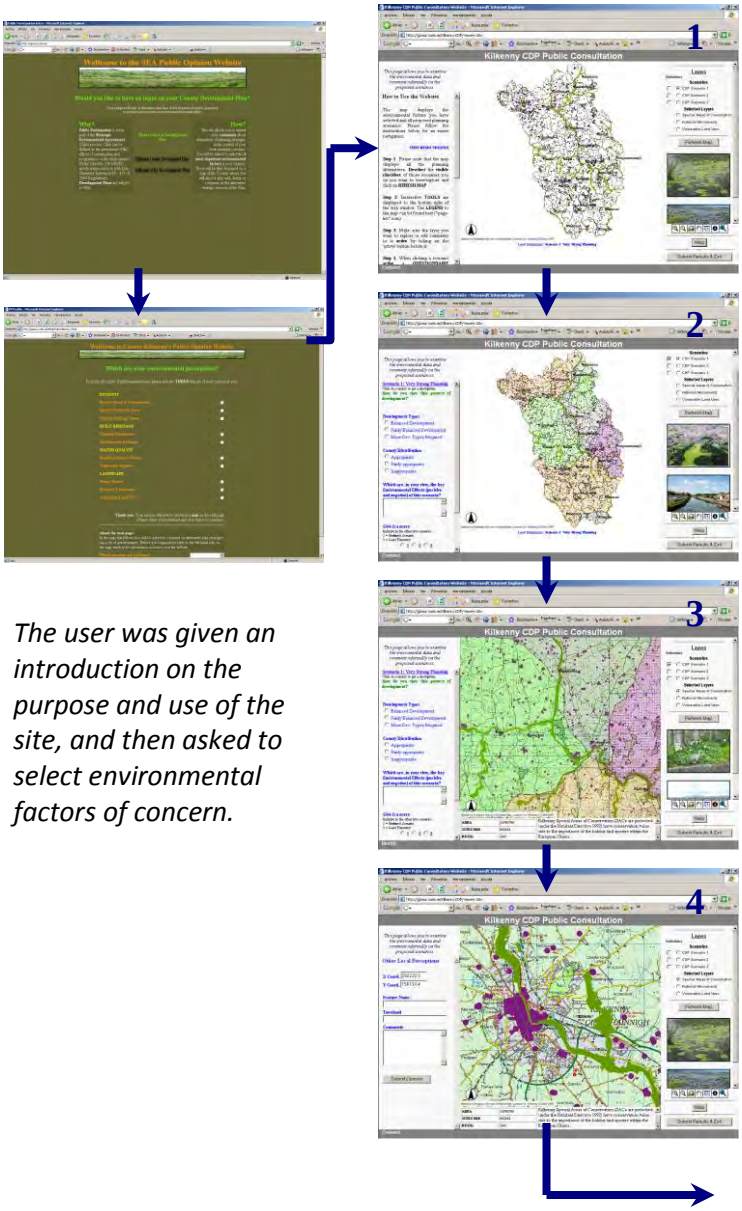
5.9. Public Participation

Spatial visualisation tools embedded in GIS have the potential to improve stakeholder and public involvement through communicating information more effectively. In the context of SEA, the use of hard-copy or digital maps and their inclusion in the Environmental Report can facilitate the spatial and/or non-technical understanding of issues during public consultation. Moreover, the adoption of an Internet-based participative GIS approach provides remote access to environmental and planning data used during SEA as part of plan-making – any time, from any location with Internet access (Box 19). This would enhance the transparency of processes and promote the gathering of public opinion in spatially specific format from a wider audience.

[41] http://www.sdcc.ie/sites/default/files/publications/development-plan-2010-2016-sea-monitoring-report-dec-2012.pdf

Box 19. Kilkenny County Development Plan 2008-2014 Public Participation Website

The following is a schematic representation of the sequential stages included in the participatory GIS website published during the Kilkenny CDP public consultation process. The website included an introductory page describing the purpose of the site and users were given a multiple choice option in relation to environmental aspects and asked to select environmental factors of concern, which were subsequently displayed on a map for users to view and interact with the information. The website enabled submission of personal perceptions, observations or comments on any environmental (and socio-economic) aspect via semi-structured questionnaires. It also contained a rated voting system enabling users to rank proposed planning alternatives. Despite the limited number of online submissions received, these qualitative and quantitative data were gathered on a database for analysis, together with the hard-copy submissions, and considered in the assessment.



The user was given an introduction on the purpose and use of the site, and then asked to select environmental factors of concern.

GIS-based webpage displaying geographic data.

1. The user could view the selected environmental factors and the proposed alternatives.
2. The user could explore the displayed data.
3. The user could comment on the proposed CDP alternatives via questionnaires.
4. The user could add new data using the interactive tools

.

The user could comment on the usefulness of the site, access the draft plan or e-mail the local authority for further information.

The public can be given an opportunity to interact with hard copy or digital maps and rank the environmental factors according to their relative importance. Incorporation of subjective weights gathered during public consultation could be contested (as weighting values can often be arbitrary and are open to debate), and they may be viewed as decreasing the scientific validity of the assessment. However, weighting ensures that articulation of values from all affected parties – including the public – are incorporated into the assessment, fulfilling the requirements of the SEA Directive and the Aarhus Convention.[42] Based on public perceptions, additional maps can be generated to prioritise those environmental aspects of concern or most valuable to the stakeholders/public (e.g. Figure 3). Additional environmental considerations can also be discussed and, if considered relevant/necessary, included in the assessment.

Best Practice Tip: Use hard copy maps during workshops to depict the location of environmental sensitivities, sketch up reasonable alternatives and discuss the implications of each considered option.

[42] http://www.unece.org/env/pp/documents/cep43e.pdf

6. Step-by-Step Guidance on How to Effectively Apply GIS in SEA

The following recommendations provide practical guidance on how to apply GIS to support SEA, and how to integrate the resulting GIS outputs into the various SEA stages and the Environmental Report. The recommendations refer to GIS aspects, but current practice issues (e.g. restricted time-frames, institutional arrangements) may affect the effective implementation of a GIS-based SEA approach. In this regard, the following is recommended.

A. **Start SEA screening early in the plan-making process**. SEA should commence with the announcement of plan/programme preparation/revision. SEA and plan-making should run in parallel, and continuous interaction and feedback should exist between processes. This would provide more adequate time-frames for applying GIS in the relevant assessment and plan-making stages.

B. **Establish and maintain communication channels**. The interplay between SEA and planning teams, as well as GIS technicians, stakeholders, decision-makers and the general public should be established early in the process to ensure information exchange and sharing. This would facilitate spatial data gathering and, thereby, GIS-based assessments, as well as ensuring that the issues arising through the SEA inform the development of the plan and its objectives.

C. **Raise awareness on the importance of SEA**. Educating planners, stakeholders, the public and, most importantly, decision-makers can contribute to a more effective incorporation of environmental and biodiversity considerations into the final decision. Environmental awareness can be enhanced by utilising visual and mapped representations.

D. **Promote the incorporation of spatial approaches into SEA methodologies**. The adequate consideration of the spatial dimension of environmental aspects can complement other assessment methods (e.g. matrix-based), improve the explicitness of assessment outcomes and facilitate the understanding of potential issues and land-use conflicts promoting a baseline-led approach to environmental planning and decision-making.

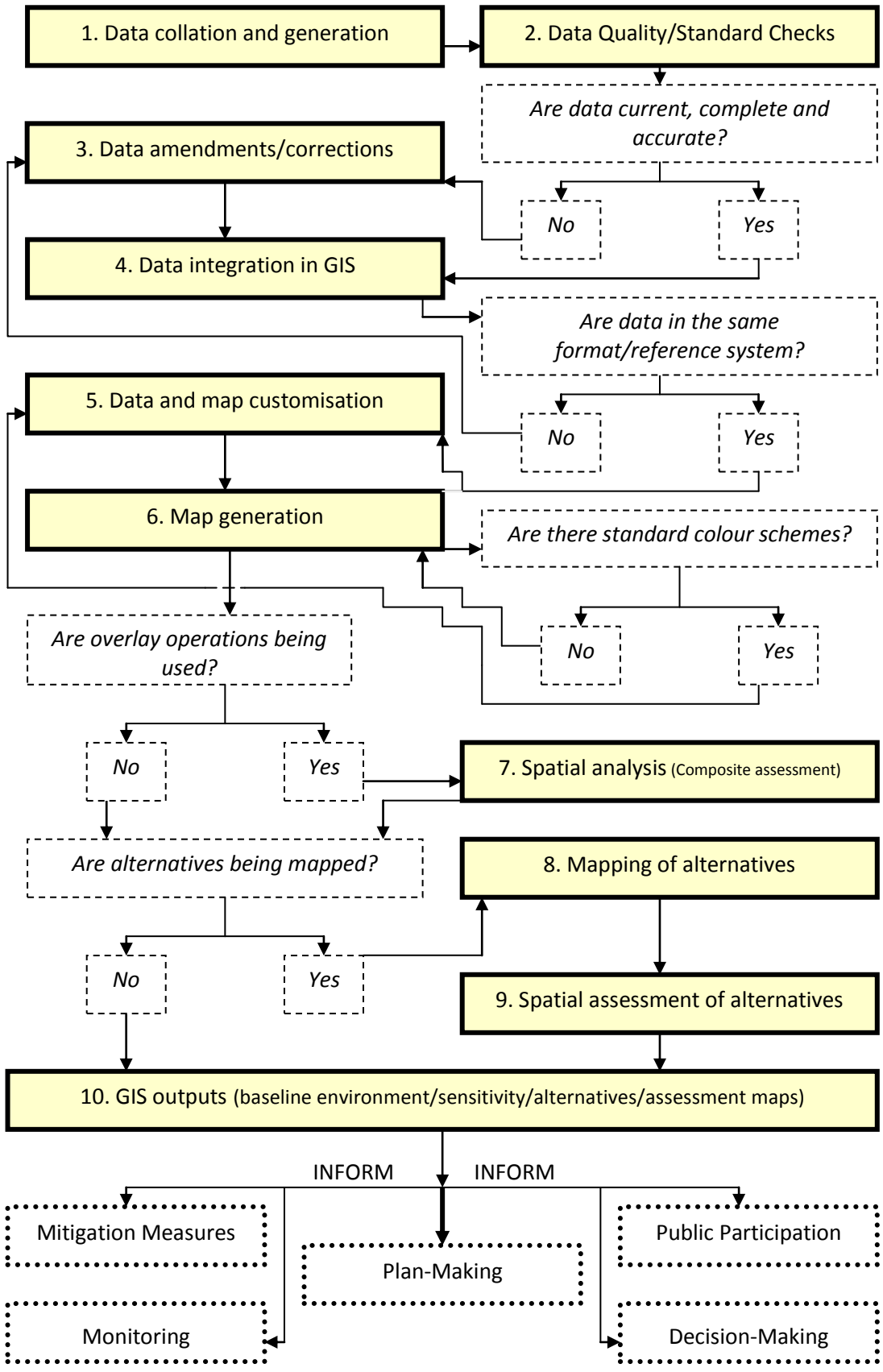
E. **Raise spatial awareness**. Improving the map-reading skills and the spatial thinking of stakeholders, decision-makers and the general public (through training) can enhance the understanding of spatial data and the use of GIS technologies during plan-making and consultation.

F. **Promote spatial data generation**. Data gathering and creation should be spatial (i.e. co-ordinates of gathered/created features should be recorded). This would improve existing datasets and metadata, increase the availability of spatial information, standardise data surveys, and contribute to more comprehensive assessments.

G. **Establish spatial data sharing mechanism**. Local authorities, private businesses and research institutes alike should embrace data sharing mechanisms to ensure that existing datasets are freely available or available at marginal costs and, therefore, readily applicable to support planning and impact assessment.

The following guidelines are indicative, and alternative or case-specific analysis and modelling techniques can also be used where appropriate. A flowchart guide to data management and map generation is provided in Figure 10. In addition, a step-by-step diagram on the general application of GIS in SEA is provided in Figure 11. Further detail on methods and techniques can be found in Section 5.

Figure 10. Flowchart guide for data management and map generation.



Screening and Scoping

1. **Start collating data early in the process** to ensure the timely application of GIS. Despite the recent initiatives to centralise data sharing (e.g. MyPlan.ie, Heritage Viewer or ISDE), the remaining absence of a fully operational national central repository constrains easy retrieval of certain geographic information. An inventory of relevant available datasets is provided in Appendix D. Data from third parties may require additional time and effort to collate and integrate into GIS. Delays in data provision can affect their timely incorporation and, thereby, restrain the effectiveness of a GIS-based assessment process.

2. **Prepare a data checklist to verify that all relevant datasets have been gathered**. Based on the significant environmental factors and the assessment scope, prepare a list of required spatial datasets (such as the list provided in Table 2). To assist the gathering and incorporation of such datasets, and support data management tasks, record when the dataset was provided, in which format, who provided it (i.e. source), whether it included any metadata or quality statement, and whether it contained any copyright/licensing conditions. This information can be of significant value when describing the difficulties encountered or any data limitations in the Environmental Report. It can also assist future SEAs and EIAs, facilitating data retrieval and quality control, as well as establishing priorities for future data collation.

3. **Check the quality of each dataset**. Verify that it is the most current (i.e. up to date) available set, that both the layer and its attributes are coherent and complete, and that it contains all the relevant information for the plan/programme area (Appendix E).

4. **Document data inconsistencies** (e.g. topological mismatches, data gaps, unexplained or missing attributes). Where inconsistencies and errors are discovered in the datasets, acknowledge them in the Environmental Report. In addition, contact the data source or provider to report on and amend the identified error or, alternatively, improve the dataset in-house through consultation with the data owner.

5. **Integrate all relevant data into a single GIS analysis**. Verify that all datasets are in the same GIS format (i.e. compatible with the software being applied, such as shapefiles for ArcGIS or tables for MapInfo) and in the same georeference system (e.g. ING or ITM).

6. **Create thematic maps by colour-coding each layer**. The features in a map should be differentiated to highlight relevant attributes. It is recommended that standardised colour schemes be adopted to ensure consistency (e.g. CORINE land-uses, bedrock geology and WFD risk assessments). Verify that the colours and shades display properly and are clearly distinguishable when printed.

7. **Generate a map for each environmental factor** (e.g. ecological designations, archaeological heritage, surface waters, landscape character areas). The number of maps generated depends on the number of significant/relevant environmental and planning factors within the study area. As a general rule, generate a map at least for each SEA environmental topic.

8. **Use the set of maps as complementary illustrative figures in the Scoping Report**. Make use of these maps to describe the significant environmental issues in the plan/programme area identified during scoping and give them a geographical context. Reporting the location of each environmental factor and its correlation with other environmental and planning considerations provides clarity and focuses the assessment.

9. **Use these maps when undertaking consultation workshops** (e.g. scoping workshop with the environmental authorities and stakeholders). They can help in visually and rapidly identifying potential land-use conflicts and promote debate among planners and stakeholders.

Baseline Environment (SEA)

10. **Continue to collate (new) data**. Datasets not gathered early in the assessment can still be incorporated (when available), and the inclusion of additional information can be of significant value to the subsequent stages of the SEA process.
11. **Generate additional maps.** Any additional spatial data gathered throughout the SEA should be mapped to provide a full account of the baseline of environmental factors. Any data deficiencies should also be addressed, as far as feasible, throughout the assessment.
12. **Overlay all the relevant environmental datasets to assess composite environmental sensitivities within the study area**. Apply the transparency tool in vector models or undertake weighted-overlay operations with raster models to facilitate the spatial assessment (Section 5.3). This would contribute to a more comprehensive environmental baseline.

When using a vector overlay approach:

13. **Apply the same colour and shade to all the environmental factors**. All GIS layers should display exactly the same colour (e.g. red) and sit in the same GIS project.
14. **Apply the same transparency ratio to all the environmental factors.** Use the transparency tool to assign a 50% transparency to all the GIS layers. Observe their level of overlap, which will be apparent from the darker shaded areas.

When using a raster overlay approach:

15. **Convert the vector layers to raster, applying a pixel size that correlates to the geographical scale of the study area**. A pixel size of 20 m × 20 m is recommended for county-wide assessments (e.g. CDP); a pixel size of 10 m × 10 m may be adopted for LAPs, and 5 m × 5 m for Action Area Plans (AAPs).
16. **Reclassify the raster layers to indicate their relative importance value.** Categorisations should be previously agreed through consultation and standardised. For example, it can be established that highly sensitive environmental factors (e.g. surface waters designated as being at risk [1a] under the WFD risk categories or landscapes classified as highly sensitive in the CDP) equate to 10, while sensitive factors (e.g. surface waters designated as being potentially at risk [1b] or landscapes classified as sensitive) equate to 5. A value of 0 must be given to the cells that had no occurrence of environmental sensitivities (commonly displayed as 'No Value' in the reclassification toolbar).
17. **Apply raster calculation tools to compute the overlapping environmental layers.** The raster calculation tools embedded in GIS can be used to combine all the relevant layers and, thus, generate a new dataset that indicates the degree of overlap between the layers (colour-code the results according to the level of overlap). At this point, any of the layers can be multiplied by a given weight (or relative importance value) to emphasise its significance in the overall assessment.

18. **Use the environmental sensitivity map/s to further describe the environmental characteristics of the area in the Environmental Report**. These maps encompass cumulative environmental factors and may include subjective 'weights'. They illustrate environmental 'hot-spots' that are likely to be more vulnerable to potential impact(s) from development (e.g. urban, industrial or infrastructure) and, therefore, should be avoided/protected by the plan/programme.

Strategic Environmental Objectives (SEA)

19. **Use the baseline environment maps and the sensitivity maps to inform the formulation of SEOs**. SEOs are also strongly linked to national and international treaties, legislative requirements and higher plan/programme objectives and, therefore, may not be solely articulated using the generated maps.

Definition of Alternatives (SEA)

20. **Facilitate the spatially specific definition of sectoral land-uses and areas of policy application from the earliest stages of plan development**. Although the zoning of lands is more explicit at local area level, the definition of indicative strategic areas at county level can help address any spatial issues. These strategic zonings help maintain focus when formulating policies and actions. Moreover, they can potentially contribute to a more balanced and equally distributed development plan that ensures environmental protection while allowing for economic and social development.

21. **Use GIS when sketching out alternative scenarios**. This can be achieved by bringing hard copy maps to the workshop and encouraging planners, stakeholders and/or the general public to draw on them. Alternatively, a mediator could use either GIS or acetate maps to draw up different zonings resulting from workshop deliberations. These maps can be further defined by presenting them back to participants, appropriately amending them and reaching consensus on the final alternatives to be considered in the assessment.

22. **Use modelling tools** where available and applicable to simulate and explore possible future scenarios based on population trends, land-use changes, climate, energy supply and consumption, waste water volume and treatment capacity, etc. These can further inform the identification and development of reasonable and realistic alternatives.

Assessment of Alternatives (SEA)

23. **Contrast spatially specific areas of zoning or policy with the previously prepared environmental sensitivity maps**. This allows for the rapid and clear detection of potential land-use conflicts. The areas zoned for development that coincide spatially (i.e. overlay) with the areas containing environmental sensitivities (i.e. 'hot-spots' illustrating a high degree of environmental sensitivity) can be easily identified and quantified.

24. **Use the number of planning applications for a particular project-type within the study area to inform the development and assessment of alternatives**. The assessment of alternatives can be informed, for example, by the number of planning applications for rural housing or the number of wind farms or quarrying permits in a sensitive landscape area. The greater the number of planning applications, the higher the development pressure, and the more potential there will be for

(cumulative) impacts. Also, arguably, the higher the environmental sensitivity of the area and the higher the number of planning applications, the greater the impact will be.

25. **Quantify and map areas under urban/industrial/infrastructure development pressure using GIS**. Quantitative values often provide additional insight into the assessment. The pixel count tool can be used to calculate the number of cells under each environmental sensitivity category, which can consequently be converted to km^2 or % of total county area (e.g. Box 6). Such quantification can enhance the understanding of issues for individuals with limited spatial literacy.

26. **Use reporting or matrix-based assessment to support the spatial analysis, particularly where the alternatives have not been (or cannot be) mapped**. GIS-based assessments commonly need to be supported by matrix-based approaches or written descriptions. Moreover, certain policies and actions in the draft plan/programme may not be spatially specific and, therefore, need to be assessed using other non-GIS assessment approaches (e.g. matrix-based, statistical analysis).

27. **Use the spatial assessment of proposed alternatives to detect and highlight potential direct and cumulative environmental effects/impacts**. The mapping of environmental constraints alongside the spatially specific provision of a plan can facilitate easy and early anticipation of the principal direct and cumulative impacts associated with the accommodation of growth. These can be further assessed using other published documents/data. The geographic representation of environmental resources/sensitivities and development pressures within the area can significantly enhance the explicitness of assessments.

28. **Use the assessment maps as complementary illustrative figures in the Environmental Report**. Make use of these maps to describe the potential issues associated with each alternative, the 'preferred' option in particular, and give all environmental and planning considerations a geographical context.

Definition of Mitigation Measures (SEA)

29. **Use the spatial analysis of the preferred alternative to identify potential issues that need mitigation**. Although mitigation measures require expert knowledge on existing environmental protection measures and thresholds, the spatial context provided by the maps can help in formulating them in a more specific and quantitative manner – particularly at local area level (e.g. Box 16).

Definition of Monitoring Measures (SEA)

30. **Use the results of the spatial assessment of the preferred alternative to determine monitoring measures**. Detailed quantitative methods (e.g. number of planning applications or changes in concentration values) can be linked to a location (e.g. number of planning applications in an ecologically protected area or changes in nitrogen concentration values on a given river stretch) to guide monitoring activities and make them more precise.

Public Participation and Decision-Making (SEA)

31. **Use the GIS outputs throughout the SEA processes to inform plan-making**. The generated maps (representing both environmental and planning issues) and the quantitative data extracted (e.g. km^2 of affected areas) can enhance the evidence base. GIS outputs can be of value when drafting land-use zonings or formulating planning policies/actions.

32. **Use GIS maps when undertaking public consultation**. It is recommended that maps are also utilised to convey information to the general public and gather public opinion. In this manner, any issues raised can be better understood in their geographic context and incorporated into GIS for their assessment.

33. **Use GIS maps to inform decision-making**. Maps have the ability to portray multiple datasets in a very concentrated and visually explicit manner. They can articulate the information contained in Environmental Reports, summarise findings in graphic form, and highlight issues that alphanumerical data may fail to underline.

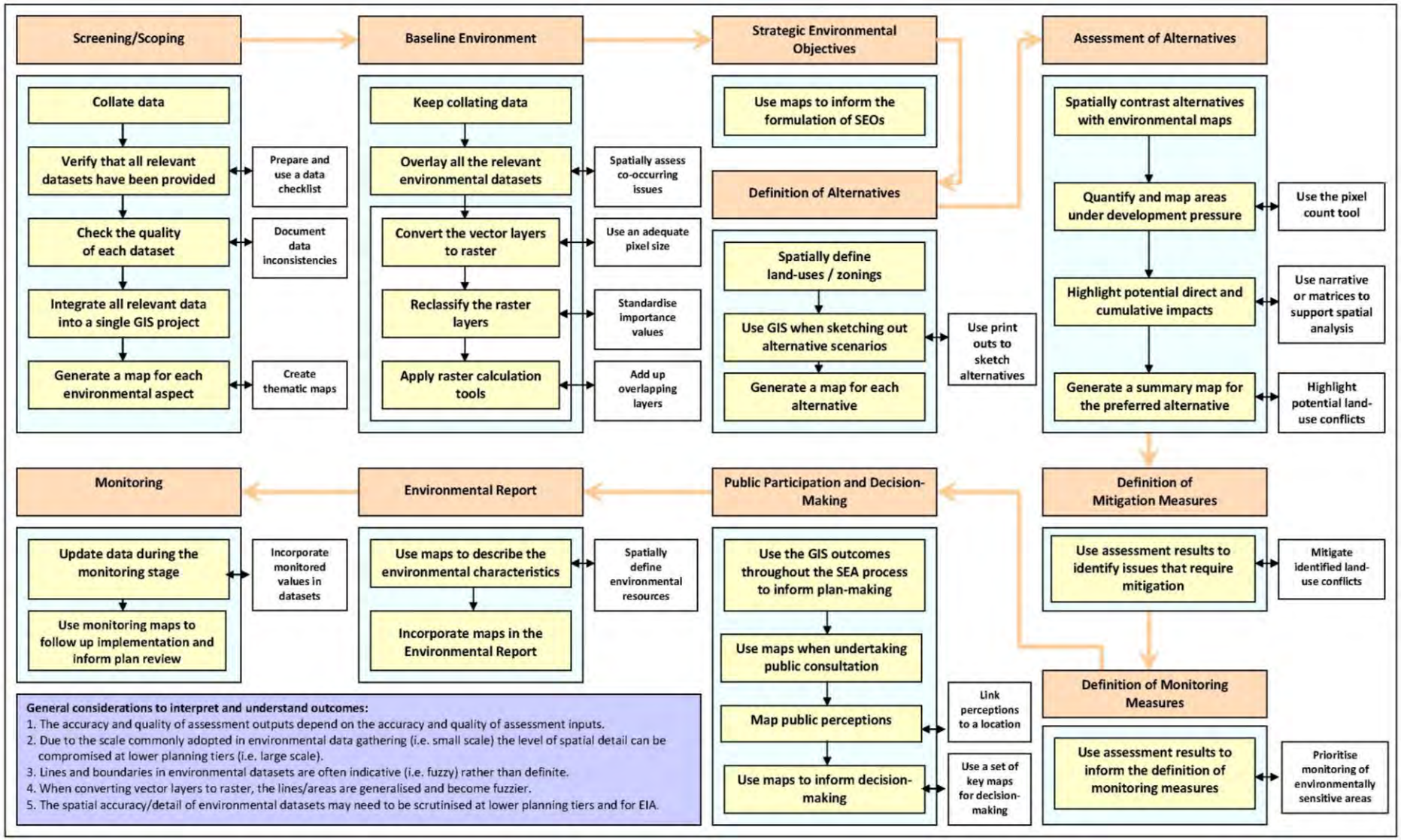
34. **Identify and use only a limited set of key maps for decision-making.** The information overload to which decision-makers are generally exposed and the primacy of planning documents tend to dilute the legibility of Environmental Reports. The graphic illustration of potential environmental sensitivities may help convey SEA outcomes and raise awareness of those involved in the final decision. Moreover, the aggregation of environmental issues (through composite environmental maps) reduces the amount of information provided to decision-makers.

Monitoring

35. **Update data during the monitoring stage**. Use the collated values (either using GPS during fieldwork or from other monitoring arrangements) to rapidly update relevant spatial datasets. This is achieved by incorporating the monitoring results/values as attributes to the relevant feature(s). The updated values can be re-mapped and re-analysed following steps 3 to 7 above. Subsequently, the monitoring maps can be contrasted with the baseline environment maps to assess the increase/decrease in environmental quality (e.g. water quality) or the relative degree of impact from development (e.g. planning consents on an area).

36. **Use monitoring maps in the Monitoring Report to inform the review of the plan/programme**. Applying the previously established methodological steps (i.e. 11 to 17 above), the assessment procedure can be replicated in a systematic, rapid and efficient manner to aid plan implementation and review.

Figure 11. Step-by-step diagram on the application of GIS to SEA (SEA steps in orange, GIS steps in yellow – grouped for each SEA stage in blue, complementary tasks in white).



APPENDIX A: PLANS AND PROGRAMMES SUBJECT TO SEA

Article 3, paragraph 2(a), of Directive 2001/42/EC lists the 11 types of **sectoral plans and programmes**, which set the framework for future development consent of projects requiring EIA, and which are **automatically subject to SEA**:

- Agriculture;
- Forestry;
- Fisheries;
- Energy;
- Industry;
- Transport;
- Waste management;
- Water management;
- Telecommunications;
- Tourism; and
- Country/town or land-use planning. The amendment of Part 3 of 2001 Regulations of SI No. 436 of 2004 makes SEA mandatory for the preparation or review of county development plans, town development plans and local area plans where the population of the area is 10,000 persons or more.

Similarly, paragraph 2(b) of the SEA Directive establishes SEA requirement for **plans/programmes significantly affecting Natura 2000 sites** – addressing the requirements for Appropriate Assessment of the Habitats Directive. Natura 2000 sites include Special Areas of Conservation (SACs) designated under the European Habitats Directive (Directive 92/43/EEC) and Special Protection Areas (SPAs) designated under the Birds Directive (Directive 79/409/EEC).

In contrast, paragraphs 8 and 9 of the Directive's Article 3 present exemptions, identifying a number of categories of plans/programmes (i.e. national defence, civil emergency and financial or budgeting plans/programmes) that are automatically excluded from SEA.

Annex II (in concordance with paragraphs 4, 5 and 6 of Article 3) sets up a discretional **case-by-case screening** approach to SEA that should be used for all other plans/programmes (i.e. those not covered by the positive list or in those cases where the population falls below the established threshold of 10,000 persons). Criteria include references to the characteristics of the plan/programme, the magnitude of the potential adverse effects and the vulnerability of the area(s) likely to be affected as set out in Schedule 2A of SI No. 435 of 2004 Regulations (DEHLG, 2004).

APPENDIX B: CONTENTS OF AN ENVIRONMENTAL REPORT

Annex I of Directive 2001/42/EC specifies the information to be contained in an Environmental Report as follows:

a) An outline of the contents, main objectives of the plan or programme and relationship with other relevant plans and programmes;

b) The relevant aspects of the current state of the environment and the likely evolution thereof without implementation of the plan or programme;

c) The environmental characteristics of areas likely to be significantly affected;

d) Any existing environmental problems which are relevant to the plan or programme including, in particular, those relating to any areas of a particular environmental importance, such as areas designated pursuant to Directives 79/409/EEC and 92/43/EEC;

e) The environmental protection objectives, established at international, Community or Member State level, which are relevant to the plan or programme and the way those objectives and any environmental considerations have been taken into account during its preparation;

f) The likely significant (secondary; cumulative; synergistic; short-, medium- and long-term; permanent and temporary; positive and negative) effects on the environment, including on issues such as biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage including architectural and archaeological heritage, landscape and the interrelationship between the above factors;

g) The measures envisaged to prevent, reduce and as fully as possible offset any significant adverse effects on the environment of implementing the plan or programme;

h) An outline of the reasons for selecting the alternatives dealt with, and a description of how the assessment was undertaken including any difficulties (such as technical deficiencies or lack of know-how) encountered in compiling the required information;

i) A description of the measures envisaged concerning monitoring, to identify at an early stage unforeseen adverse effects, and to be able to undertake appropriate remedial action; and

j) A non-technical summary of the information provided under the above headings.

APPENDIX C: SPATIAL DATA THEMES IN THE INSPIRE DIRECTIVE

Directive 2007/02/EC establishes that metadata are to be created for the spatial datasets corresponding to the themes included in Annexes I, II and III (and listed next), and that they are to be kept up to date. Under Article 6 of Directive 2007/2/EC, metadata shall be created for the themes listed in Annexes I and II, not later than 2 years after the date of adoption of implementing rules; and not later than 5 years after the date of adoption of implementing rules for the themes listed in Annex III. For the themes listed in Annex I, the implementing rules shall be created 2 years following the date of entry into force of the Directive; which will extend to 5 years for the themes listed in Annex II and III.

Metadata shall include information on the following:

1. The conformity of spatial datasets with the implementing rules – which lay down technical arrangements for the interoperability and, where practicable, harmonisation of spatial datasets. These will include: a common framework for the unique identification of spatial objects; the relationship between spatial objects; the key attributes; information on the temporal dimension of the data; and any updates of the data. The implementing rules aim at ensuring consistency between items of information which refer to the same location or between items of information which refer to the same object represented at different scales.
2. Conditions applying to access to, and use of, spatial datasets and, where applicable, corresponding fees.
3. The quality and validity of spatial datasets.
4. The public authorities responsible for the establishment, management, maintenance and distribution of spatial datasets.
5. Limitations on public access and the reasons for such limitations (e.g. adverse effect on international relations, public security, national defence; issues of confidentiality or intellectual property rights).

The INSPIRE Directive indicates that the necessary measures shall be taken to ensure that metadata are complete and of a quality sufficient to facilitate their discovery, inventory and use.

ANNEX I
1. Coordinate Reference Systems Systems for uniquely referencing spatial information in space as a set of coordinates (x, y, z) and/or latitude and longitude and height, based on a geodetic horizontal and vertical datum.
2. Geographical Grid Systems Harmonised multi-resolution grid with a common point of origin and standardised location and size of grid cells.
3. Geographical Names Names of areas, regions, localities, cities, suburbs, towns or settlements, or any geographical or topographical feature of public or historical interest.
4. Administrative units Units of administration, dividing areas where Member States have and/or exercise jurisdictional rights, for local, regional and national governance, separated by administrative boundaries.
5. Addresses

Location of properties based on address identifiers, usually by road name, house number, postal code.
6. Cadastral Parcels Areas defined by cadastral registers or equivalent.
7. Transport Networks Road, rail, air and water transport networks and related infrastructure. Includes links between different networks. Also includes the trans-European transport network as defined in Decision No 1692/96/EC of the European Parliament and of the Council of 23 July 1996 on Community Guidelines for the development of the trans-European transport network and future revisions of that Decision.
8. Hydrography Hydrographic elements, including marine areas and all other water bodies and items related to them, including river basins and sub-basins. Where appropriate, according to the definitions set out in Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy and in the form of networks.
9. Protected Sites Area designated or managed within a framework of international, Community and Member States' legislation to achieve specific conservation objectives.
ANNEX II
1. Elevation Digital elevation models for land, ice and ocean surface. Includes terrestrial elevation, bathymetry and shoreline.
2. Land cover Physical and biological cover of the earth's surface including artificial surfaces, agricultural areas, forests, semi-natural areas, wetlands, water bodies.
3. Orthoimagery Geo-referenced image data of the Earth's surface, from either satellite or airborne sensors.
4. Geology Geology characterised according to composition and structure. Includes bedrock, aquifers and geomorphology.
ANNEX III
1. Statistical units Units for dissemination or use of statistical information.
2. Buildings Geographical location of buildings.
3. Soil Soils and subsoil characterised according to depth, texture, structure and content of particles and organic material, stoniness, erosion, where appropriate mean slope and anticipated water storage capacity.
4. Land-use Territory characterised according to its current and future planned functional dimension or socio-economic purpose (e.g. residential, industrial, commercial, agricultural, forestry, recreational).
5. Human health and safety Geographical distribution of dominance of pathologies (allergies, cancers, respiratory diseases, etc.), information indicating the effect on health (biomarkers, decline of fertility, epidemics) or well-being of humans (fatigue, stress, etc.) linked directly (air pollution, chemicals, depletion of the ozone layer, noise, etc.) or indirectly (food, genetically modified organisms, etc.) to the quality of the environment.
6. Utility and governmental services Includes utility facilities such as sewage, waste management, energy supply and water supply, administrative and social governmental services such as public administrations, civil protection sites, schools and hospitals.
7. Environmental monitoring facilities Location and operation of environmental monitoring facilities includes observation and measurement of emissions, of the state of environmental media and of other ecosystem parameters (biodiversity, ecological conditions of vegetation, etc.) by or on behalf of public authorities.
8. Production and industrial facilities Industrial production sites, including installations covered by Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control and water abstraction facilities, mining, storage sites.

9. Agricultural and Aquaculture Facilities Farming equipment and production facilities (including irrigation systems, greenhouses and stables).
10. Population Distribution – Demography Geographical distribution of people, including population characteristics and activity levels, aggregated by grid, region, administrative unit or other analytical unit.
11. Area management/restriction/regulation zones and reporting units Areas managed, regulated or used for reporting at international, European, national, regional and local levels. Includes dumping sites, restricted areas around drinking water sources, nitrate-vulnerable zones, regulated fairways at sea or large inland waters, areas for the dumping of waste, noise restriction zones, prospecting and mining permit areas, river basin districts, relevant reporting units and coastal zone management areas.
12. Natural risk zones Vulnerable areas characterised according to natural hazards (all atmospheric, hydrologic, seismic, volcanic and wildfire phenomena that, because of their location, severity, and frequency, have the potential to seriously affect society), e.g. floods, landslides and subsidence, avalanches, forest fires, earthquakes, volcanic eruptions.
13. Atmospheric conditions Physical conditions in the atmosphere. Includes spatial data based on measurements, on models or on a combination thereof and includes measurement locations.
14. Meteorological geographical features Weather conditions and their measurements; precipitation, temperature, evapotranspiration, wind speed and direction.
15. Oceanographic geographical features Physical conditions of oceans (currents, salinity, wave heights, etc.).
16. Sea regions Physical conditions of seas and saline water bodies divided into regions and sub-regions with common characteristics.
17. Bio-geographical regions Areas of relatively homogeneous ecological conditions with common characteristics.
18. Habitats and biotopes Geographical areas characterised by specific ecological conditions, processes, structure, and (life support) functions that physically support the organisms that live there. Includes terrestrial and aquatic areas distinguished by geographical, abiotic and biotic features, whether entirely natural or semi-natural.
19. Species distribution Geographical distribution of occurrence of animal and plant species aggregated by grid, region, administrative unit or other analytical unit.
20. Energy resources Energy resources including hydrocarbons, hydropower, bio-energy, solar, wind, etc., where relevant including depth/height information on the extent of the resource.
21. Mineral resources Mineral resources including metal ores, industrial minerals, etc., where relevant including depth/height information on the extent of the resource.

APPENDIX D: SPATIAL DATA SOURCES IN THE REPUBLIC OF IRELAND

The majority of Irish datasets have been created at national (e.g. soils), regional (e.g. River Basin District surface water risk assessment) and county (e.g. protected structures) level. The number of locally specific GIS-based studies (e.g. habitat survey, lake water quality monitoring) is limited. Although a comprehensive array of both privately and publicly generated spatial data are available, no central spatial data repository exists in Ireland. A number of initiatives have been launched to address this (such as the Irish Spatial Data Exchange – ISDE, and the Environmental Data Exchange Network – EDEN). These initiatives aim to establish a distributed and sustained environmental information system to improve accessibility and sharing of spatial data. This is to be achieved by providing a centralised information exchange for both environmental monitoring data and metadata, with input from a large number of organisations.

However, not all spatial datasets are in the public domain and there is a lack of complete knowledge of datasets created by private businesses and research institutes. Moreover, lack of coherency among datasets exists across borders with Northern Ireland, as well as between counties and research studies. In some cases, spatial datasets can be viewed or downloaded through GIS-based websites; in the majority of cases, data owners need to be contacted for data retrieval.

An SEA spatial data source inventory, with relevant datasets available in the Republic of Ireland is available in the SEA Section of the EPA's website:
http://www.epa.ie/pubs/advice/ea/seaspatialinfomationsourcesjune2016.html
For metadata searches, see also: www.isde.ie

APPENDIX E: CHECKING DATA CONSISTENCY

The following checklist is intended to help establish the validity of the spatial datasets for the GIS-based assessment. It can also contribute to identifying any difficulties in compiling the required information (e.g. data inconsistencies and information gaps), which need to be acknowledged in the Environmental Report as established in Annex I of the SEA Directive.

The primary consistency check should answer the following question: are all the relevant spatial datasets (associated with the relevant environmental considerations identified during scoping) available? If the answer is no, such data gaps should be clearly acknowledged, and alternative quantitative or qualitative information sources should be used for the assessment. For available datasets, the following checklist should be applied to validate the quality, fitness for use and purpose, and consistency of each dataset.

Question	Yes	No	Comments
1. Are there any constraints for using the dataset (e.g. licence agreements, copyright)?			
2. Does the dataset contain metadata?			
3. Has the data source/owner provided any quality statement?			
4. Is the dataset up to date?			
5. Is the dataset complete? Does it cover the entire study area? Are there any significant geographic gaps?			
6. Is the dataset in the appropriate spatial reference system?			
7. Is the scale of the dataset valid for the assessment?			
8. Is the dataset spatially accurate? Does it overlay correctly on space?			
9. Does the dataset contain useful and comprehensible attribute information?			
10. Is the attribute information complete? Does it provide values for all the contained features? Are there any critical information or attribute inaccuracies/errors?			
11. Does the dataset contain indicators?			
12. Have alternative datasets been identified to validate and complement any identified gaps/inaccuracies?			
13. Have the identified gaps/inaccuracies been amended/corrected?			

APPENDIX F: CHECKING THE VALIDITY OF GIS APPLICATIONS

The following checklist is intended to help establish the validity of GIS applications during the SEA and planning processes. The main aim of this checklist is to establish whether a GIS-based approach facilitated undertaking SEA and whether it was considered of value to plan-making.

In conjunction with the checklist provided in Appendix E, it can help identify the major technical and operational barriers encountered. This, in turn, can assist in defining measures to improve SEA methodologies.

Question	Yes	No	Comments
1. Was there support for incorporation and use of GIS technology?			
2. Was the level of GIS skills of personnel operating the system adequate?			
3. Was enough time provided to undertake the GIS operations?			
4. Were any data sharing, availability or access barriers encountered? Were many datasets missing?			
5. Were there many gaps and/or inaccuracies in the datasets?			
6. Were the operations undertaken in GIS understood by the planning team?			
7. Were the outputs considered to be sufficient (i.e. amount of information)?			
8. Were the outputs considered to be reliable (i.e. quality of information)?			
9. Were the GIS outputs integrated into the Environmental Report (or the Natura Impact Report)?			
10. Did the outputs facilitate the SEA process?			
11. Did the outputs facilitate plan-making?			
12. Were the outputs used during decision-making?			
13. Did the outputs have an impact on decision-making?			

AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL
Tá an Ghníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaol a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialú: *Déanaimid córais éifeachtacha rialaithe agus comhlíonta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.*

Eolas: *Soláthraímid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírithe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.*

Tacaíocht: *Bímid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaol atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaol inbhuanaithe.*

Ár bhFreagrachtaí

Ceadúnú
Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaol:
- saoráidí dramhaíola *(m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistrithe dramhaíola)*;
- gníomhaíochtaí tionsclaíocha ar scála mór *(m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta)*;
- an diantalmhaíocht *(m.sh. muca, éanlaith)*;
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe *(OGM)*;
- foinsí radaíochta ianúcháin *(m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíocha)*;
- áiseanna móra stórála peitril;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil
- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
- Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhíriú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídíonn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Uisce
- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uiscí idirchriosacha agus cósta na hÉireann, agus screamhuiscí; leibhéil uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

Monatóireacht, Anailís agus Tuairisciú ar an gComhshaol
- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil *(m.sh. tuairisciú tréimhsiúil ar staid Chomhshaol na hÉireann agus Tuarascálacha ar Tháscairí)*.

Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn
- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

Taighde agus Forbairt Comhshaoil
- Taighde comhshaoil a chistiú chun brúnna a shainaithint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeráide, an uisce agus na hinbhuanaitheachta.

Measúnacht Straitéiseach Timpeallachta
- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaol in Éirinn *(m.sh. mórphleananna forbartha)*.

Cosaint Raideolaíoch
- Monatóireacht a dhéanamh ar leibhéil radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Faisnéis Inrochtana agus Oideachas
- Comhairle agus treoir a chur ar fáil d'earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaol ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaol *(m.sh. Timpeall an Tí, léarscáileanna radóin)*.
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhaíl ghuaiseach a chosc agus a bhainistiú.

Múscailt Feasachta agus Athrú Iompraíochta
- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil
Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d'Oifigí:
- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- Oifig um Chosaint Radaíochta agus Monatóireachta Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

ENVIRONMENTAL PROTECTION AGENCY

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