



National Landcover and Habitat Mapping Programme for Ireland

Use Case Analysis and Economic Value Study

An Chomhairle Oidhreachta
The Heritage Council



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Cover image: Example from Fossitt 2B landcover map of Roscommon.

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Executive Summary

This report presents the findings of a use case analysis and economic value study for a national Land Cover and Habitat Mapping (LCHM) Programme in Ireland which was carried out in 2016 for a group of government departments and agencies including the Environmental Protection Agency (EPA), National Parks and Wildlife Service of the Department of Arts, Heritage, Regional, Rural and the Gaeltacht Affairs (DAHRRG), the Heritage Council, Ordnance Survey Ireland (OSi), Department of Agriculture, Food and Marine (DAFM,) Department of Housing, Planning, Community and Local Government (DHPCLG), and Teagasc.

Effective, sustainable land management requires an understanding of the status and condition of the land surface, including changes and trends over time. For this, the availability of high quality information on national land cover and habitats is essential.

The robust business case for the national LCHM programme is clear given the extent and diversity of benefits that the programme will bring to public sector reform, to the national response to EU environmental legislative requirements, to Ireland's response to climate change, for our national innovative capacity, and so on. The programme offers value for money and with the multi-sectoral efficiencies gained, it will result in a strong return on investment.

Present situation

A national land cover and habitat mapping programme does not currently exist in Ireland. High quality mapping and geospatial data is a hugely important resource for land use planning and development management, agricultural and forestry, flood risk management, emergency planning, environmental resource management, climate change adaptation, heritage management, tourism and recreational planning, and conservation of national resources. It allows changes on our land surface to be tracked and monitored over time, and the identification of potential conflicts between natural landscapes and man-made developed landscapes. Furthermore, it can offer major opportunities to support social cohesion and economic development by providing a robust evidence base for decision making on investments, such as, for example, the appropriate location of public services.

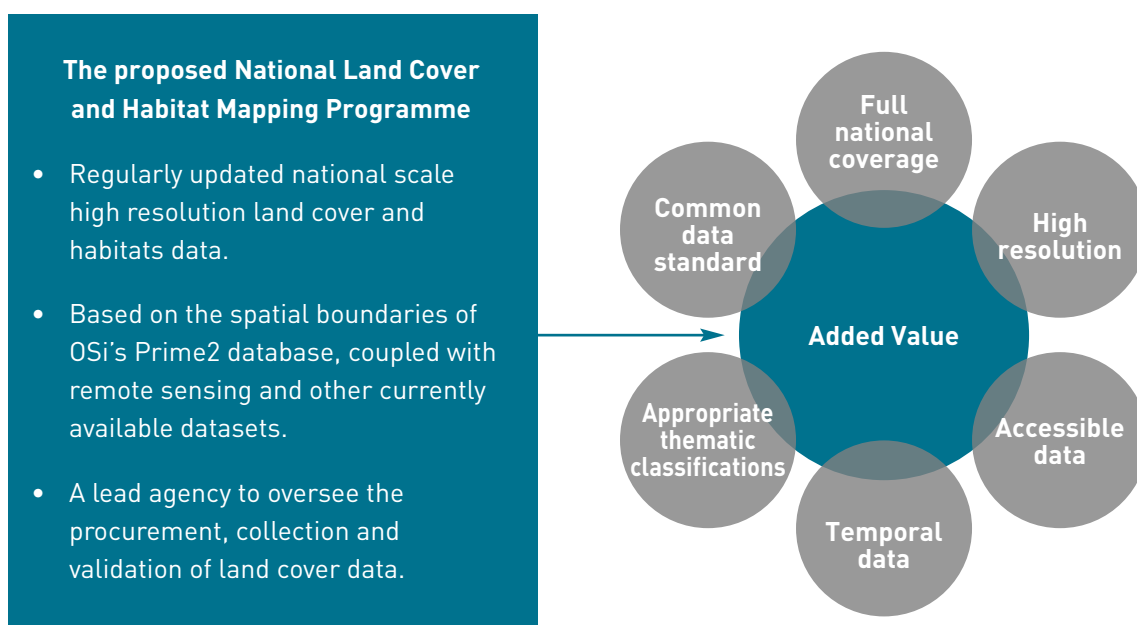
While geospatial information is available for many of the sectors referred to previously, there is no single national authority mandated with the production of national land cover and habitat data and maps. Organisations with an interest in land cover and habitat mapping are currently reliant on disparate information sources which are often based on different data models and structures. Incompatibility between relevant datasets is a key obstacle to harnessing the full potential of existing datasets and the benefits that could be realised if standardised data models were used for complementary datasets. In 2011, it became apparent that significant resources were being invested by various national agencies in the development of separate land cover and habitat data programmes, many of which were overlapping or inconsistent with each other.

This fragmented approach to land cover and habitat data collection does not offer best value for money and points strongly to the need for a national approach to minimise overlaps and to optimise knowledge sharing efficiencies across the public sector. Furthermore, existing land cover datasets such as CORINE land cover¹ are misleading as they do not offer the level of accuracy required to respond effectively to environmental legislative obligations and to wider societal challenges presented by climate change and

¹ CORINE is an EU-wide land cover programme designed for the standardised compilation of geo-spatial environmental information across 28 Member states; it is not designed for use at a national level. As a result, inadequate spatial and temporal resolution, and the limitations of the thematic classes offered by the inventory (as further described in Section 2.3), present a strong rationale for developing a national programme of land cover and habitat mapping.

development pressures. Insufficient thematic classifications, gaps in spatial coverage, a lack of time series data, and inconsistent standards for national land cover and habitats data, place a serious limitation on the effective application of existing information. **Through the use, re-use and novel use of existing datasets collected by European and state agencies for land cover and habitats, coupled with new mapping initiatives, major efficiencies can be achieved.**

In 2011, a working group was established to explore the options around the development of a national LCHM programme. This group now comprises the EPA, DAHRRG, the Heritage Council, OSi, DAFM, DHPCLG, Teagasc, the Geological Survey of Ireland (GSI) and the Office of Public Works (OPW). The group has developed a proposal for a national LCHM programme to include the following elements:



This proposal was sent to the Minister for Arts, Heritage and the Gaeltacht, Heather Humphreys, in June 2015. Subsequent work on the programme has concentrated on a common standards framework and further investigation of the benefits of such a programme and its economic value.

In March 2016 a project team² was appointed by the working group to identify and describe use cases for national land cover and habitat data, and to establish the economic value of the proposed programme. As part of this study, cross sectoral stakeholder engagement was undertaken with a range of public and private sector agencies to determine the ways in which existing land cover and habitat data is used in Ireland, and the potential advantages of a national programme.

The main outcomes of the research make a compelling case to establish a national programme for land cover and habitat mapping (LCMH) and are outlined in this summary.

Filling a key data gap

The availability of a 'big picture' of national land cover and habitats will fill a key data gap, consequently facilitating the development and implementation of national and regional planning and land management programmes and supporting strategic decision making and investment targeting. This will have far reaching benefits for the environment, the economy and for quality of life.

² Future Analytics Consulting in collaboration with Optimize Economic Consultants, Dr. Michael Brennan and Mary Tubridy & Associates

Fulfilling legislative obligations (section 3.2)

The programme increases Ireland's capacity to respond to and comply with a broad range of EU legislative requirements. As a reliable source of baseline information, it will bring efficiencies and enhanced quality in the implementation of the Water Framework Directive (WFD), the Habitats and Birds Directives, the Floods Directive, the Air Quality Directive, the Environmental Liabilities Directive, SEA Directive, INSPIRE Directive and many more.

Supporting public sector reform (section 3.1)

The programme presents a major opportunity to deliver on a range of commitments set out within the Government's Public Sector Reform Plans such as the *Public Service Reform Plan 2014-2016*, *Supporting Public Service Reform eGovernment 2012-2015* and the *Public Service ICT Strategy 2015*. The programme will provide a shared information base for public sector agencies supporting collaboration, data exchange, and expertise sharing, avoiding inconsistencies and incompatibility while facilitating integration, transparency and interoperability. It also represents a viable, cost-efficient mechanism by which geospatial information can be shared across the public and private sectors.

A broad range of applications (section 4)

The potential applications and the target end user groups for the programme are diverse, spanning the public and private sectors in areas such as agriculture, forestry, flood risk and emergency planning, climate change, land use planning, air quality, biodiversity and tourism. Its relevance to a broad range of applications offers real value for money and has a competitive advantage over existing disparate data systems for land cover and habitat information.

Building on existing investments

The programme will build on existing investment made by Ireland into European programmes such as the European Space Agency (ESA) earth observation systems – €17.3million from Ireland in 2015. In addition, by making use of the ESA data, other benefits will cascade down to the SME and academic sectors in terms of reuse and research applications.

Use case studies (section 4.3)

Three national policy initiatives were selected to demonstrate the practical application of a national LCHM programme: the forthcoming National Planning Framework (NPF), the National Catchment Flood Risk Assessment and Management Programme (CFRAM), and the Climate Action and Low Carbon Development Act 2015 [section 4.3].

Additional hypothetical scenarios of typical projects across the built and natural environment fields are also described in Appendix 3 to demonstrate the multi-sectoral application of the LCHM programme. These include: the Implementation of the Green Low Carbon Agri-environment Scheme GLAS; the Implementation of Sustainable Forest Management (SFM); Land use planning and water resource management (Waterways Ireland); Air pollutant modelling and the monitoring of critical loads of nitrogen to assess impacts on sensitivity habitats; Formulation of a local authority Biodiversity Action Plan.

Economic value (section 5)

The economic benefits of the programme have been categorised into four thematic areas: efficiency, productivity, policy effectiveness and sustainability:

Efficiency	Productivity	Policy Effectiveness	Sustainability
High accuracy	Reduced overlap	Policy implementation	Sustainable development
Time & cost savings	Knowledge sharing	Policy targeting	Damage avoided
	Accessible data & innovation		The Ecosystem Approach
			Environmental Reporting & accounting

It should be noted that while distinct benefits such as greater precision, better analysis and efficiencies have been identified, all of which contribute to economic growth, attributing monetary values to these benefits is subject to uncertainty and subjectiveness. As such, it was not considered appropriate to attempt to monetise the economic benefits identified during this study.

Efficiency

High Accuracy – the low resolution of CORINE limits its use as an effective land management tool and has led to inaccurate reporting of condition and status. The national LCHM data outputs will have a higher resolution, more appropriate classification system, and will offer full and complete national coverage. These features will ensure much greater accuracy in baseline descriptions of the environment and in detecting changes occurring within the landscape, than is currently offered.

Time & Cost Savings –

The reduced risk of inaccuracies will bring time and cost savings. For example, a new road or pipeline route option could fail to identify a protected feature that may require a re-alignment of several kilometres with the result that new surveying work is required in all disciplines. A realignment of just one kilometre of road at a preliminary design stage could require new surveying and specialist input resulting in a delay of a month at a cost of €100,000 or more in staff time and specialist services.

Knowledge Sharing - A central programme to coordinate the collation of land cover data will bring greater clarity to the full range of applications for land cover and habitat data thus making it easier to identify potential synergies and opportunities for information sharing across sectors. In this regard, the programme has strong potential to boost the culture of knowledge and expertise sharing in public sector agencies working with spatial data.

Accessible Data & Innovation – Greater access to public data will bring forward new opportunities for collaboration between the public sector, private sector and research institutions, stimulating innovation and new opportunities for job creation.

Policy Implementation - The national LCHM outputs will support policy formulation and implementation processes. Potentially conflicting land types will be easier to identify, and opportunities for more effective land management and risk mitigation (e.g. avoidance of potential land use conflicts, identification of flood retention areas etc.) will become more apparent. Furthermore, the availability of regularly updated data will enable the monitoring of policy initiatives (through changes occurring on the landscape), the results of which can be used to inform future policy initiatives. Opportunities for better targeted policies will also arise. For example, areas vulnerable to flooding will be easier to identify and policy initiatives such as

control and mitigation measures can be focused on these priority areas.

Damage avoided – Improved policy implementation, and better targeted policy will make it easier to safeguard against the impacts of pollution events or climate change such as flooding or storm damage. Consequently, future environmental, economic and social costs (including impacts on public health) can be reduced.

Ecosystem approach to climate mitigation and adaptation - The programme will support greater integration in the management of land, water and living resources in line with the ecosystem approach. This approach has benefits for cost effective climate change responses in that opportunities to mitigate CO₂ emissions will be easier to identify where high quality land cover data is available, e.g. the identification of carbon sequestration opportunities, as will adaptation options.

Environmental Reporting and Accounting - There are extensive reporting and accounting requirements arising from international, European and national legislation and policy initiatives. These include assessing the condition of the environment, identifying environmental pressures and challenges, formulating and implementing plans or actions to address pressures or challenges, monitoring and evaluating change, undertaking temporal trend analysis, and reporting on environmental conditions. Currently, the absence of accurate, high resolution national data on land cover and habitats is compromising our capacity to respond effectively to these requirements.

Risks of continuing the Status Quo

The significant risks associated with continuing the status quo, i.e., the absence of a national LCHM programme, provides a strong rationale for establishing the programme. Risks identified through this research study include the following:

- Inaccuracies and misleading information leading to poorly informed decision making;
- A sub-optimal knowledge base for EU and national legislative obligations;
- A failure to meet national policy commitments for public sector reform;
- A missed opportunity to maximise the use and value of satellite data and Ireland's contribution to the ESA earth observation systems.
- A lack of awareness of the value of land cover and habitat information; and,
- Inhibiting the research and innovation capacity of sectors that rely on quality land cover information.

The introduction of the proposed programme will militate against all of these risks. Furthermore, the programme has the potential to improve risk mitigation on a strategic level by helping to address challenges included in the key thematic areas set out in the National Risk Assessment 2015. These include the loss of competitiveness arising as a result of inefficiencies in the public sector, and a risk of failing to sufficiently adapt to climate change.

Conclusions

This report concludes with a strong endorsement for the proposed national LCHM programme. The initial funding payment of €4 million sought over a six-year period will result in a strong return on investment given the efficiency and productivity gains that will arise, and the benefits for policy implementation, policy targeting, and sustainability.

An overview of the national LCHM programme is illustrated in Figure 1 opposite.

NATIONAL LAND COVER AND HABITAT MAPPING PROGRAMME

**Common data standard - High resolution - Full national coverage - Temporal data -
Appropriate thematic classifications**

Multi-sectoral applications:

Agriculture and Food Production, Forestry, Land Use Planning, Air Quality, Climate Change Mitigation/Adaptation, Biodiversity, Environmental Resource Management and many more.

<p>Addressing existing constraints</p> <ul style="list-style-type: none"> • A lack of detail on the characteristics of national land cover; • Insufficient thematic classifications available for land cover and habitats in Ireland; • Gaps in spatial coverage and poor delineation of land cover features; • A lack of temporal data on land cover and habitats; • Inconsistent standards in land cover and habitat data sources in Ireland. 	<p>Mitigating Risks</p> <p>To address existing constraints & respond to weaknesses in:</p> <ul style="list-style-type: none"> • Knowledge base for responding to international, EU & national legislative & policy commitments; • Accuracy of assessment and reporting on baseline environmental conditions; • Poorly informed decision making; • A lack of awareness of value of land cover & habitat data; • Poor understanding of interactions between different land cover, habitat and land use features; • Changes in landcover and habitats not captured; • Poor availability of open data on land cover & habitats; • Overlaps in data collection by the Public Sector; • Inhibited research & innovation; • Poor land use management; • Failure to recognise mitigation opportunities for protection of the environment; • A lack of understanding of changes in the landscape; • Missed opportunities for climate change adaptation. 	<p>Responding to legislation & policy commitments</p> <ul style="list-style-type: none"> • The Public Sector Reform Plan • The Public Service ICT strategy 2015- • Open Data initiative • Water Framework Directive • Habitats & Birds Directive • Floods Directive • Air Quality Directive • Environmental Liabilities Directive • SEA Directive • INSPIRE Directive • UN FCC, Kyoto Protocol • Decision No 529/2013/EU Accounting of Agricultural and Forestry emissions • Environmental Impact Assessment • Planning and Development Act 2000 amendments • The Rural Development Plan & Agri-Environment policy • National Biodiversity Plan ‘Actions for Biodiversity’ 2011-2016’ • EU Biodiversity Strategy to 2020 • Food Wise 2025 • The National Landscape Strategy • Aarhus Convention and related Directives
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ECONOMIC BENEFITS			
<p>Efficiency</p> <p>Greater Accuracy Time & Cost Savings</p>	<p>Productivity</p> <p>Reduced Overlaps Knowledge Sharing</p>	<p>Policy Effectiveness</p> <p>Policy Implementation Policy Targeting</p>	<p>Sustainability</p> <p>Environmental Reporting & Accounting Sustainable Development Open data & Innovation Damage Avoided Ecosystem Approach</p>

Figure 1: Features and benefits of the National Land Cover and Habitat Mapping Programme

1. Establishing the Context

1.1 Overview

The value of understanding the characteristics of land cover is widely recognised for the contribution it brings to effective decision making in the public and private sectors. Land cover refers to the physical matter that forms the surface of land e.g. grassland, peatland, woodlands etc. Land uses describe the anthropogenic usage of an area of land e.g. forestry, pasture, arable, as well as developed land consisting of buildings, public realm areas etc. Habitat maps describe in finer detail, the vegetation assemblages and other biotic and abiotic elements on the ground.

A national land cover and habitat mapping programme does not currently exist in Ireland. The mapping of land cover and habitats is a challenging task, but it will bring extensive environmental, economic and societal benefits. High quality mapping and geospatial data is a hugely important resource for land use planning and development management, agriculture and forestry, environmental resource management, climate change adaptation, heritage management, tourism and recreational planning, and conservation of national resources. It can allow changes on our land surface to be tracked and monitored over time, and for the identification of potential conflicts between natural landscapes and developed landscapes. Furthermore, it can offer major opportunities to support social cohesion and economic development by providing a robust evidence base for decision making on investments, such as, for example, the appropriate siting of public services.

While geospatial information is available for many of the sectors referred to above, Ireland lacks a single comprehensive resource on its land cover, habitats and land uses. Organisations with an interest in spatial data and mapping are currently reliant on disparate information sources which are often based on different data models and structures. Incompatibility between relevant datasets is a key obstacle to harnessing the full potential of existing datasets and the benefits that could be realised if standardised data models were used for complementary datasets.

A state sponsored Land Cover and Habitat Mapping (LCHM) Programme for Ireland offers the most effective mechanism by which comprehensive, regularly updated national datasets on land cover and habitats for Ireland can be made available. This programme will optimise the latent value of existing land cover, habitats and land use datasets available in Ireland with widespread benefits arising in terms of our ability to respond to environmental, economic and societal challenges.

This report advances the progress made by the national LCHM Working Group (WG) which has campaigned for establishment of the Programme. In March 2016, the national LCHM WG commissioned a project team³ led by Future Analytics Consulting to undertake a *Use Case Analysis and Economic Value Study*, in support of a national LCHM Programme for Ireland. This report presents the findings of that study.

1.2 Background

In 2011, a national workshop on land cover and habitat mapping identified that although significant resources were being invested by various national agencies in the development of spatial datasets, incompatibility and overlap between datasets was presenting a serious limitation to their potential application, and consequently, inhibiting exploitation of their value. Key constraints identified include:

- A lack of detail on the characteristics of national land cover;

³ The project team comprises Future Analytics Consulting, Optimize Economic Consultants, Dr. Michael Brennan and Mary Tubridy & Associates

- Insufficient thematic classifications available for land cover and habitats in Ireland;
- Gaps in spatial coverage and poor delineation of land cover features;
- A lack of temporal data on land cover and habitats;
- Inconsistent standards in land cover and habitat data sources in Ireland.

A working group was then established to examine the most effective and sustainable way to address these constraints. From this, the idea of developing a national LCHM Programme within the framework of the Public Service Reform Plan and ICT strategy 2015 was established. The working group comprises representatives of DAFM, including the Forest Service, DAHRRG, the Heritage Council, EPA, OSi, and Teagasc. The working group has the support of a wide range of organisations including the Office of Public Works (OPW), DHPCLG, and the Marine Institute.

Over the past five years the working group has explored in detail the issues and technical requirements for national LCHM datasets. In addition to conducting extensive consultation with leading experts in the use of land cover and habitat mapping, a pilot project focusing on County Roscommon was carried out to examine the technical feasibility of the programme. The pilot project combined the digital geospatial referencing platform, Prime 2 (developed by OSi), with other available datasets that would be viable in terms of a national data series.

The results of the Roscommon Pilot project indicate that the technology is available for this extensive cross sectoral capacity building programme. The OSi Prime 2 data model has been confirmed as the preferable data model to base the national LCHM datasets on and a commitment has been received from the OSi to support the national LCHM initiative through the provision of the Prime 2 data.

1.3 The proposal for a national LCHM Programme

The proposal for the national LCHM Programme involves the following elements:

- The establishment of a lead agency to oversee the procurement, collection and validation of land cover data on an on-going basis. It is proposed the Programme should be developed as a theme under the forthcoming National Spatial Data Strategy. Ordnance Survey Ireland (OSi) (to become *Tailte Éireann*⁴) will provide and manage the technical systems for its dissemination to the wider public service and citizens. This will also allow the use of best available technologies and standards in data collection. The data products will be easily accessible and implemented in line with the provisions of the National Mapping Agreement.
- National high resolution land cover and habitat data will be produced and updated regularly – the national LCHM product. The programme will adopt a phased approach, in the first instance generating high resolution national land cover datasets, followed by more detailed habitat mapping. This will be based on the spatial boundaries of OSi's Prime2 data model, coupled with remote sensing and other currently available datasets such as:
 - LPIS 2011 (DAFM);
 - Forestry 2007 and afforestation 2007-2012 (Forest Service, DAFM);
 - Forestry Land use map 2012 (Coillte);
 - Field based ecological surveys (DAHRRG and others);

⁴ Tailte Éireann will be the statutory body created from the merger of the Property Registration Authority, the OSi, and the Valuation Office. It will have responsibility for developing and maintaining Ireland's national spatial data infrastructure.

- IRS 25m multi-spectral satellite imagery (EPA);
- Worldview 2m satellite imagery (DAFM); and,
- Nextmap 5m digital elevation model (EPA).

The use of satellite imagery will feature strongly in the production of the land cover datasets. High quality, dual season satellite imagery is needed to confidently complete the spectral classification phase.

- A common standards framework will be prepared. This will provide data standards and classifications that will allow land cover, habitat and land use data produced by public agencies to be integrated within the OSi's Prime 2 Data Model as the hosting framework for data publishing.

Initially, the focus will be to produce a schema compatible with the Fossitt Level 2B dataset. The agreed scheme is provided in Appendix 1. To illustrate the enhanced detail that will be delivered by the mapping programme, extracts from the Roscommon technical study are provided below. Figure 2 shows an aerial image of Roscommon town. Figure 3 shows how this is depicted by the CORINE 2012 land cover dataset. The enhanced detail that will be delivered by the proposed mapping system based on Fossitt Level 2B is illustrated in Figure 4.



Figure 2: Roscommon town (2005 OSi Ortho-photos)



Figure 3: Roscommon town, 2012 CORINE Land cover dataset (current national land cover dataset)



Figure 4: Roscommon town, Fossitt 2B classification

1.4 Objectives

It is essential that there is a clear understanding of the value of a national LCHM programme among senior decision-makers in both the public and private sector. In preparing the use cases and determining the economic benefits of the proposed programme, the project team were guided by the following objectives:

- a) To identify a series of use cases for a national land cover and habitat mapping programme. Specifically, this study presents three use case examples showing how the programme can support the effective delivery of national and regional strategies in the areas of land use planning, climate action and flood management. Additional scenario examples demonstrating the potential applications of the programme to a range of areas including agriculture, forestry, biodiversity and air quality are provided in Appendix 3.
- b) To establish the economic value of a national land cover and habitat mapping programme on the Irish economy. Specifically, this study will determine the economic value of a national land cover and habitat mapping programme and its contribution to competitiveness and innovation in Ireland within the context of the Economic Assessment of the Geospatial Industry in Ireland carried out for OSi in 2013;
- c) Determine the risks and costs of continuing the status quo: determine the risks and benefits associated both with maintaining the status quo and with progressing the programme;
- d) Develop a suite of recommendations based on the findings for consideration by the WG.

1.5 Methodology

A two stage methodological approach was adopted in the preparation of this study.

- **Stage 1** comprised desktop research of best practice examples in the collation and use of national land cover and habitat datasets from an international, European and national perspective.
- **Stage 2** involved cross sectoral stakeholder engagement. Interviews were held with representatives from various organisations involved in agriculture, forestry, flood risk management, land use planning, air quality, climate change mitigation/adaptation and

biodiversity. Care was taken to target organisations from the public and private sectors, NGOs and academic and research representatives. The full list of consultees engaged with as part of this study is provided in Appendix 2.

1.6 Report structure

Following this introductory chapter, Section 2 commences with an overview of **current approaches** to land cover and habitats data systems from international, European and national perspectives (*Section 2.0*). The opportunities for supporting Ireland's **European and national legislative commitments**, and for delivering key national policy objectives are then set out (*Section 3.0*). **Cross sectoral applications** for a national LCHM programme are then explored with a focus on selected areas including agriculture, forestry, flood risk, land use planning, air quality, climate change and biodiversity. Following this, **use case examples** of the ways in which the proposed programme can support the delivery of national policy in the areas of planning, climate change and flooding are set out (*Section 4.0*). Further hypothetical scenarios that demonstrate the use of national land cover and habitat data are provided in Appendix 3. The **economic value** of a national LCHM programme is then presented. The **risks of maintaining the status quo** i.e. the absence of a national LCHM programme is also outlined (*Section 5.0*). The report concludes with a suite of **recommendations** to advance the case for a national LCHM programme (*Section 6.0*).

2. Current Land Cover and Habitat Mapping Approaches

This section provides a brief overview of land cover and habitat mapping approaches in place at an international, European and national level.

2.1 International

Global forces such as urbanisation and climate change continue to bring ongoing challenges for sustainable development. In responding to these challenges, it is hugely important that reliable geospatial information that captures the dynamics of land cover is available. Indeed, international responses, such as the United Nations 2030 Agenda for Sustainable Development⁵, rely on the availability of such data. For example, the Agenda comprises 17 Sustainable Development Goals (SDGs) and targets. Trustworthy geospatial information on land cover is needed to support the effective implementation and monitoring of these SDGs. Recent advances in the quality and availability of land-cover data systems include the 2014 launch of GlobeLand30, a key application of which has been to derive the indicators for monitoring of the UN SDGs⁶. Globeland30 is a free public resource⁷ that provides a 30m-resolution global land cover (GLC) dataset. The dataset, which has been downloaded by users from over 110 countries, has applications for a wide range of areas including environmental resource management, urban planning and climate change modelling.

Growing recognition of the value of geospatial information (including land cover and habitat data) in supporting economic growth, critical services and sustainable development, led to the 2011 establishment of the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM). The UN-GGIM was set up to encourage collaboration and knowledge sharing between users of geo-spatial information, and to support the development of strong information bases. One of the key activity areas of the UN-GGIM has been to document novel and innovative uses of geo-spatial information within participating countries. The case studies provide practical examples of how land cover data (and other geospatial data) can support economic development and the efficient delivery of public services. Two case studies are summarised below, the first of which highlights an example of the application of land cover data to support efficiencies in the agri-food industry. The second describes the coordinating mechanism in place for geospatial information management in Canada.

UN-CASE Study 1: Brazil uses Geospatial Technology to improve production of sugarcane, in Piracicaba, a region where sugar cane occupies 8.3 million hectares⁸. To monitor production areas of sugar cane and to identify problems and their causes, a system of land cover mapping has been introduced. The project involved the creation of thematic maps and field surveys to identify the causes of problems, and to monitor the result of the actions taken.

⁵ United Nations [2015] 'Transforming our World: The 2030 Agenda for Sustainable Development'. Available at: <https://sustainabledevelopment.un.org/post2015/transformingourworld>. Accessed 24.05.16

⁶ National Geomatics Center of China, Xinyan, Z [2016] 'International Workshop on Analysis and Application of Global, Land Cover Information'. Available at: <http://www.ngcc.cn/article/en/GLC2016/>. Accessed 24.05.2016

⁷ Globeland30. Available at: <http://www.globallandcover.com/GLC30Download/index.aspx>. Accessed 24.05.16

⁸ de Araújo, V. [2013] 'Brazil: Use of Geospatial Technology to improve production of sugarcane', United Nations Initiative on Global Geospatial Information Management. Accessed 13.04.2016

UN-CASE Study 2: The geospatial information initiative, Multi-Agency Situational Awareness System (MASAS), is a Canadian national framework to integrate trusted, authoritative emergency data in a geographic context⁹. The system involves a government and private sector collaboration agreement to improve information sharing.

Key benefits include increased efficiency in emergency management through faster awareness, notification and response; improved communications through increased awareness and reduction of information silos; improved decision making ability through amalgamation and visualisation of information; cost reduction through the use of open standards; and, improved efficiency in the deployment of resources.

Ultimately, the UN-GGIM seeks to demonstrate the importance of geospatial information in terms of understanding how places work, and in providing an essential evidence base to inform decision making. However, the case studies captured by the UN-GGIM also reveal the depth and diversity of challenges in terms of developing and maintaining robust, reliable and accurate geospatial information. These challenges include the up keep of the system; working with data available at different spatial scales, and setting up and gathering data inventory.

The United States has been undertaking land cover mapping since the 1970s, using remote sensing techniques and satellite imagery from satellites such as Landsat and EOS Terra. Due to the often decentralised nature of institutional governance in the United States, land cover mapping falls under the remit of a number of organisations. Chief among these is the United States Geological Survey Land Cover Institute (LCI). The LCI serves to facilitate the land cover data produced by a variety of other organisations, collating it in one place and allowing for easy access and cross-reference. One such program is the USGS GAP Analysis Program, which assists in modelling wildlife habitat and biodiversity.¹⁰ Initially, this program was focused along state lines, but recognition that ecosystems tend to cross political boundaries has led to increased cooperation and coordination in mapping across bioregions. One area where land cover mapping has been particularly useful is forestry¹¹, with the US Forest Service using the USGS data to inform many of its forestry management programmes.

The U.S Federal Geographic Data Committee (FGDC) endorses the National Vegetation Classification Standard (Version 2)¹². This standard ensures accuracy, consistency, and clarity in the structure, labelling, definition and application of a vegetation taxonomy for the U.S. Minimum metadata requirements are set out in order to support consistency in reporting on national vegetation resources. Furthermore, the U.S. Fish and Wildlife Service (USFWS)¹³ have adopted data standards to ensure the quality and compatibility of its data so that it can be shared with a wide range of users.

The technology available in the United States has allowed land cover mapping to go beyond American borders. The Global Land Cover Facility (GLCF), produced by a collaboration of the USGS, NASA, and the

⁹ Shukle, P. (2013) 'Canada's Multi-Agency Situational Awareness System – MASAS', United Nations Initiative on Global Geospatial Information Management. Available at: <http://www.iscramlive.org/ISCRAM2012/proceedings/306.pdf>. Accessed 13.04.2016

¹⁰ U.S. Geological Survey (2016) National Gap Analysis Program (GAP) – Core Science Analytics and Synthesis. Available at: <https://gapanalysis.usgs.gov/>. Accessed 26.05.2016.

¹¹ U.S. Geological Survey (2014) Evaluation of the National Gap Analysis Program (GAP): A Survey of Users of GAP Data – Report to Respondents. Available at: <https://pubs.usgs.gov/of/2014/1166/pdf/ofr2014-1166.pdf>. Accessed 26.05.17

¹² Federal Geographic Data Committee (FGDC) of the United States (2008) 'National Vegetation Classification'. Available at: <https://www.fgdc.gov/standards/projects/FGDC-standards-projects/vegetation>. Accessed 26.05.2016.

¹³ Fish and Wildlife Service (USFWS) of the United States (2016) 'Federal Data Standards for Wetlands'. Available at: <http://www.fws.gov/wetlands/Data/Data-Standards.html>. Accessed 26.05.2016.

University of Maryland, is one of the most comprehensive land cover mapping systems in existence, providing peak-season imagery for the entire globe at 30m resolution, based off Landsat images and Terra and Aqua satellite sensing.¹⁴ Additionally, GLCF data dates back to 1975, providing a multi-decade perspective on land cover changes at a global scale. Various datasets of the GLCF are updated within 16 days and are freely disseminated, presenting a nearly-continuous picture of global land cover, particularly with the MODIS sensing system¹⁵.

The North American Land Change Monitoring System (NALCMS) is a collaborative effort of the Commission for Environmental Cooperation, a tri-national organisation of the United States, Mexico, and Canada. This system allows land cover change across international borders to be compared, allowing for a more complete inventory of bioregions and the impact of human use patterns.

The Australian Collaborative Land Use and Management Programme (ACLUMP) promote the development of nationally consistent land use and land management practices information for Australia. A National Committee is in place to oversee the programme activities which include mapping at national and catchment scale, coordination and implementation of standards for data systems, communication and dissemination, and analysis and reporting.

2.2 European

The CORINE (Co-ORdinated INformation on the Environment) land cover programme was established by the European Community (EC) in 1990. CORINE is an EU wide land cover programme designed for the standardised compilation of geo-spatial environmental information. It was most recently updated in 2012. However, the inadequate spatial and temporal resolution, and the limitations of the thematic classes offered by the inventory (as further described in Section 2.3 below), present a strong rationale for developing new techniques with a greater capacity to capture the rich diversity of land cover at a local, regional and national level.

An important driver for the enhancement of national land cover and habitat data in Europe is the EU Biodiversity Strategy 2020¹⁶ (described in Section 3.2 below). A core aspect of this strategy is *Target 2: 'To maintain and restore ecosystems'*. Specific actions are set out to achieve this target including Action 5 which calls for the mapping and assessment of the state and economic value of ecosystems and their services across the entire EU. The Mapping and Assessment of Ecosystems and their Services in Europe (MAES) initiative was formed as a delivery mechanism for Action 5. A recently published MAES report¹⁷ highlights the value of ecosystems and national habitats monitoring, and the importance of having concurrent data and integrated mapping approaches. The report evaluates existing pressures on environmental systems arising as a result of habitat change, climate change, over-exploitation, pollution and nutrient enrichment, and identifies key knowledge gaps to further understanding these pressures. In this regard, the need for further mapping and assessment of habitats and ecosystems is emphasised.

¹⁴ Channan, S. et al. (2015) 'The GLS+: An Enhancement of the Global Land Survey D016 Datasets PE&RS', 31.7. pp. 521-525. Available at: https://www.researchgate.net/publication/279782685_The_GLS_An_Enhancement_of_the_Global_Land_Survey_Datasets. Accessed 26.05.2016.

¹⁵ Zhan, X. et al. (2002) 'Detection of land cover changes using MODIS 250 m data, Remote Sensing of the Environment', 83 pp. 336-350.

¹⁶ European Commission (2011) 'The EU Biodiversity Strategy to 2020'. Publications Office of the European Union, 2011.

¹⁷ European Environment Agency (2016) 'Mapping and Assessment of Ecosystems and their Services. Mapping and assessing the condition of Europe's ecosystems: Progress and challenges. 3rd Report – Final, March 2016'. Available at: http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/3rdMAESReport_Condition.pdf. Accessed 27.04.2016

Action 6 of target 2 promotes the European Commission Green Infrastructure Strategy, another significant driver for improved land cover information (land use and habitats data provide important input to green infrastructure initiatives).

Critically, there is a wealth of existing datasets which can be re-interpreted for enhanced classification and increased resolution at national levels. This has been the approach of several European countries that have sought to build on available datasets through careful re-use and integration of compatible datasets for land cover mapping. For example, in July 2011, the UK Centre for Ecology & Hydrology¹⁸ produced its *Final Report* on the UK Land Cover Map 2007 (LCM2007). LCM2007 is the first UK land cover map with land parcels derived from national cartography by a generalisation (simplification) process. The framework is based on the UK Ordnance Survey Master Map topography layer. It is supplemented with generalised national cartography drawing using agricultural census data boundaries and image segments. This approach brought significant improvements in spatial and thematic accuracy of land cover and provides continuous vector coverage of UK Broad Habitats derived from satellite data. The map contains almost 10 million land parcels (8.6 million for GB; 0.9 million for NI). The LCM 2007 is used to inform habitat monitoring and acts as an evidence base for the formulation of policy in areas such as biodiversity, urban and rural planning and catchment management.

In Sweden, there is a nation-wide programme to monitor conditions and changes in landscape biodiversity and land use. The National Inventory of Landscapes (NILS) programme¹⁹ is based on a combined approach of field inventories and interpretation of all land cover types in Sweden from 1:30,000 stereo colour infrared aerial photography. The NILS surveys are carried out every 5 years with the first survey covering the period 2003-2007 and the most recently available survey covering 2008-2012. The surveys encompass 631 plots (5km x 5km grids) covering all terrestrial habitats in Sweden. A key driving force for the programme has been the need to develop a resource base that can support the delivery of commitments under national and international environmental frameworks. Basing the programme on two parallel and integrated inventory routes this programme provides scope for multidisciplinary and multi scale analysis of data field inventory that can be used by multiple agencies e.g. the grid is also used by the national bird directive. Because of the extensive nature of land cover information available, NILS is widely used in Sweden by authorities, NGOs and the scientific community with applications for the agricultural environment, urban environment, forestry, climate change and many more.

The European Environment Agency's report on terrestrial habitat mapping in Europe published in 2014²⁰ presents the habitat mapping approaches adopted in over 30 European countries. Most of the projects referred to are large area mapping schemes carried out on a national level. The most important projects in terms of coverage and fieldwork include national programmes undertaken in the Czech Republic, Hungary and Italy, as briefly summarised below.

Biotype mapping programme: Czech Republic

This project was initially established to map the Natura 2000 network. The habitat maps produced are based on the Biotopes Catalogue of the Czech Republic. Mapping carried out at a 1:10 000 scales allowed

¹⁸ Morton, D. Rowland, C. Wood, C. Meek, L. Marston, C. Smith, G. Wadsworth, R. Simpson, IC. (2011) 'Countryside Survey - Final Report for LCM2007 - the new UK Land Cover Map'. Available at: <https://www.ceh.ac.uk/sites/default/files/LCM2007%20Final%20Report.pdf>. Accessed 27.04.2016

¹⁹ Swedish University of Agricultural Science (2016) 'National Inventory of Landscapes in Sweden, NILS'. Available at: <http://www.slu.se/en/collaborative-centres-and-projects/nils/>. Accessed 24.05.2016

²⁰ European Environment Agency (2014) 'Terrestrial habitat mapping in Europe: An Overview', Publications Office of the European Union: Luxembourg. Available at: <http://www.eea.europa.eu/publications/terrestrial-habitat-mapping-in-europe>. Accessed 24.05.2016

for identification of Annex I habitat types for Natura 2000 sites designation. Over 750 persons were involved in the mapping process. The biotope mapping programme gathered data on all natural habitats types and their distribution across the entire country. It presents a significant national resource, providing summary data for projects and reports that require data for the whole Czech Republic. The results are used as a basis for identifying Sites of Community Importance (SCI's), and as a data source to support reporting under Article 17 of the Habitats Directive for Annex I habitat types, for appropriate assessments and for environmental impact assessment, as well as for scientific research, theses or decision-making procedures.

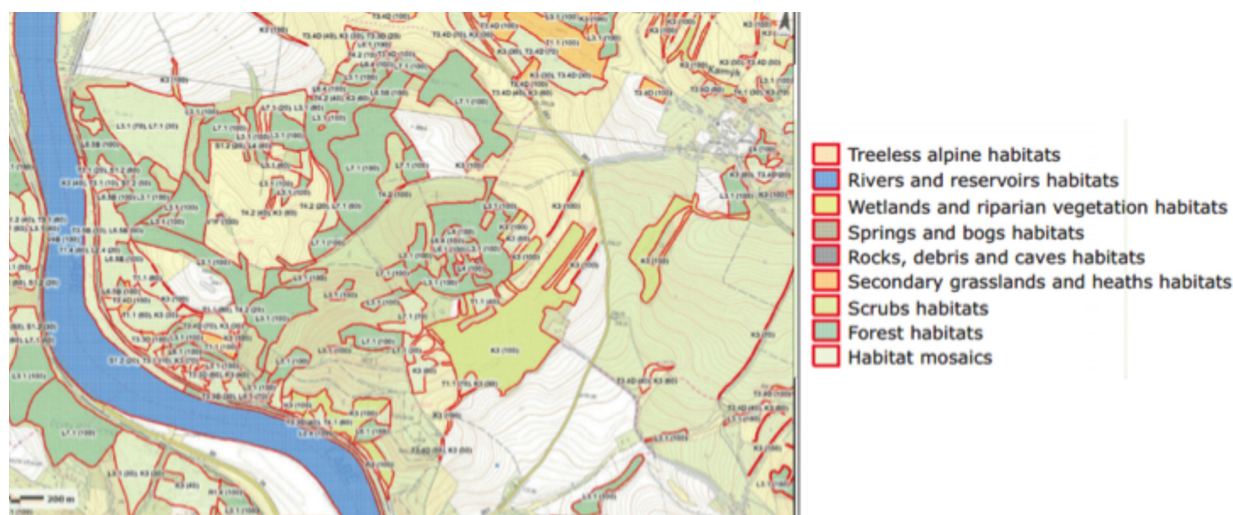


Figure 5: An example of Czech Republic biotope map (as extracted from 'Terrestrial habitat mapping in Europe' – EEA, 2014)

The MÉTA programme in Hungary

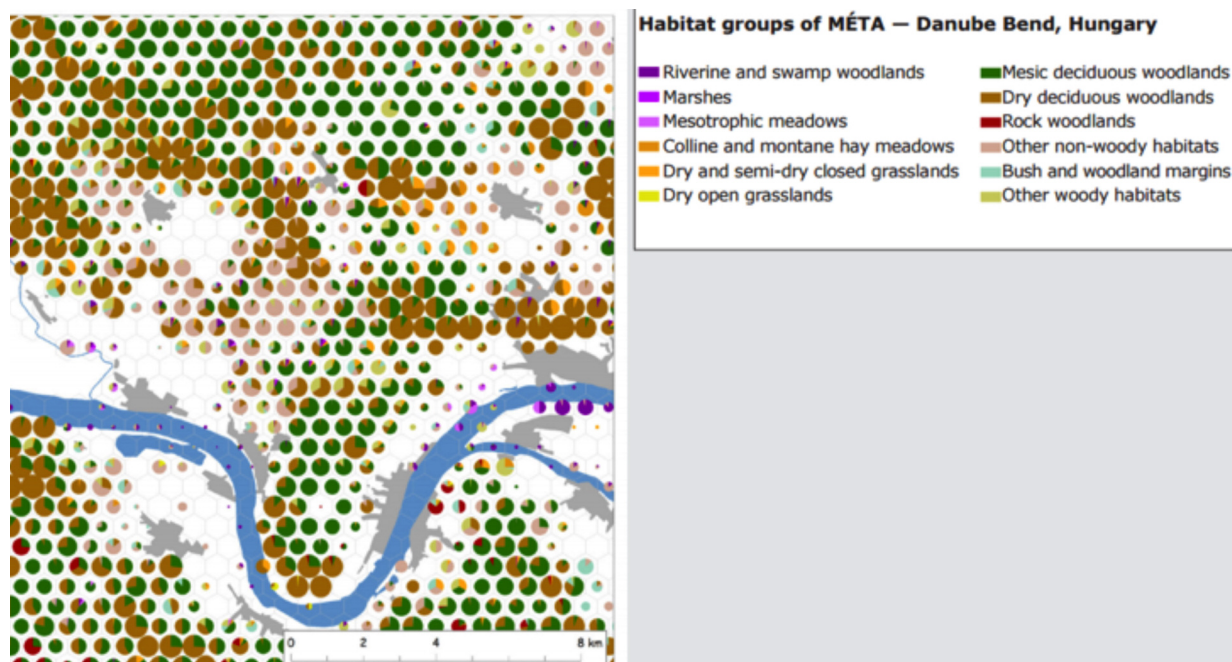
The Hungarian habitat mapping programme known as *Database and Map of Hungarian Habitats* (MÉTA) mapped the natural vegetation of Hungary. All areas of Hungary (93010km²) with vegetation of natural heritage interest were documented. In these areas, all natural and semi-natural habitat types were mapped. The project adopted a national habitat typology, the Hungarian General National Habitat Classification System (ÁNÉR)²¹ which was updated before and after the MÉTA project²². A combination of field survey and satellite image interpretation (SPOT4) was used to carry out the mapping. The mapping was based on a hexagonal grid. All hexagons where natural vegetation covered at least 20 % of the area were surveyed and the maps are contained in a national habitat database. They provide important baseline input on habitat type and quality supporting impact assessment, landscape evaluations, agri-environmental monitoring protocols and scientific research on the impact of climate change of natural ecosystems.

The distributed information system of Carta della Natura in Italy

The aims of the Carta della Natura project are (i) to identify the status of the natural environment in Italy; and (ii) to assess the quality and fragility of Italian habitats. The outputs to date include a map of the Italian Landscape Units (at a scale of 1:250 000) completed in 2001 and habitats maps at regional (1:50 000) and local (1:10 000) scales. The production of regional and local maps is still ongoing with over half of the

²¹ Bölöni, J., Kun, A., & Molnár, Z., Eds. (2003) *Él hely-ismereti útmutató 2.0, mmÁ-NÉR* [manuscript], Vácrátót, MTA ÖBKI.

²² Bölöni, J., Molnár, Z., & Kun, A. (2011) *Magyarország él helyei, A hazai vegetációtípusok leírása és határozója*, p. 441, Vácrátót, MTA ÖBKI.



**Figure 6: Extract of the MÉTA habitat mapping programme in Hungary
(as extracted from 'Terrestrial habitat mapping in Europe' – EEA, 2014)**

national territory covered to date. Maps that are now available include ecological value maps, the quality map of ecological sensitivity, and the quality map of human impact. The production of the maps involves the integration of information from satellite images, field surveys and other spatial data (e.g. land use or forest type maps).

The Carta della Natura system is organised in a distributed way, based on existing systems of the different actors involved in the mapping production, but with a central validation to verify consistency and interoperability between systems.

Other approaches to national habitat mapping include the French CARHAB project. This project which was launched in 2011 by the French Ministry of Ecology is focused on producing a large scale vegetation map (1:25000) of the French national territory using both phytosociological and symphytosociological approaches²³. The goal of CARHAB is to produce a national strategic spatial tool that can support biodiversity monitoring, conservation planning, and related ecosystem services and that can be used as an information base to enable reliable reporting on the conservation status of habitat and species of community interest within the EU. This ongoing national programme uses state of the art remote sensing (RS) mapping and modelling vegetation assemblages. Its approach is to develop vegetation mapping using base maps on the physiognomic and environmental characteristics of vegetation. The base maps are used to support phytosociological field surveys before the completion of the final vegetation map. Phytosociological surveys are undertaken by National Botanical Conservatories working in each region.

²³ Thierion, V. Alleaume, S. Jacqueminet, C. Vigneau, C. Renaud, J. et al. (2014) 'The potential of Pléiades imagery for vegetation mapping: an example of grasslands and pastoral environments. *Revue Francaise de Photogrammétrie et de Télédétection*, Société Française de Photogrammétrie et de Télédétection', pp.105-110. Available at: <https://hal-ens-lyon.archives-ouvertes.fr/hal-01335884/document>. Accessed 25.05.2016

The 2011 *Harmonised European Land Monitoring* (HELM)²⁴ project led by the Austrian Environment Agency encompasses a large number of partners throughout Europe. The objective of HELM is to produce coherent European land monitoring system characterised by high quality data and efficient productivity. The HELM project aims to increase the majority of European land monitoring along five sequential steps:

- 1) Mutual interest in achieving reciprocal knowledge;
- 2) Shared visions and planning for the future;
- 3) Joint activities by taking on tasks collectively;
- 4) Alignment of national systems involving the mutual adaptation of data interpretation methods and of the timing of data gathering; and,
- 5) Lasting integration and combining data across all administrative levels.

One of the findings of the HELM project was the need for “*aligned national land monitoring activities where the many different datasets are linked and combined between and across administrative levels while allowing for freedom of data interpretation needed at the regional and national scale.*” Key to the research undertaken during the HELM project was the integration of remote sensing with existing data into a production database that facilitates aggregation to harmonised land monitoring. From the research undertaken, the HELM project team recommended the adaption of the EAGLE concept which describes landscape by its elementary properties instead of traditional classification methodology.

The overview of approaches adopted across Europe represent just a snapshot of the novel uses that national land cover, land use and habitat mapping can support. A brief description of current practise in Ireland is provided below.

2.3 National

Ireland is one of the few remaining countries in Europe without a coordinated national programme for either land cover or habitat mapping. Responsibility for data collection of land cover types and the production of maps is currently dispersed across a range of public sector agencies. Research carried out by EPA²⁵ in 2011 revealed that substantial resources has been invested by various government departments and state agencies on mapping activities to meet their land use and land cover needs. However, despite the clear complementarities that exist between agencies in terms of their need for land cover, land use and habitat data, an integrated national solution to meet this requirement, has not thus far been achieved.

The most detailed land use and land cover (LULC) dataset currently available in Ireland is the CORINE land cover series. CORINE comprises two products: LULC data which displays Ireland's land cover at 25 ha scale, and the LULC change datasets which displays land cover change at a scale of greater than 5 ha between reporting periods. A summary of the weaknesses of CORINE as a national land cover dataset for Ireland is described below:

- CORINE was developed as a pan-European dataset, rather than a national data set and as such, there are considerable limitations in its use as a **national** land cover dataset.

²⁴ HELM, Harmoni Ben-Asher, Z. (ed.) (2013) 'HELM – Harmonised European Land Monitoring: Findings and Recommendations of the HELM Project', Tel-Aviv, Israel: The HELM Project. Available at: http://www.umweltbundesamt.at/fileadmin/site/en/pdf/HELM_Book_2nd_Edition.pdf. Accessed 27.04.2016.

²⁵ Environmental Protection Agency (2011) 'Land Cover & Habitat Review'. Available at: http://www.epa.ie/pubs/reports/biodiversity/EPA%20Bio%20AP_final.pdf. Accessed 27.04.2016

- The large minimum mapping unit of 25 ha delivered at a 1:100,000 scale means that it is not suitable as a resource for reporting, assessment and research applications in sectors such as land use planning, biodiversity, forestry management.
- CORINE includes land cover classes that are appropriate for all of Europe which are more generalised in nature rather than providing detailed information for the land cover of individual countries. As such, it does not show the level of detail available for some Irish classification systems, such as the Fossitt Classification.

Existing spatial datasets, such as CORINE, do not possess the spatial resolution accuracy to categorise small scale ecological features that are important to local biodiversity, such as river courses, and other water bodies, small woodland areas and drainage channels. Furthermore, OSi Prime2 has a limited thematic classification of landcover (with just 5 classes). For example, land cover and habitats comprising peatland, marshy grassland and scrubland are detected by Prime2 as one large boundary unit, instead of appearing disaggregated. These areas comprise important habitats and biodiversity value, but as demonstrated with CORINE and Prime2, their presence is misrepresented by current land cover spatial mapping tools. The national LCHM programme aims to break these down into many more classes (possibly using the Fossitt Level 2B for Landcover).

To illustrate the differences between CORINE land cover and actual land cover, an example of land cover attributes in the vicinity of Lough Key near Knockvicar in County Roscommon is set out in Table 1. This example shows land cover attributes that are not captured by the low resolution of the CORINE landcover series, but which are of economic and social value.

Comparison of CORINE Land Cover and Actual Land Cover

An illustration of how CORINE compares with the reality of land cover on the ground in Knockvicar and Lough Key, County Roscommon is provided below.

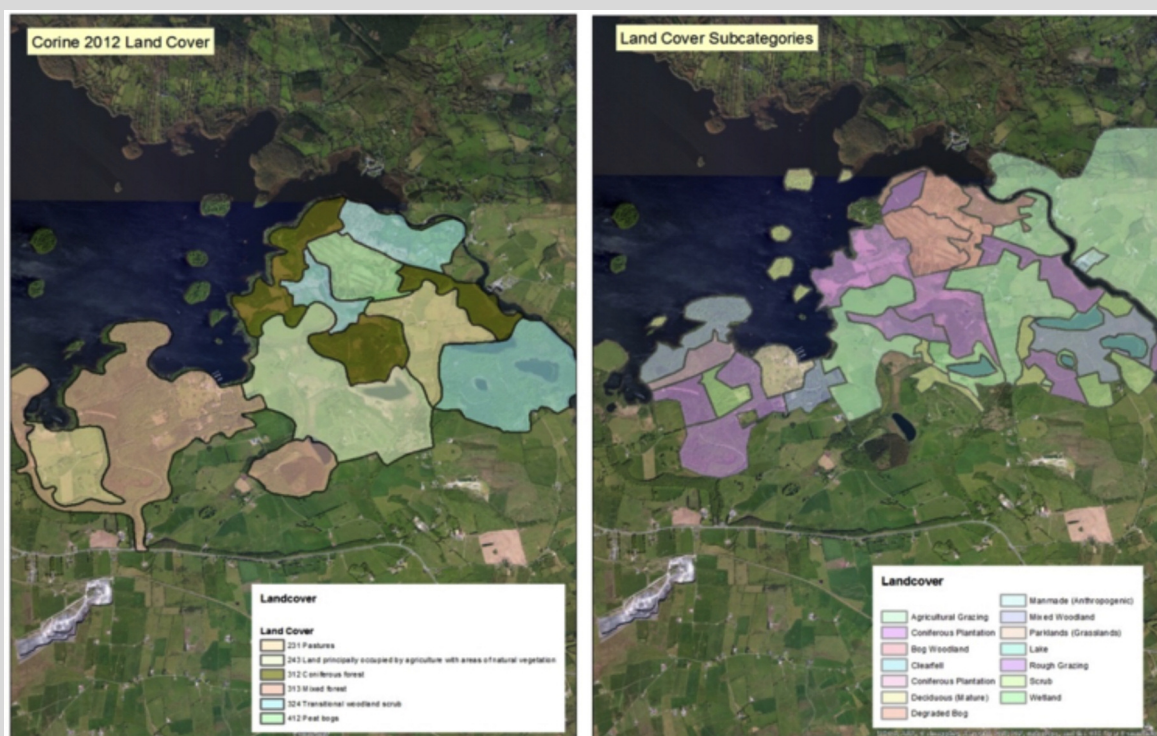


Table 1: Example of the differences between land cover captured by CORINE and actual land cover

In the CORINE map there are essentially six land cover types, i.e. pasture (code 231), land occupied predominantly by agriculture (243), coniferous forest (312), mixed forest (313), transitional woodland scrub (324) and peat bog (412). One area is misclassified. In reality the land cover is very diverse. The location includes areas of bog woodland, an Annex 1 habitat, with much of this comprising hazel woodland. It also includes areas of low intensity grazing, lake, wetland and a turlough, a habitat and topological feature common in County Roscommon but almost unique to Ireland. In addition, around 40 ha is native oak woodland. Much of the area is accessible and of high amenity and tourism value, including parts of Lough Key, a popular circular walk and a well-known bluebell wood. None of the land cover underpinning these values is indicated by the existing CORINE map.

Even in its degraded condition, the peatland provides benefits in terms of moderating run-off, along with the native woodland and turlough. This potentially reduces the risk and cost of flash flooding downstream in towns such as Carrick-on-Shannon. The whole area provides important cultural services in terms of amenity with some areas, such as the Bluebell Wood being valuable for tourism. The Lough Key Forest Park attracts at least 100,000 visitors per year who spend around €3 million in the locality. Other ecosystem service values include timber from coniferous forest plantings for which the CORINE map does provide a reasonable representation, although some areas have been recently clear felled. The standing timber crop value of this area of 248ha is worth around €4.2m (approx. €84,000 per year). These trees also sequester carbon at around 2.4-3.6 tC ha yr. worth €29,000 per year in terms of alternative climate change abatement costs at around €39 tC. The sequestration contribution of the mature deciduous woodland is lower, but is of economic value as a store of carbon. The 72ha of raised bog could be sequestering €970 of carbon per year, but is badly degraded or actively harvested and unless restored at some future time will continue as a net source of emissions and of economic and social cost.

The CORINE data does indicate the location of forested areas. However, only a detailed LCHM programme can demonstrate where these trees are young and sequestering carbon, or mature and a potential source of timber. A LCHM programme would demonstrate precisely where existing land cover provides ecosystem service benefits or where land cover could be enhanced or restored. This information would be an invaluable resource for land and catchment management.

The differences between the land cover captured by CORINE and actual land cover in the Knockvicar example provided above are further illustrated in Figure 7. This shows how improved land cover and habitat information, provided at Fossitt Level 2B and above, can provide a more accurate account of ecosystem services benefits and environmental costs compared with existing CORINE data.

As part of the 2012 national update of the CORINE programme, the EPA sought to address the weaknesses of the dataset through the integration of the Land Parcel Information System (LPIS) dataset, national forestry datasets and the EPA's Water Framework Directive waterbody network to the CORINE dataset. Advanced remote sensing and GIS tools were used to combine these data sources along with satellite imagery to both improve the spatial delineation of feature boundaries and the thematic classification of all polygon features. Other land cover and habitat datasets available in Ireland include Forestry Cover Maps produced by the DAFM. The forestry layer comprises extracts from the Forest Inventory and Planning System (FIPS) and the Land Parcel Information System (LPIS), also prepared by DAFM. National datasets developed by DAHRRG and by Teagasc, cover habitats and species data mapping, and soils data. In 2014, the national authoritative, standards-based, digital geospatial referencing platform, known as Prime 2, developed by OSi, greatly advanced the referencing, storing, maintenance and accessibility of national topographic mapping data.

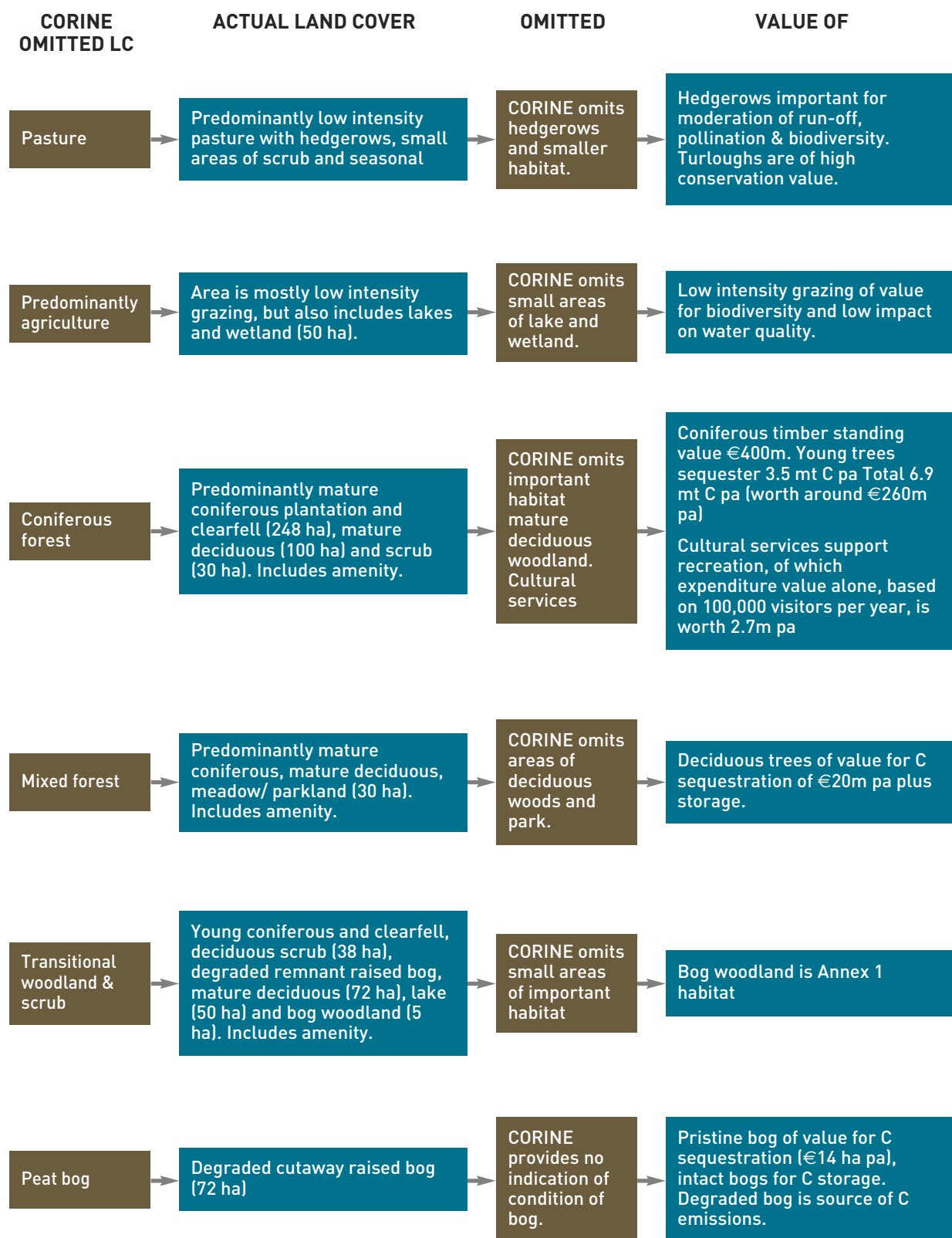


Figure 7: CORINE land cover vs. actual land cover

The National Biodiversity Data Centre (NBDC) established under the direction of the Heritage Council and supported by DAHRRG, offers a hugely valuable resource for biodiversity in Ireland by means of its mapping and data collection programmes.

The Heritage Council, supported by over 24 local authorities, has developed *heritagemaps.ie* which collates thematic information on natural and cultural heritage. It incorporates a range of datasets from a variety of sources including land use zonings from Planning Authorities, landscape designations and landscape character assessments amongst others.

With all of these data collection and mapping programmes, a significant amount of spatial information is being generated. However, the absence of an authoritative management agency has resulted in disparate collation methods and overlapping datasets. This fragmented approach has led to inefficiencies in how land cover is understood and managed in Ireland, with fundamental gaps in our knowledge base. This is inhibiting our capacity to provide quality responses to European and national legislative and policy commitments and reporting requirements (summarised in Section 3.0). A national programme would offer far higher value for money.

3. Supporting European and National Legislation and Policy Initiatives

A national LCHM programme will improve delivery of a range of government policy initiatives and statutory obligations arising from European and National legislation, as described below.

Supporting Public Service Reform eGovernment 2012-2015	<ul style="list-style-type: none"> • Deliver efficiency, effectiveness and value for money gains; • Enhance collaboration between public bodies and the general public; • Facilitates data, knowledge and expertise sharing; • Enables re-use of data in keeping with the National Mapping Agreement (thereby reducing administrative burdens); • Reduces duplication, inconsistencies, incompatibility and a lack of integration;
Public Service ICT Strategy 2015²⁶	<ul style="list-style-type: none"> • A cost efficient mechanism for sharing of geospatial information across the public sector and relevant private sector organisations.
Public Sector Reform Plan 2014-2016²⁷	<ul style="list-style-type: none"> • Supports the objective of maximum use of digitisation and open data to deliver services and information to the public in innovative ways; • Facilitates openness, transparency and accountability; • Provides a mechanism to support engagement with citizens; • Support efficiencies, increased productivity and provide greater value for money as called for by the National Interoperability Framework.
National Geospatial Data Strategy (NGDS)	<ul style="list-style-type: none"> • Improves access to geo-spatial information for public services, businesses and citizens; • A direct delivery mechanism for the collation and regular update of a national land cover and habitat mapping data to form part of the NSDS infrastructure; • Contributes to the maintenance of an authoritative, standardised set of core geospatial reference data; • Provides for a common data standard (for land cover & habitats) to enable the joining up and integration of government geospatial data and systems.
Open Government Partnership National Action Plan 2014²⁸	<ul style="list-style-type: none"> • Makes data held by public bodies more freely available and accessible reuse and redistribution; • Improves the quality of data available to public bodies for analysis and decision-making; • Promotes a consistent approach to open data for public bodies.

Table 2: Benefits of the national LCHM programme for Public Service Reform plans

²⁶ Department of Public Expenditure and Reform (2015) 'Public Service ICT Strategy 2015'. Available at: <http://ictstrategy.per.gov.ie/ictstrategy/files/Public%20Service%20ICT%20Strategy.pdf>. Accessed 19.04.2016

²⁷ Department of Public Expenditure and Reform (2015) 'Annual Progress Report on the Public Service Reform Plan 2014-2016'. Available at: www.per.gov.ie/wp-content/uploads/DPER_progress-report-2015_WEB1.pdf. Accessed 18.04.2016

²⁸ Department of Public Expenditure & Reform (2014) 'Open Government Partnership Ireland National Action Plan 2014 – 2016'. Available at: per.gov.ie/wp-content/uploads/OGP-National-Action-Plan.pdf. Accessed 17.04.2016

3.1 Supporting the delivery of Government Policy

The proposal for establishment of a national LCHM programme directly aligns with and provides a feasible delivery mechanism for a wide range of government policy initiatives including many of the measures set out within the Governments Public Service Reform plans, as summarised in Table 2.

In addition, the national LCHM programme also has strong potential to build on and advance the national response to the INSPIRE Directive²⁹ by offering a knowledge sharing platform in a similar vein to that of GeoPortal.ie but with a focus on land cover information. INSPIRE aims to establish a pan-European infrastructure of geographic data to support environmental policy and facilitate the sharing of environmental spatial information among key public sector bodies. It will also support improved public access to spatial data across Europe by means of an on-line service offering data and metadata. INSPIRE must be implemented in full by 2019. INSPIRE will facilitate improved compliance with national, EU and international legislation.

The programme will also bring new opportunities to support progress in cross cutting strategic policy areas such as sustainability, for example, by providing an information resource to assist the delivery of measures set out in *'Our Sustainable Future – A Framework for Sustainable Development for Ireland'*³⁰. In particular, the programme will fill a key data gap to facilitate measures for the conservation and management of natural resources such as the development of a National Terrestrial and Marine Habitat Map, and the development of indicators and accounting systems (satellite accounts) for natural capital.

3.2 Responding to International, European and National Obligations

One of the most valuable applications of geospatial information is in supporting public sector agencies in monitoring and reporting on a wide range of executive and legislative responsibilities; this allows for more informed and effective policy and legislation implementation and monitoring. The national LCHM programme will add value to a range of policy and legislative programmes, providing national agencies with the tools to fulfil their environmental responsibilities in a far more efficient, focused and authoritative manner than is currently the case. A non-exhaustive list of legislative obligations³¹ and associated policy initiatives that the programme could contribute to is provided in the series of tables set out on the following pages.

³⁰ Department of Environment, Community and Local Government (2012) 'Our Sustainable Future – A Framework for Sustainable Development in Ireland'. Available at: <http://www.housing.gov.ie/sites/default/files/migrated-files/en/Publications/Environment/Miscellaneous/FileDownload.30452.en.pdf>. Accessed 17.04.2016

³¹ The legislative requirements listed are provided as a summary overview only. They do not purport to be representative of the full obligations arising from any of the legal instruments referred to.

Legislation	Requirements (in summary)	Existing constraint	Expected Benefit
Water Framework Directive (WFD) and associated regulations³²	<p>The high level aims of the WFD are to:</p> <ul style="list-style-type: none"> • protect/enhance all waters (surface, ground and coastal waters); • achieve "good status" for all waters; • manage water bodies based on river basins or catchments; • involve the public. <p>Responsibility for actions relating to the above is shared amongst the following agencies:</p> <p>DHPCLG Policy, legislation and resources. Sign-off river basin management plans.</p> <p>EPA Monitoring, assessment and reporting including characterisation reports. Evaluation and implementation of measures. Catchment Characterisation and River Basin Management Plans (RBMPs). Monitoring of enforcement tasks and environmental outcomes.</p> <p>Lead Coordinating Authority Local Authority monitoring, licensing and enforcement actions. Implementation of Programmes of Measures by relevant public bodies, tracking and reporting in consultation with EPA. Measures for effective public participation.</p>	<p>Insufficient (temporal and thematic) information on land cover factors that influence water quality.</p> <p>The habitat data gap adversely affects the implementation of the WFD compromising the assessment of pressures & impacts on water quality.</p> <p>The spatial resolution of CORINE can lead to over estimation of pasture classes and under estimation of other main LULC types - urban, arable, forestry and wetlands. This can significantly affect the risk score given to a catchment.</p>	<p>National data on 5 water categories will bring the following benefits:</p> <p>DHPCLG Provide contextual data to support the continued relevancy of policy and implementation strategies.</p> <p>EPA Supports monitoring and assessments activities including the preparation of characterisation reports and RBMPs. A key data source for the assessment of diffuse pressure in WFD sub-catchments (including transboundary effects). Supports assessment of the impact of human activity. Supports identification of pressures and impacts. Improved accuracy in reporting on the status of water bodies reducing risk of censure or legal action.</p> <p>Lead Coordinating Authority The interoperability of data (habitats data and data on cultivated and built land) will support efficiencies in licensing applications bringing time and cost savings. Facilitates public access to and provision of user friendly information on water bodies.</p>

³² Surface Water Regulations, 2012 (S.I. No. 327 OF 2012), Groundwater Regulations 2012 (S.I. No. 149 OF 2012), Waste Water Discharge (Authorisation) Regulations, 2007 (S.I. No. 684 of 2007)

Air Quality

Legislation	Requirements (in summary)	Existing constraint	Expected Benefit
Convention on Long Range Transboundary Air Pollution (CLRTAP) Directive on ambient air quality and cleaner air for Europe (2008/50/EC) and associated regulation³³	<p>The submission of pollutant inventories as well as the mapping of air pollutants (such as critical loads of nitrogen) nationally on a regular basis.</p> <p>The EPA manages the national ambient air quality monitoring network, maintains an up to date database on ambient air quality and produces air quality reports.</p>	<p>Gaps in spatial coverage and a lack of detail on land cover characteristics across the state can make it difficult to assess environmental linkages and to determine the impacts of human activity on air quality.</p>	<p>Supports more detailed analysis of environmental interactions and the effect of air quality on land cover and habitats.</p> <p>Allow for monitoring of land use changes over time and how these are linked to trends in air quality.</p> <p>Supports the mapping of critical loads of nitrogen and other pollutants to monitor impact on sensitive habitats.</p>

Flood Management

Legislation	Requirements (in summary)	Existing constraint	Expected Benefit
Floods Directive (2007/60/EC)	<p>Assessment of water courses and coast lines at risk from flooding.</p> <p>Flood risk assessment, flood hazard and risk maps, and flood risk management plans are prepared by the OPW in respect of the requirements of the Directive.</p>	<p>Difficulties in identifying flood vulnerable features within a catchment (particularly smaller features not picked up on by CORINE).</p> <p>Missed opportunities for flood retention.</p> <p>Inappropriate targeting of investment.</p> <p>Difficulties in analysing impact of land cover changes over time on flood risk.</p>	<p>Allow for the valorisation of vulnerable areas located close to flood zones.</p> <p>Provide important input to the preparation of flood risk management plans.</p> <p>Monitoring of changes over time supports enhanced understanding of impact of new or existing developments on flood risk.</p>

³³ Air Quality Standards Regulations 2011 (S.I No. 180 of 2011)

Pollution Control

Legislation	Requirements (in summary)	Existing constraint	Expected Benefit
EU Directive 2004/35/CE on environmental liability with regard to the prevention and remedying of environmental damage and associated regulation³⁴	<p>The EPA is also the competent authority for the Environmental Liability Regulations.</p> <p>The prevention and remediation of environmental damage.</p> <p>Places an obligation on operators to report incidents of actual or threatened environmental damage.</p>	Disparate sources of information on land cover make it difficult to see potential impacts of human activity (agricultural, industrial, development activity etc.) on species and habitats, particularly for the general public.	<p>The broad definition of 'environmental damage', covering water, land damage and damage to protected species and natural habitats means that information on a wide range of land cover, habitats and land use data is required in order to assess the status of a receiving environment and to investigate pollution incidents.</p> <p>In this regard, the potential range of land cover and use data held in national LCHM data product can support the EPA in its monitoring and enforcement actions.</p>

Climate Change

Legislation	Requirements (in summary)	Existing constraint	Expected Benefit
The UN Framework Convention on Climate Change (Kyoto Protocol, Paris Agreement) Associated EU and national legislation and policy³⁵	<p>Reduce concentrations of GHG in the atmosphere within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable sustainable economic development.</p> <p>EU wide objective of reducing greenhouse gas emissions by 80-95% by 2050 compared to 1990.</p> <p>Wide ranging measures under national mitigation and adaptation plans (national low carbon roadmaps and adaptation frameworks).</p>	<p>Potential risk of failing to include the full extent of carbon sinks within Irish managed ecosystems in the national assessment of progress towards meeting emissions reduction commitments.</p> <p>Failure to identify opportunities for effective climate adaptation measures (e.g. flood retention areas).</p>	<p>Assists the formulation of climate change adaptation and mitigation measures and targets by enabling a better understanding of land cover composition and the management processes and balance of considerations involved (habitats and land use etc).</p> <p>Provides baseline information to support tracking of mitigation measures to reduce GHG emissions (lands with potential to accommodate renewal energy schemes to advance progress for a national low carbon transition).</p> <p>Supports the identification of land that is best suited to delivering environmentally sustainable economic opportunities (balancing agricultural and land use requirements with climate change impacts).</p> <p>Improved accuracy in the assessment and reporting on carbon balancing (identification of potential carbon sources and sinks).</p>

³⁴ Environmental Liability Regulations, 2008 (S.I No. 547 of 2008)

³⁵ National Policy Position on Climate Action and Low-Carbon Development 2014, Climate Action and Low Carbon Development Act 2015, and forthcoming National Mitigation Plans.

Planning and Environmental Assessment Legislation

Legislation	Requirements (in summary)	Existing constraint	Expected Benefit
Planning and Development Acts 2000 to 2015 Planning and Development Regulations 2001-2013	These statutory instruments guide strategic planning processes such as the preparation of County and City Development Plans, and development control activities, such as planning applications for development.	The absence of national land cover datasets compromises the ability of national, regional and local plans to determine the most appropriate land use management strategies leading to sub-optimal land resource management or increasing the risk of land use conflicts occurring.	<p>By providing a national picture of the characteristics of land cover and land use in Ireland, the LCHM product will directly assist Irish planners in carrying out activities such as site suitability appraisals and the assessment of environmental impacts of a development (through EIA, SEA and AA).</p> <p>It will also provide an important resource for the preparation of County, City and Local Area Development Plans.</p>
Strategic Environmental Assessment Directive 2001/42/EC and associated regulations³⁶	To provide for a high level of protection of the environment and to promote sustainable development by contributing to the integration of environmental considerations into the preparation and adoption of specified Plans and Programmes.	<p>Misleading or inaccurate description of baseline conditions of land cover and habitats.</p> <p>Integrity and reliability of the entire assessment process compromised.</p> <p>Potential impacts on sensitive habitats might not be detected.</p>	<p>A key data gap will be addressed (baseline information on the environment i.e. land cover and habitats).</p> <p>Greater accuracy in the description of land cover conditions which will support a more robust assessment of the impact of a plan or programme on the environment.</p> <p>By supporting more effective SEAs, the programme will support improvements in environmental management and protection.</p>
EIA Directive (Council Directive 85/337/EEC as amended by Directive 97/11/EC and 2003/35/EC) and associated regulations³⁷:	<p>The assessment of the effects of certain public and private projects on soils, water, noise, air, climate, the landscape, flora and fauna, and the human environment.</p> <p>Basic stages of EIS: Screening, Scoping, Consultation, Consideration of alternatives, Description of development, Detailed assessments of existing environment, Assessment of impacts (construction and operation), Cumulative impacts, Formulation of mitigation measures, Residual impacts</p>	<p>Description of existing environment may not capture the full range of land cover, habitats and land use within a specific study area</p> <p>Potential 'in-combination' or cumulative impacts may not fully be appreciated.</p>	<p>Improved land cover and habitat data will support the private sector (environmental, planning and engineering consultancies) in all stages of the EIS process particular the assessment of existing environment and impacts.</p> <p>Supports the consideration of alternatives (site selection etc.), the scoping, identification and evaluation of cumulative effects, impact causation factors and impact interactions.</p> <p>Ex-ante potential risks can also be avoided with improved knowledge of baseline conditions.</p>

³⁶ Planning and Development (Strategic Environmental Assessment) (Amendment) Regulations 2011 (S.I. No. 201 of 2011)

³⁷ Planning and Development Act 2000 (as amended) and the Planning and Development Regulations 2001 (as amended) and is governed by the European Communities (Environmental Impact Assessment) Regulations.

Legislation	Requirements (in summary)	Existing constraint	Expected Benefit
The UN CBD Strategic Plan for Biodiversity 2011-2020	Integrate biodiversity values to national and local development, planning processes, poverty reduction strategies, national accounting and associated reporting systems by 2020 (Target 2).	Absence of national habitat datasets weakens the evidence base for inclusion of biodiversity values in national and local plans and strategies can be made.	With the standardisation of datasets and the benefits arising for comparability, trend analysis etc., it will be easier to assess the impact of national and local planning initiatives and policies, thereby supporting the achievement of Target 2.
EU Biodiversity Strategy to 2020 and associated national plans³⁸	<p>A dedicated framework that aims to address the main drivers of biodiversity loss and reduce pressures on the environment and ecosystems throughout the EU.</p> <p>Action 5 - Mapping and Assessment of Ecosystems and their Services</p> <p>National Biodiversity Plan (NBP) comprises strategic objectives for biodiversity management including the mainstreaming of biodiversity in decision making processes across all sectors.</p>	A national habitat map was one of the five key data gaps identified in terms of the management of biodiversity loss in the NBP.	<p>Supports effective responses to monitoring requirements on ecosystem services.</p> <p>Supports improvements in the knowledge base available for 'conservation, management and sustainable use of biodiversity' (Objective 2 of NBP); and, 'help identify opportunities to conserve and restore biodiversity and ecosystem services in the wider countryside' (objective 5 of NBP).</p> <p>Enhanced capacity to identify high value habitats (not only designated sites) will support the mainstreaming of biodiversity considerations in the planning process.</p> <p>Directly responds to the call for a national habitat map set out in the NBP. Allows for a greater understanding of habitats across administrative boundaries and encourages a more integrated approach to biodiversity management.</p> <p>Provides a useful basis for the development of the MAES framework in Ireland.</p>
EU Directive on the Conservation of Habitats, Flora and Fauna (92/43/EEC)	<p>The DAHRRG is the responsible agency. Key tasks include:</p> <p>Designation and monitoring of Special Areas of Conservation (SACs) and Special Protection Areas (SPAs).</p> <p>Reporting on status (extent and condition) of designated areas, and the national 'area of suitable habitat' available for protected species.</p>	Inaccuracies in reporting arising from poor spatial and thematic resolutions of existing LC and habitat data sources e.g. CORINE.	<p>A key data gap (national habitats) would be filled. This information on broad habitat distribution will assist the development of a better national monitoring sample of annexed habitats for enhanced spatial targeting of habitat surveying.</p> <p>More accurate assessment and reporting (e.g. by assisting in the identification and extent of suitable habitat for protected species on a national level).</p>
EU Directive on the Conservation of Wild Birds (2009/147/EC)	<p>Appropriate Assessment (AA)³⁹ of plans and projects:</p> <p>Consider the possible nature conservation implications of any plan or project on Special Areas of Conservation (SACs) and Special Protection Areas (SPAs)</p> <p>Consideration of in combination effects of a plan or project with other plans and projects.</p>	It can be difficult to identify potential pathways (e.g. water courses) that would link a development proposal to an SAC or SPA.	<p>The NLCHM product will offer a helpful resource to support private individuals and professionals in undertaking AA screening.</p> <p>Public sector bodies responsible for preparing spatial development plans also have responsibilities to assess the impact of the plan on SPAs and SACs by way of AA.</p>

³⁸ National Biodiversity Plan (NBP), Actions for Biodiversity 2011-2016

³⁹ Article 6(3) and 6(4) of the Habitats Directive

Landscape

Legislation	Requirements (in summary)	Existing constraint	Expected Benefit
European Landscape Convention and associated national strategy: The National Landscape Strategy (NLS)	<p>The protection, management and planning of European landscapes and coordinates European cooperation on landscape issues.</p> <p>Principles to protect and enhance the landscape, and support sustainable landscape change and a public process of gathering, sharing and interpreting scientific, technical and cultural information in order to carry out informed evidence-based National Landscape Character Assessment.</p>	<p>Absence of complete information on the characteristics of the land cover presents a serious impediment to the preparation of a National Landscape Character Assessment.</p>	<p>Directly informs the National Landscape Character Assessment and will assist in the identification and resolution of landscape related challenges e.g. in relation to the siting of critical infrastructure.</p>

Public Participation in Decision Making

Legislation	Requirements (in summary)	Existing constraint	Expected Benefit
Aarhus Convention and related Directives⁴⁰	<p>Three pillars dealing with access to information, public participation in decision making, and access to justice.</p> <p>Public authorities are obliged to make available and actively disseminate environmental information that will support public participation in environmental decision-making.</p>	<p>Limited public access to land cover information compromises the ability of members of the public to make informed submissions on plans/projects that may affect them.</p>	<p>The freely accessible data model proposed will strengthen public accessibility to information - supporting the public in actively engaging in decision making processes.</p> <p>For example, members of the public wishing to comment on planning applications that may affect the integrity of a conservation site might wish to access the data series to explore potential impacts of the development on specific types of land cover. In turn this information can be used to inform a submission or observation to the Planning Authority or An Bord Pleanála on the project.</p>

⁴⁰ The Access to Information pillar has been implemented in the EU Directive 2003/4/EC on Public Access to Environmental Information, and in Ireland by the European Communities (Access to Information on the Environment) Regulations 2007-2011. Public participation in decision making pillar has been implemented in the EU by Directive 2003/35/EC on public participation ('the Public Participation Directive'). The 'access to justice' pillar is implemented in Ireland through a number of pieces of legislation including the Environment (Miscellaneous Provisions) Act 2011.

Rural Development, Agriculture and Food

Legislation	Requirements (in summary)	Existing constraint	Expected Benefit
Rural Development Regulation 2013	The Rural Development Programme 2014-2020 (implements the Regulations) introduced GLAS, an agri-environment scheme operated by the DAFM. Aligns with the green vision for Irish agriculture committed to in Food Wise 2025 and promoted by Bord Bia in the Origin Green campaign. Establishes different rates of payment for Natura 2000 sites (SPAs and SACs).	Potential inaccuracies in the extent of environmentally sensitive land.	Potential to facilitate spatial targeting (and at different rates of payment) and would allow for recording of impact on these areas.
Decision No. 529/2013/EU Accounting of Agricultural & Forestry related emissions	Accounting of emissions produced by land use, including the management of wetlands, croplands, and grasslands. Changes in agricultural and forested areas will need to be accounted for annually. Mandatory reporting on different aspects of land management including forestry, crop and grazing after a period of improving systems, and voluntary reporting from wetland management.	Without accurate knowledge on land cover type and condition, it is difficult to carry out accurate accounting of emissions and progress on achieving GHG reduction targets.	Will support the tracking of changes in relevant land cover types thereby assisting accounting and reporting requirements.
Food Wise 2025⁴¹	A strategy to guide the growth of the agri-food and fisheries industries through 2020 Embraces the concept of sustainability and environmental protection. Identifies over 400 recommendations to achieve sustainable growth within the sector including 'Measurement of Ireland's environmental sustainability credential'.	Absence of national land cover and habitat datasets compromises the ability to identify potential linkages between agricultural practices and vulnerable landscape features e.g. undermining the recommendations of the strategy in terms of environmental protection.	A trustworthy information source on that status and condition of land cover and habitats in Ireland will support the identification of LULC types that could be prioritised for agri-food purposes. Identifying patterns in land management practices, and changes in practices over time, can assist in monitoring and measuring natural resource conditions, which will bring opportunities for the agri-food sector. Contextualises and support the availability of verifiable land cover, habitat and land use activity data which will assist the measurement of environment sustainability

⁴¹ Department of Agriculture, Food and the Marine (2016) 'Food Wise 2025 – A 10-year vision for the Irish agri-food industry'. Available at: <https://www.agriculture.gov.ie/media/migration/foodindustrydevelopmenttrademarkets/foodwise2025/report/FoodWise2025.pdf>. Accessed 16.06.16

4.0 Cross Sectoral Applications for the National LCHM Programme

4.1 Overview

Improved information on land cover and habitats will have widespread benefits for a multitude of cross-sectoral users. This section describes some of the ways in which the programme can bring benefits to a range of sectors, as illustrated below.

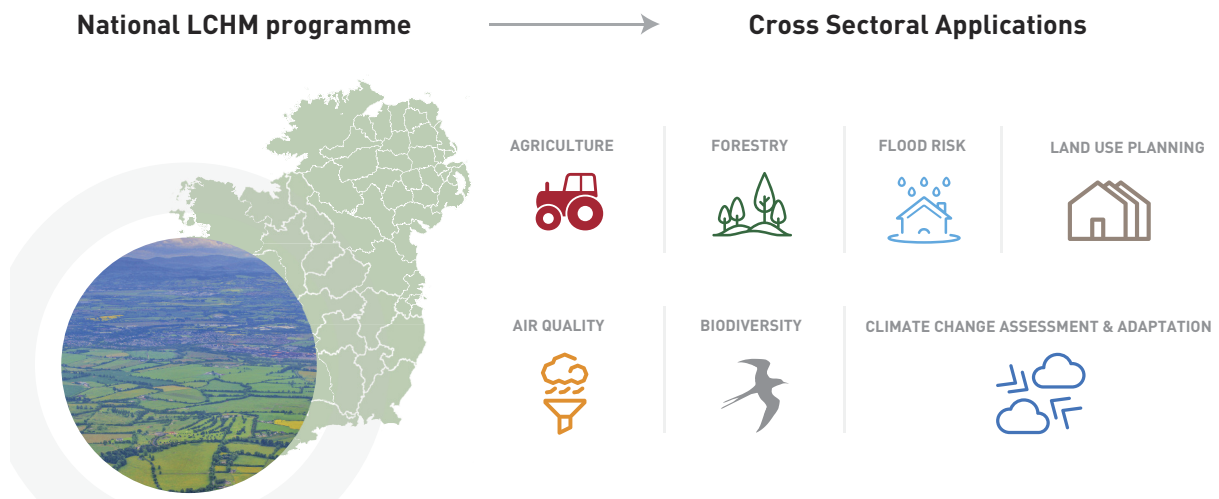


Figure 8: Cross Sectoral Applications

Applications for scientific research and education are also referenced. It should be noted that these are **representative applications** only and do not constitute the full range of cross-sectoral applications that the national LCHM programme will enhance substantially.

The applications and benefits described in Section 4.2 have been largely informed by consultation carried out with professionals working within each of the sectors referred to above.

While the value of individual datasets was recognised, it is the combination of datasets proposed under the programme, encompassing land cover, habitats and land uses that has the most significant appeal to professionals. This reflects the complexity of the natural and built environment and the fact that no single element of the landscape stands in isolation or occurs without interacting with surrounding features. As such, the relationships between different features of the landscape (both natural and built) tend to be of general interest to almost all of the professionals engaged with as part of this study.

A full list of professionals spoken to for the purpose of this report is provided in Appendix 2.

The general overview of sectoral applications in Section 4.2 is followed by three use case examples showing how the programme can support the effective delivery of national and regional strategies in the areas of land use planning, climate action and flooding.

Furthermore, a series of hypothetical scenarios have been prepared to demonstrate the potential applications of the national LCHM programme across a range of sectors. These are provided in Appendix 3. Each use case includes a summary of the risk(s) of maintaining the status quo and the benefits of applying the proposed national LCHM programme.

4.2 Cross sectoral applications

4.2.1 Agriculture

A trusted, accurate and consistent dataset on land cover will have multiple applications for the agricultural sector and will facilitate more informed decision making across a range of regulatory, policy and strategy fields. Discussions with agricultural sector stakeholders including representatives from the Department of Agriculture, Food and the Marine (DAFM) and Teagasc highlighted several potential applications areas, a brief selection of which are presented below:

- i. Facilitates more informed policy and decision making to ensure that agricultural impacts on areas of valuable habitat are minimised or avoided. For instance, habitats and water resource data will support the spatial targeting of agri-environmental policy (especially in the area of eco-agriculture). It will also help to direct biodiversity protection supports and other environmental support measures. This will bring new opportunities for cost savings with, for example, incentives being directed to help protect semi-natural habitats in a manner acceptable to landowners and compatible with farming objectives.
- ii. Improves capacity to combine information on current land use, land use intensity and the presence of areas of high environmental value or vulnerability.
- iii. Supports greater understanding of the relationships between farming activities and carbon sequestration. This will have benefits for regional and national monitoring of programmes in this area, and will also inform scientific research in areas such as climate change.
- iv. Assists in the identification of rural diversification needs or opportunities by supporting agri-productivity analysis and assessment of the feasibility of converting from one farm enterprise to another.
- v. Offers an additional resource to the DAFM to supplement the LPIS spatial dataset and can potentially be used to support the assessment of eligibility for payments for ecosystem services (PES).
- vi. Offers potential to act as a supporting tool in monitoring the health of crops.
- vii. Helps to identify agricultural activities that present a pollution risk e.g. from poor livestock management, and fertiliser/slurry application (thereby contributing to more effective pollution control and nutrient management).

4.2.2 Forestry

The national LCHM programme will have significant benefits for the forestry sector in the implementation of regulatory, policy and strategy requirements. One of the principal benefits results from the capacity of the proposed programme to capture land cover and forestry change through the provision of consistent, time series mapping. From discussions with the Forest Service and other stakeholders, a number of applications for the sector were identified, as summarised below:

- i. Facilitates the monitoring of land cover and land use change on a consistent basis helping to

inform site suitability assessments for tree planting programmes and to identify potential land use conflicts.

- ii. Information on land cover will assist the Forest Service in the attainment of the Sustainable Forest Management and in identifying and monitoring forestry activities that may present a potential risk of pollution, for example, timber harvesting (contributing to more effective risk management through pollution control and nutrient management).
- iii. The identification of potential pollution risks will also assist the targeting of appropriate protection and mitigation measures to safeguard the ecological value and integrity of forests.
- iv. Assists in establishing the ecological value of potential afforestation sites within the wider land cover and habitat context. This will help with the identification of ecological important habitats or species on specific sites that should not be forested. Of particular use, would be the availability of habitat mapping for areas of semi-natural grassland and heath habitats, areas for which proposals for afforestation are often submitted to the Forest Service.
- v. Helps to determine the optimal use and potential value of particular sites e.g. as productive forests, or in performing important environmental functions such as protecting water quality with riparian woodland.
- vi. Assists the Forest Service in meeting Water Framework Directive legislative requirements, particularly those relating to biodiversity and environmental protection.
- vii. Assists in the identification and delineation of deforestation areas.
- viii. Assists the forestry sector in attaining a more consistent national landscape management approach.

4.2.3 Flood risk management

Climate change is increasing the intensity of rainfall events with the result that more areas, and more homes and infrastructure, will be vulnerable to sudden rises in sea and river levels, and subsequently, at risk of flooding. Effective flood risk management is a concern for farmers, critical infrastructure operators, home owners, businesses, developers, the insurance industry and those with responsibility for planning and land use management.

A selection of the potential ways in which the national LCHM programme can inform work carried out in the area flood risk management are set out below. These have been informed by discussions with representatives of the DHPCLG, OPW, Irish Water and Waterways Ireland.

- i. The type of land cover that exists in a given area determines the volume and rate at which water finds its way into rivers. The landcover and habitat datasets will help to correctly define the spatial characteristics of river catchments which is required for the next iteration of the OPW's Flood Studies Update Programme. Finer detail on land uses such as forestry, pasture, peatlands, wetlands, urbanised areas and lakes will support greater accuracy in flood estimation. Flood data can be cross referenced against land cover, habitat and land use datasets to support more effective vulnerability analysis for areas prone to flooding. This has benefits for key elements of flood risk management strategies such as hydrographic modelling, the preparation of Physical Catchment Descriptors (PCDs - numerical representations of the proportion of each type of land cover within a catchment used for flood estimation), and for preparation of predictive flood maps prepared under the Catchment Flood Risk Assessment Management (CFRAM). In turn, this will support the design of flood relief

measures, flood forecasting, design of road bridges, culverts and predictive flood mapping.

- ii. More detailed information on the location of smaller features and the composition of land use categories than influence run-off, for example, the extent of actively worked and drained peatlands, worked degraded bog, bog woodland, intact and pristine bog as well as fens. The first of these will rapidly discharge water to rivers, whereas other categories variously retain additional water or, in the case of pristine bog, are saturated with limited capacity for additional retention.
- iii. The identification of human and environmental receptors at greatest risk - homes, community facilities, critical infrastructure, areas of conservation or heritage value, offers value in terms of planning, mitigating for and responding to flood events. This will bring efficiencies in flood risk management and will deliver cost avoidance in terms of inappropriate singular interventions, damage to property and wider societal implications.
- iv. Supports prioritisation and targeted investment of flood prevention and control measures. For instance, the identification of locations that could act as percolation areas, or for the retention of water using upstream catchment management or wetland creation.
- v. The freely accessible data framework for the national LCHM programme will support information sharing and in turn enhanced coordination between responsible agencies, the public and emergency services. This will have benefits for flood preparation, response and recovery and will strengthen resilience to flood events.
- vi. Supports Planning Authorities and developers in terms of guiding the siting of specific developments to avoid high vulnerability areas.
- vii. Provides important input to the design of Sustainable Urban Drainage Systems (SUDs). This typically involves the identification of suitable areas within or in the vicinity of urban areas that can allow for the percolation or retention of water e.g. low-lying areas of urban parks or other green spaces. Effective SUDs requires a thorough understanding of the relationship between such areas and the locations where damage could be experienced.
- viii. The convenience of having an easily accessible online data series for land cover and habitats in Ireland will also support cross border cooperation and interoperability between management plans prepared by the OPW and its equivalent body in the north, the Rivers Agency of Northern Ireland.

4.2.4 Land use planning

Planning is concerned with balancing physical development against wider societal, environmental and economic needs. Any mechanism by which the characteristics and interactions of land cover and land use can be better understood will have widespread benefits for the planning process.

People involved in land use planning, who engaged with this research included academics in the field of regional and urban planning (UCD, DIT and UCC), DHPCLG, Local Authority and private practice planning professionals. Discussions with these stakeholders helped to identify ways in which the proposed national datasets can be used to support planning professionals, as briefly described below:

- i. Supports analysis of the suitability of development strategies and proposals in terms of the wider environmental context (surrounding land cover, habitats and uses) e.g. as part of EIA or AA. This will help to identify incompatible land uses and potential conflicts between proposals and the natural environment.

- ii. Assists spatial planners in the assessment of the impacts of development on habitats and other sensitive land cover areas across county boundaries. This will have important strategic benefits in terms of informing the development of regional and national planning policy, and assessing the contribution to sustainable development.
- iii. Statutory documents such as Development Plans, Local Area Plans and Local Economic and Community Plans all use mapping in order to illustrate the policies of the planning authority. Reliable information on land cover and land use will deliver greater detail and accuracy to existing mapping and analysis processes.
- iv. Provides a robust evidence base to demonstrate the rationale and integrity of policies and objectives set out in Development Plans at a regional and county level.
- v. The availability of regular time series data will support the assessment of progress on achieving planning policy objectives and targets. For instance, it might be possible to assess the extent to which objectives and targets for green infrastructure have been achieved. The capacity to review past trends in land use and landcover management will also provide an evidence base for future land management programmes.
- vi. Provides an important information base for the SEA of plans and programmes.
- vii. Supports planning and investment decisions in relation to site selection for critical national infrastructure developments for transport, water services, housing, energy, communications and waste management. For example, organisations such as the National Transport Authority could use the mapping system to assist in the planning and delivering of public transport services, particularly where these are being organised and distributed across different providers, so that individual operators can all work off common datasets.
- viii. The opportunities extend to a full range of infrastructure and utility providers, supporting the careful planning and design of projects, for example, routing pipelines or roadways so that sensitive areas are avoided. For instance, Irish Water could use this extensive national land cover dataset in the planning of large drainage projects requiring pipeline works. A detailed land cover dataset that displays habitat types and land uses over a large area would greatly support the route selection and scoping stages of these types of infrastructure projects.
- ix. Provides a stronger evidence base for investment decisions on land acquisition by presenting a more comprehensive representation of the characteristics of an area, thereby enhancing awareness of potential sensitivities occurring within specific areas.
- x. Provides input to due diligence assessments of specific sites. It could be used to identify the best locations for drainage or greenspaces within an area and can assist in identifying vulnerable areas of a site that might be prone to flooding. Improved habitat data can be used to identify impact pathways such as invasive species, or habitats at risk. It could also provide additional data to determine the cause of an impact. For instance, the impact of air emissions on vulnerable habitats could be more conveniently assessed.
- xi. Provides a mechanism to green infrastructure (GI) planning. GI planning is concerned with improving how the built and natural environment work together for mutual benefit and the national LCHM programme will support this.
- xii. Supports the integration of habitat and biodiversity information such as ecological corridors and areas supporting protected species, as a consistent layer in the planning process such as, for example, in the formulation of land use zoning objectives. This will support a more holistic approach to safeguarding the natural environment and will help to meet environmental statutory obligations described in Section 3.2.

- xiii. Reduces the risk of important information being overlooked in the assessments (such as SEA, EIA or AA) of development strategies or proposals, such as severance of sensitive habitats. Natural elements of the landscape which provide for ecosystem services in the form of flood protection, good water quality, biodiversity, storm and erosion protection, amenity and climate regulation, can be identified and protected within strategic spatial planning. This can allow new built development to make best use of available land and to proceed with minimal environmental impact.
- xiv. For those involved in the area of spatial planning research, the mapping system will support more in-depth contextualisation of the land cover and land use interactions that affect sustainable development e.g. the impact of one-off rural housing on habitats. It will enhance understanding of the impact of planning policies which will in turn support more effective policy making.
- xv. There is also strong potential for the Programme to act as a learning resource for training spatial planners at all levels (undergraduate, postgraduate) and policy makers. In particular, it can demonstrate the complexities of land use management, and the balance required between different attributes of land cover and land use in pursuit of proper planning and sustainable development.

4.2.5 Air quality

The availability of improved land cover and habitat data can be used to support greater understanding of air quality and air pollution. A selection of the environmental and public health benefits pertaining to the area of air quality are set out below. These have been informed by air quality experts from the DHPCLG and the EPA consulted with as part of this study.

- i. Supports the identification of air pollution sources, the analysis of plume dispersal modelling of pollution incidences, and how this relates to the characteristics of land cover within the plume dispersal area. In combination with meteorological information and socio-demographic data, this information can be used to demonstrate the risk to public health, to crops, to building fabric or to water bodies.
- ii. The impacts of air pollution, in particular nitrogen deposition such as ammonia from agriculture, are increasingly being understood through interdisciplinary biodiversity and atmospheric research. Indeed, parties to the Convention on Long-range Transboundary Air Pollution (CLRTAP) are requested to submit maps showing critical loads of nitrogen by grid on a regular basis to assess the impacts that air pollution is having on sensitive habitats. The national LCHM map will directly support efforts in this area.
- iii. With the proposed integration of future land use data sets to the national LCHM programme, emissions hot spots such as congested road networks can potentially be cross referenced with point data for pollution sources, supporting enhancements in monitoring, modelling and the forecasting of air quality in Ireland. In turn, this may have positive applications for scientific research and for wider areas such as public health, the identification and care of vulnerable people as well as transport policy.

4.2.6 Climate change mitigation and adaptation

As part of this research study, climate researchers from leading universities were spoken to. It became

apparent from these discussions that there are multiple opportunities for the national LCHM programme to further inform research on climate change and adaptation measures,

- i. Biodiversity, agriculture, flood risk management, forestry and land use planning datasets amongst others are routinely used to inform climate research. The programme will support climate adaptation and mitigation initiatives by enabling the assessment of baseline conditions on the above land cover types, and by enabling changes on these land cover areas to be analysed over time. For adaptation, national land cover and habitat data can be used to identify the location of populations or heritage at risk from climate change effects. This will support the design and targeting of measures to strengthen resilience, for instance through the use of flood plains, catchment management, the recreation of wetlands or coastal realignment. For example, an EPA funded research project coordinated by the Environmental Research Institute of UCC, '*The Climate Information Platform for Ireland (ICIP)*'*, is using spatial data to assist Local Authorities and other stakeholders to adapt to climate change in their local areas.
- ii. Supports the identification of land forms that are capable of sequestering carbon from the atmosphere such as forests and peatlands (and support monitoring requirements under the Climate Action and Low Carbon Development Act 2015 referred to earlier). This will facilitate a more accurate overview of national carbon stocks supporting a robust assessment of greenhouse gas emissions and removals.
- iii. Supports research on the management of the decarbonisation of Ireland's energy resources. It will help to define the location for deployment of land extensive renewable energy systems on areas of marginal or suboptimal agricultural value. This has potential to augment the incomes of the operators of that land, while diversifying the manner in which renewable energy is generated in Ireland. For example, the potential income arising from the deployment of such infrastructure is appealing to land owners, such as farmers, as a viable means for diversification and as a safeguard against the volatility of the agricultural commodities market.
- iv. Higher resolutions would enable the fine tuning of land cover changes (e.g. land use) within climate modelling and thus inform scenarios on future climate change. For example, changes in extent and type of habitat may help to identify habitats that are vulnerable to change under future climates.
- v. Helps to identify risk factors (e.g. in forestry, the likely dispersal pattern of pest species) and allow for remediation action to be taken in advance (e.g. changing tree stock type, appropriate use of pest control measures, etc.).
- vi. Facilitates improved understanding of the interrelations between topography, storm events, storm surges, flooding or water deficit.
- vii. In time, the potential opportunity to add other datasets such as the Building Energy Rating (BER) of structures, the energy supply of dwellings, modes of transport etc. will bring further applications for climate research.
- viii. Adaptation measures require a multi-disciplinary approach across sectors such as engineering, science and land use planning. In this regard, the availability of a shared national resource on land cover and habitats will support improvements in information sharing across the climate research

* The Climate Information Platform for Ireland (2016) 'Climate Adaption Tools'. Available at: <http://www.climateireland.ie/climateinfo/about.html>. Accessed 17.04.2016

- ix. Provides a stronger scientific basis for climate change research. More accurate data on land cover types such as cultivated and built land will contribute to enhanced understanding of the impacts of climate change on areas such as agricultural productivity, biodiversity change, groundwater vulnerability, flooding and forestry vulnerability (e.g. which forests are vulnerable to pest/disease attack, where will exogenous pests (pine weevils), enter Ireland and where are they likely to spread).

4.2.7 Biodiversity applications –habitats and species

The enhanced understanding of the location and status of habitats and species deriving from a national mapping programme will aid the design of more effective biodiversity policies and their integration with other land use demands and pressures.

The DAHRRG, Bat Conservation Ireland, Irish Water, Teagasc and other independent researchers were spoken to as part of this study. These discussions highlighted myriad ways in which the national programme, (particularly the availability of a national habitat map but also the provision of information on wider land cover and land use context,) can be used to support applications in the biodiversity field. A selection of the most pertinent of these are summarised below:

- i. The contextualisation of habitats will support sensitivity mapping exercises to identify vulnerable areas and species, and their interaction with other land cover types and uses. By combining information on vulnerable receptors of conservation or amenity interest with wider land cover information, for example, high flood risk areas, new opportunities will arise for biodiversity management.
- ii. Enables the tracking of change occurring within the landscape which will help to determine the extent of habitat loss and degradation over time and arising as a result of environmental damage e.g. pollution or fire incidents. In this way the resilience of habitats can be better understood. It will also be easier to analyse the response of habitats and species to changes in management and biodiversity monitoring programmes. The availability of regularly updated mapping at a finer scale showing linear landscape features such as hedgerows, will further enhance the modelling and monitoring of change to key habitats and species at a national, regional and local scale.
- iii. The availability of national habitats information will fill a key data gap for ecologists and other professionals that need to consider impacts on habitats, such as land use planners. The focus on national habitats (and not just annexed habitats) will greatly enhance the information base to support the preparation of Local Biodiversity Plans (at a Local Authority level), the National Biodiversity Plan, sectoral Biodiversity Plans and other plans such as the National Peatland Strategy. The consistent spatial and thematic resolutions will also enable greater integration between plans at local and regional levels and cross-county coordination for management plans.
- iv. Provides a mechanism for information sharing between ecologists and other professionals involved in land management. This will support a greater understanding of the interactions between biodiversity and land use planning, flood risk management and climate change.
- v. Supports greater integration of biodiversity considerations to planning processes by making it easier to identify potential conflicts between land use zonings and development proposals. Furthermore, planning assessment processes such as EIA, SEA and AA will all benefit from the availability of the proposed national LCHM programme.

- vi. Helps build an evidence base to promote the value of ecosystems services and to support economic assessments of the importance of biodiversity.
- vii. An enhanced capacity to understand the implications of climate change impacts and other pressures such as development activity, on species count and distribution.
- viii. Supports the identification of potentially suitable ecological networks for species migration and connectivity, including the movement of invasive species. It will also facilitate the analysis of relationships between habitats at different locations and the identification of supporting physical or ecological systems, for example, water courses or connecting habitats. Environmental management is increasingly reliant on thorough statistical analysis to identify ecological relationships and to determine where expenditure would be most effective. In this regard, knowledge of the location of valued habitats and species, and of the links and interactions between them, will permit the State to meet its obligations in relation to the Habitats Directive.
- ix. Supports efficiencies in the spatial targeting of surveys/field assessments carried out in support of scientific research or as part of development projects. It will also enable improvements in the interpretation of biodiversity data, and will support preparation for field survey work and analysis by ecologists and biodiversity researchers.
- x. Supports the preparation of a better national monitoring sample than that which is currently available. This can be used to support more efficient preparatory work in advance of a field survey. For example, if an agency such as the DAHRRG wishes to carry out a baseline national fen survey, it can refer to the national habitat map as a reference to help narrow down the areas potentially supporting fen habitats. This would remove the current laborious process of having to manually collate and review scientific publications, individual local authority habitat surveys, previously carried out ecological surveys, as well as reviewing coarser data sources such as LPIS and CORINE.

4.2.8 Applications for research and educational purposes

From a research perspective, spatial data is enormously beneficial. The introduction of a national LCHM programme will provide a stimulus for many areas of environmental research in Ireland – providing a ‘data tsunami’ on the Irish landscape. The enriched capacity for understanding and monitoring changes in our national land cover will greatly contribute to a more competitive research environment in Ireland, and will bring new opportunities for scientific research and our capacity to respond to international and European research calls and to compete for funding under EU programmes such as Horizon 2020 (this pertains to both the public and private sector).

There is also a use for the national LCHM programme to act as an educational resource to encourage a greater appreciation of the value of geospatial information. The freely accessible data model proposed for the programme will allow its use as part of teaching programmes not only at university level, but also as a resource for primary and secondary level schools. It was suggested by one leading climate expert interviewed as part of this study that it would be useful for mapping tools to be more integrated into teaching programmes, as if students were aware of the different tools, they will continue to use them in their professional careers. In turn, this will fuel future demand for such tools, supporting the growth and development of the wider geo-spatial industry in Ireland

4.3 Use Cases

Three use case examples have been prepared to demonstrate the value of the proposed national LCHM programme to national policy commitments in the areas of planning, climate change and flood risk management.

1. The forthcoming National Planning Framework

A new National Planning Framework (NPF) is currently being prepared to succeed the National Spatial Strategy (NSS). The NPF will be a long term, 20-year strategic planning and development strategy for Ireland. It offers huge opportunities for addressing significant challenges currently facing the country, such as the housing crisis, and for quality of life, economic growth and a high quality environment.

The NPF will set out an overarching planning policy for the country. As such, key issues that feature in the NPF will be reflected at regional and county level in the forthcoming Regional Spatial and Economic Strategies (RSES), and in County Development Plan (CDPs) and Local Area Plans (LAPs).

As described in *'Towards a National Planning Framework'*⁴², the NPF will identify national **strategic development requirements** for the growth of and investment in cities, towns and rural areas. This will involve the identification of **national infrastructure priorities** including transportation, water services, waste management, communications and energy networks and the provision of housing, educational, healthcare, retail, cultural and recreational facilities.

The national LCHM programme proposes sub-classifications for cultivated and built land which include arable land, horticulture, buildings, artificial green surfaces and roads, ways and other infrastructures. The availability of this type of information will provide a 'big picture' of national land cover, which can be used as an important supporting resource and evidence base for the identification of national developments and national infrastructure within the NPF. The ability to view the locations of existing infrastructure across county and regional boundaries in combination with population centres, and areas of natural land cover, including habitats and sensitive landscapes, will directly support decision making on the spatial planning of national development and infrastructure priorities in all of the areas mentioned above.

The NPF will promote **sustainable settlement and transportation strategies** in urban and rural areas. The **reduction of greenhouse gas emissions** will also be addressed alongside an emphasis on **climate change adaptation measures**.

⁴² Department of Environment, Community and Local Government (2015) 'Towards a National Planning Framework, A Roadmap for the delivery of the National Planning Framework 2016'. Available at: http://www.housing.gov.ie/sites/default/files/publications/files/towards_a_national_planning_framework_december_2015.pdf. Accessed 18.04.2016

The national LCHM programme will become an important resource for gathering baseline information as national, regional, and local planning authorities seek to integrate these measures into regional and local development plans. For example, land parcels with inherent capacity for carbon sequestration can be identified and protected, and areas of high population density situated within catchment zones prone to flooding can be earmarked as target areas for flood defences. The availability of consistent, high resolution national land cover information will also support decision making on investments and the most appropriate distribution of resources. Furthermore, the availability of time series data on specific land cover classifications will make it easier to identify changes occurring within the landscape that can be attributed to climate change, helping to build a robust rationale for decision making.

The NPF will also contain commitments for **conservation of the environment and its amenities**, including the landscape and archaeological, architectural and natural heritage.

Effective conservation planning involves the identification of issues (both positive and negative) that might influence natural or built heritage sites. For this, a comprehensive body of information on all land cover types is essential in order to identify critical interactions between land cover types, and to determine the risk of conflicts arising between new land use development proposals and the conservation objectives of protected sites.

Another key issue likely to feature strongly in the NPF⁴³ is the coordination of development between the **terrestrial and marine sectors** taking account of the provisions of the EU Marine Strategy Framework Directive and a future Maritime Spatial Plan.

As described in Section 3.1, the national LCHM programme offers a major opportunity to support ICT enabled public sector innovation, providing a mechanism for cross-agency collaboration and information sharing.

The NPF will also seek to address the *'need for greater emphasis on environmental matters such as climate change and sustainability, as informed by European Union legislative requirements'*⁴⁴, many of which are described in Section 3.2 of this report. Furthermore, second and third tier planning strategies, including the RSES, to be prepared by the three Regional Assemblies in tandem with the preparation of the NPF, will also need to integrate these environmental requirements and considerations. In this regard, an overview of the value offered by the national LCHM programme to national, regional and local plans is set out on the following page.

⁴³ Ibid (p4)

⁴⁴ Ibid (p4)

Environmental requirements	NPF	RSES	CPD	LECPs ⁴⁵	LAPs	Role of the national LCHM programme
Strategic Environmental Assessment	✓	✓	✓	✓	✓	<p>Baseline information on habitats will provide direct input to the SEA process, helping to identify connections between important environmental attributes that might be impacted on by the proposed objectives of the plans.</p> <p>This will lead to a more effective SEA process and the formulation of appropriate protection measures to safeguard the environment.</p>
Appropriate Assessment	✓	✓	✓	✓	✓	<p>Potential linkages to designated sites (SPAs and SACs) can be more easily identified where high resolution national land cover and habitat information, such as ecological corridors between development zones and conservation areas, is available. This will inform AA Screening of plans and full assessment, where required.</p> <p>Full knowledge of the nature of land cover and habitats is essential to accurately determine flood risk, and ensure that this is reflected in the SEA and in turn, in the policies and objectives of plans.</p>
Flood Risk Assessment⁴⁶	✓	✓	✓	✓	✓	<p>The nature of flood risk requires a coordinated approach as, for example, the area affected by coastal or river flooding of an extensive floodplain often crosses county and regional boundaries. As a freely available national resource, the LCHM programme will offer a shared information base supporting more effective coordination and consistency between national, regional and local development plans. It will support more efficient communication between planning bodies and statutory consultees, such as the OPW.</p>

The benefit of having a shared information base will also support efficiencies in terms of the linkages between environmental obligations such as SFRA, SEA, and AA, which should be mutually reinforcing in nature, and ultimately the integration of environmental considerations within planning policy frameworks. It will also make it easier to identify actions that offer dispersed benefits, for example, the provision of green infrastructure within urban areas, has potential benefits for flood management, recreation and amenity and biodiversity. Where multiple benefits are apparent it will be easier to justify investment decisions.

⁴⁵ Local Economic and Community Plans (LECPs)

⁴⁶ Flood risk assessments are often integrated with the SEA process

The provision of a shared national information base on land cover and habitats will also support coordination between planning policy and wider environmental policy initiatives such as the National Landscape Strategy, the forthcoming Maritime Spatial Plan and climate change adaptation strategy. Opportunities to integrate the measures contained in these plans, for example, Landscape Character Assessments, as an integral part of planning policy objectives and zonings designations, will be more clearly identifiable where accurate, high resolution data is available on the characteristics of land.

2. The Climate Action and Low Carbon Development Act 2015

The Climate Action and Low Carbon Development Act 2015 is Ireland's first ever dedicated climate change law. It provides the legislative basis on which measures to reduce and mitigate greenhouse gas emissions and to adapt to the impacts of climate change will be pursued. Specifically, it introduced a requirement to produce and implement five-yearly National Mitigation Plans, and to prepare a National Adaptation Framework (also on a five-yearly basis) for climate change resilience.

The National Mitigation Plan

The first National Mitigation⁴⁷ Plan is currently under preparation. The plan will outline a series of measures to reduce greenhouse gas emissions (GHG) and to enable a transition to a low carbon, climate resilience and environmentally sustainable economy by the end of the year 2050. It will set out measures to track progress in the area and will propose measures for implementation in the longer term. The measures will be tailored to address specific challenges facing a range of sectors including agriculture, transport, and the built environment.

The land cover and habitat data outputs of the national LCHM programme can be used as an important information resource to inform the development and implementation of GHG mitigation measures. Furthermore, as the plan will be reviewed and updated every 5 years, it also offers potential to assess progress on the implementation of measures and their contribution to the low carbon transition objective.

The National Adaptation Framework

The Act provides a statutory basis for the development of National Climate Change Adaptation Frameworks⁴⁸ (the first of which is currently under preparation) and Sectoral Adaptation Plans (also under preparation). Adaptation plans **including measures to cope with or minimise the impact of climate change** will be required across different sectors and by local authority areas in order to reduce Ireland's vulnerability to the negative effects of climate change.

The land cover and habitat data outputs of the national LCHM programme can inform the identification of adaptation options, in particular cost effective green or sustainable options. The data outputs will assist in the assessment of climate risk for many sectors: agriculture, biodiversity, forestry, built environment, transport and critical infrastructure. Furthermore, as the plan will be reviewed and updated every 5 years, it also offers potential to assess progress on the implementation of measures and their contribution to effective adaptation.

⁴⁷ Definition of 'mitigation' under the Act: Any human intervention aimed at reducing harmful influences on the earth's climate system, including actions aimed at reducing emissions and creating or enhancing sinks.

⁴⁸ Definition of 'adaptation' under the Act: Adaptation means any adjustment to -

- (a) any system designed or operated by human beings, including an economic, agriculture or technological system, or,
- (b) any naturally occurring system, including an ecosystem,

that is intended to counteract the effects (whether actual or anticipated) of climatic stimuli, prevent or moderate environment damage resulting from climate change or confer environmental benefits.

Mitigation measures to reduce GHG emissions, and adaptation measures to enhance resilience to climate change impacts, are complementary and mutually reinforcing in the reduction and management of climate change risk. Central to both approaches at the local level is an understanding of vulnerabilities and options for mitigation and adaptation actions.

An overview of the potential contribution of the national LCHM programme to the planning, design and delivery of sectoral measures within the forthcoming National Mitigation Plan and National Adaptation Framework is provided below. The programme outputs have huge potential too for sectoral and local level decision making in this field.

Sector	Role of the national LCHM programme in sectoral mitigation and adaptation measures
Built Environment	<p>Mitigation: Future GHG emission pathways generated by activity in the built environment can be more successfully identified and mitigated where full knowledge of land cover (including developed land uses) is available.</p> <p>Pro-active mitigation action can be supported by using data from the national LCHM programme to inform planning and development processes (e.g. site selection) for projects to reduce society's reliance on fossil fuels, e.g., renewable energy schemes.</p> <p>Adaptation: Successfully adapting to climate change requires careful planning and development of new land uses in order to avoid areas vulnerable to climate change impacts such as flooding, sea level rise, coastal erosion. Improved land cover and habitat information will allow greater consideration of adaptation opportunities within land use planning processes. It can be used to identify vulnerable receptors such as homes, businesses, communities, critical infrastructure, schools and hospitals, and to support the spatial targeting of measures for resilience enhancement.</p> <p>Furthermore, the programme outputs can provide an important evidence base for an ecosystem approach to adaptation. This means taking advantage of the regulating services provided by green infrastructure, forests, peatlands, rivers, wetlands, dunes and salt marsh to reduce run-off and fluvial flood risk, to contribute to high water quality, to provide coastal protection and to sequester and store carbon. Furthermore, as described later in Section 5, management of these ecosystems can typically deliver benefits at lower cost than built adaptation defences. For example, on average, whole life costs for green space SUDs features in Scotland have been estimated at half those of conventional drainage⁴⁹.</p>
Transport	<p>Mitigation: Climate mitigation measures for the transport sector are likely to focus on continual reduction of emissions, and increasing energy efficiency across all transport modes. The national LCHM programme can assist the planning and development of sustainable, low carbon transport initiatives by supporting route selection processes so that vulnerable areas, such as flood plains, are avoided.</p> <p>Adaptation: It also offers a shared resource to the many stakeholders involved in transport planning, both in the private and public sector, thus supporting improvements in the coordination and efficiency of adaptation measures.</p>
Agriculture	<p>Agricultural mitigation and adaptation measures currently under consideration⁵⁰ for inclusion in the national plans place a focus on improving the environmental impact of agriculture through measures such as those developed under the Rural Development Programme 2014-2020, described below:</p> <p>Mitigation: Origin Green is a national sustainability development programme to help Ireland become a leader in sustainable food and drink production. As part of the</p>

Sector	Role of the national LCHM programme in sectoral mitigation and adaptation measures
	<p>scheme, farmers must participate in a sustainability survey which includes a carbon audit to assess the footprint of farms on a national scale. Knowledge of land cover and habitat types will provide important input to this survey and may be used to remotely assess the type and quality of biodiversity present on farms and to identify potential biodiversity actions that can be implemented as part of Origin Green.</p> <p>Adaptation: GLAS is an agri-environmental scheme designed to improve water quality and biodiversity and to promote climate change mitigation and adaptation in the agricultural sector. Under the scheme, farmers are required to take measures to safeguard the protection of the environment, watercourses and habitats. The data outputs from the national LCHM programme will make it easier to identify environmental features within specific farm holdings, supporting the design and implementation of agri-environment measures, and the monitoring of the effectiveness of practices to protect the environment, ecological corridors (such as hedgerows) and sensitive habitats.</p>
Forestry	<p>Mitigation: Forests perform essential services for GHG emission reduction and balancing. The effective management of forests is critical for carbon sequestration, carbon neutrality and climate change mitigation. Mitigation in the forestry sector is likely to focus on increasing the level of forest cover and the use of wood products and fuels.</p> <p>The availability of high resolution national land cover and habitat data will provide greater accuracy on the extent of forested area in Ireland, and will help to identify land suitable for afforestation, thereby maximising the carbon-sink potential of the sector.</p> <p>Adaptation: The programme will also facilitate the monitoring of changes in forestry cover, and can be used to identify land use conflicts between potential afforestation sites and sensitive watercourses and habitats. This has benefits in terms of supporting the identification of opportunities for green adaptation measures.</p>
Natural Heritage	<p>Mitigation: Terrestrial and marine ecosystems absorb carbon emissions providing essential climate regulation services. Degradation of natural heritage increases our vulnerability to climate change and its effects. Improved habitat information will support conservation programmes to protect and restore natural heritage while making us more resilient to climate impacts such as flooding.</p> <p>Adaptation: Adaptation measures proposed for biodiversity are likely to involve actions that address habitat fragmentation and reduce degradation. The national LCHM data outputs can be used to identify linear features within the landscape which are often hard to detect, such as hedgerows. This information can be used to support climate risk assessments as well as developing measures to protect important ecological networks. The programme outputs can also be used to monitor changes occurring in the distribution of plant and animal species arising as a result of climate impacts. In turn, this information can form the knowledge base for targeted policy actions.</p> <p>Furthermore, current datasets such as CORINE are not of a high enough resolution to identify natural features that can be used to mitigate climate impacts such as flooding. The proposed land cover and habitat data outputs can be used to identify areas such as peatlands or woodlands that have a high percolation capacity and which might be suitable for the retention of flood water.</p>

⁴⁹ Duffy, A. Jefferies, C. Waddell, G. Shanks, G. Blackwood, D. & Watkins, A. (2008) 'A cost comparison of traditional drainage and SUDS in Scotland'. Water Science and Technology, 57, pp. 1451-1459. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/18496012>. Accessed 27.05.2016

⁵⁰ Department of Agriculture, Food and the Marine (2015) 'A discussion document on the potential for Greenhouse Gas (GHG) mitigation within the Agriculture and Forestry sector. Public Consultation in preparation for the agriculture sector contribution to the national mitigation plan under the Climate Action and Low Carbon Development Bill 2015'. Available at: <https://www.agriculture.gov.ie/media/migration/ruralenvironment/climatechange/ghgmitigation/AgriSectorMitigationPlanPublicConsult120215.pdf>. Accessed 27.05.2016

Effective climate change mitigation and adaptation typically requires a coordinated approach with the involvement of a wide range of parties. The availability of a shared, easily accessible resource for national land cover and habitat information will support the successful targeting and implementation of measures particularly those that cross administrative boundaries. It will also support the identification of synergies between sectoral areas so that the benefits of mitigation and adaptation measures can be widely dispersed and cost efficiencies can be achieved.

3. 'Floods' Directive

The availability of accurate spatial data to support flood risk modelling is a requirement of European and national policy. The EU Directive on the Assessment and Management of Flood Risks [2007/60/EC], (the Floods Directive), came into force in 2007 with the OPW as the lead agency. The Floods Directive requires every river within the country to undergo Catchment Flood Risk Assessment and Management (CFRAM). CFRAM is appropriately named, as each CFRAM process assesses the risk of flooding within a river catchment; that is, from a river's source right down to its end. The national CFRAM process began in 2011 and the first iteration of CFRAMs for water courses is scheduled to be completed and implemented by end of 2016. The CFRAMs will then be reviewed on a rolling five-year basis, with new iterations using updated data and methods as they become available.

CFRAMs are conducted in three parts; firstly, a Preliminary Flood Risk Assessment (PFRA), secondly, development of catchment level Flood Risk Management Plans (FRMPs), and then implementation of the FRMPs beginning in 2016.

The Preliminary Flood Risk Assessment (PFRA), concluded in December 2011⁵¹. The PFRA identified areas where the risks associated with flooding might be significant. To find these areas, the OPW used both historic (where has flooded before) and predictive (where might flood in the future) analysis. For the predictive analysis, the OPW used computer models to forecast how severe or not flooding would be in a particular area. In simple terms, for each area the model takes in relevant information (e.g. rainfall, the dimensions of the river channel and water level, and what the character of the surrounding landscape), and then estimates how water flows through rivers and coastal areas for a range of different conditions. A key piece of information within these models is the nature of the surrounding landscape. This is important, as flooding can be made worse or better depending on the 'physical catchment characteristics'. As the CFRAMs programmes are reviewed into the future, the national LCHM programme will enable more precise flood risk modelling compared to existing land cover data (e.g. CORINE) by identifying key differences in land cover and land use types (e.g. various farming activities) at a much higher spatial resolution than is currently possible. This will be particularly valuable for smaller catchments for which the resolution of CORINE is too coarse. Having a better understanding of the surrounding landscape leads to better flood risk mapping; the national LCHM programme will provide better landscape information for the next iteration of CFRAM which should result in improved flood risk maps.

One outcome of PFRA is a list of Areas for Further Assessment (AFAs). These are areas where the risks associated with flooding are potentially significant and where further, more detailed assessment is required to determine the degree of flood risk, and develop measures to manage and reduce the flood risk. Once identified, these areas will be rigorously re-examined using desk-based analysis (e.g. more complicated computer models), on-site inspection and interviews with local residents and / or local authority staff.

⁵¹ National CFRAM Programme (2008) 'The National Preliminary Flood Risk Assessment Overview Report' Available at: <http://www.cfram.ie/wordpress/wp-content/uploads/2013/06/PFRA-Main-Report.pdf>. Accessed 24.04.2016

Again, the national LCHM programme will be of benefit to this process. In addition to providing the best available information for computer modelling, it allows the person making the assessment to get a clearer picture of the surrounding landscape which would enable better planning of the on-site inspections, targeting potential problem areas.

Once assessment of the AFAs is complete, a detailed Flood Risk Management Plan (FRMP) is created for each area. These FRMPs inform land use planning at the Regional, County and Local Area level⁵² and all FRMPs will be reviewed on a regular basis.

As the national LCHM programme will be common to both the planning process and the flood risk management process, this will aid compatibility between these processes. Additionally, as the national LCHM programme data offers a far higher resolution than currently available data sources (i.e. CORINE land cover)⁵³ existing CFRAMs and FRMPs can be upgraded using the improved data.

Finally, work on CFRAM programmes must be conducted alongside and support the implementation of other EU Directives, like the Water Framework Directive, Birds Directive and Habitats Directive, meaning that flood protection measures must not impact on the natural environment.

This point, that CFRAM must be conducted alongside and support the implementation of other EU Directives, is where the national LCHM programme becomes exceptionally valuable. The national LCHM programme provides the OPW with a clear understanding of where flood waters are likely to end up, and what environmental damage this might cause. It will allow flood risk maps to directly feed into the EIA, SEA, AA and NIS processes.

⁵² National CFRAM Programme (2015) 'HA09 Hydraulics Report'. Available at: http://eastcfram.irish-surge-forecast.ie/wp-content/uploads/2011/10/RpRef_4_16_0027_HA09_Leixlip_F02.pdf. Accessed 24.04.2016

⁵³ Ibid (p41)

5.0 The Economic Value of the national LCHM Programme

5.1 Overview

The review of current available datasets for land cover and habitat mapping in Ireland, and the feedback received from the consultees contacted as part of this study, provide strong justification for an authoritative national data programme on land cover and habitat mapping.

In economic terms, the case for a national Land Cover and Habitat Mapping (LCHM) programme arises from an example of market failure, namely a situation in which the market by itself is unable to deliver a product as effectively as could be achieved by State intervention. The scale of the investment required to bring together or coordinate spatial data from various sources, and the need to continuously enhance and update this data on a regular basis, is beyond the capacity of a single private organisation. Furthermore, there is a clear public good argument that this information should be openly available if the social benefits are to be maximised in terms of application and policy effectiveness. There are opportunities for a wide variety of public and private stakeholders to adopt and share this information and to specialise and innovate.

The current sectoral approaches represent, cumulatively, poor value for money and are not positioned to provide the economies of scale that a national programme could bring. Data to demonstrate time or resources savings due to high quality land cover datasets has been referenced where possible in this section. However, a detailed analysis would require insights and time series information on organisation changes, personnel and accounts over time within companies, agencies or government departments which is either not available to us or has never been recorded. Nevertheless, it is clear that the wider societal benefits associated with the improved environmental and economic performance accruing from a national programme are substantial, particularly in terms of improved public service delivery, time and cost savings, environmental accounting and in terms of maintaining options for future development and land management.

Data to demonstrate time or resources savings due to high quality land cover datasets has been referenced where possible in this section. However, a detailed analysis would require insights and time series information on organisation changes, personnel and accounts over time within companies, agencies or government departments which is either not available to us or has never been recorded. Attempts were made to assign a monetary value to the economic benefits identified⁵⁴. However, while we can identify distinct benefits such as greater precision, better analysis or efficiencies, all of which contribute to economic growth, attributing monetary values is subject to uncertainty and subjectivity. As such, it was not considered appropriate to attempt to monetise the economic benefits identified during this study. Nevertheless, it is clear that the wider societal benefits associated with the improved environmental and economic performance accruing from a national programme are substantial, particularly in terms of improved public service delivery, time and cost savings, environmental accounting and in terms of maintaining options for future development and land management.

This section crystallises the findings of Sections 2-4 to identify the key benefits of the proposed national LCHM programme and its potential for increased competitiveness and innovation within both the public and private sector. In doing so, it builds on the findings of the previous evaluations of expenditure by the public sector on land cover and land use data collation such as reviews for OSi (2014) and the EPA survey of Local Authorities carried out in 2011.

⁵⁴ Public and private sector professionals interviewed as part of this study were asked to provide information on examples of **economic gains or savings** due to geospatial information, particularly land cover and habitat data. Responses to this query were very limited with most professionals stating that it would be very difficult to place a robust monetary value to the savings achieved by the availability of this information in undertaking their work.

5.2 The benefits of the national LCHM Programme

The European Space Agency (ESA) invested €1.25 billion in earth observation systems in 2015. As this is financed by European tax payers, the investment is expected to yield a return in terms of public and economic benefits and competitiveness. Ireland contributed €17.3 in total to the ESA budget in 2015 – this is spread across numerous programmes including those in the field of earth observation and remote sensing. The data collection proposed under the national LCHM programme will involve remote sensing, and the use of ESA Sentinel data, thus presenting an opportunity for Ireland to reap the benefits of the national contribution made to ESA particularly in terms of efficiencies on reporting on land use change and of identifying economic opportunities for land use to respond to future agricultural, environment and climate policy.

A year earlier, the OSI published an *Assessment of the Economic Value of the Geospatial Information Industry in Ireland (2014)*. The assessment concluded that the sector produced direct output worth over €117 per year and was responsible for Gross Value Added of €69 million, or €126 million on an economy wide basis including indirect and induced impacts across the economy. Direct employment was estimated to be 1,677, or over 3,000 taking into account the contribution to other sectors. LCHM is only a part of this wider geospatial industry, but the report states that the contribution to the Irish economy by this sector is likely to be much higher than these estimated values as a detailed quantitative analysis was only possible for a few applications such as journey time and transport costs savings.

The OSI report discusses the importance of the geospatial sector for innovation and economic growth in areas such as aerial imaging and mapping, real time information and big data management. Innovation has been promoted by the increased level of investment in the industry over recent years and which is helping to create new employment opportunities both within the sector and in downstream applications and activities. According to a geospatial specialist interviewed as part of this study, *‘Investors have been attracted to use these facilities much more than they were in the past and see the benefits of using these services.’* The growth and vibrancy of centres of excellence such as the National Centre for Geocomputation (NCG) at NUIM, is a positive marker of the value of this sector and of the wide spread of opportunities for multiple economic sectors. Further opportunities will arise with a national LCHM programme in place as better quality data becomes available and the benefits of the wider application of the datasets are disseminated.

However, if the sector is to grow further, essential infrastructure needs to be put in place. While there would significant benefits to businesses, no single business is in a position to fund this infrastructure. Neither is it in the public interest that a single business should benefit exclusively given the potential for spill-over benefits and the public good value. LCHM represents one component of the wider geospatial industry, but it is a very important one in terms of applications for spatial planning, resource and environmental management, land use, infrastructure provision and development. While an initial upfront investment is necessary to support the establishment of a LCHM programme, this will deliver a strong return on investment by enhancing policy effectiveness, increasing efficiency and reducing costs in the medium to long term.

The national LCHM programme offers value of money and a strong return on investment in a large number of ways which are identified and discussed below, namely:

Efficiency	Productivity	Policy Effectiveness	Sustainability
High accuracy	Reduced overlap	Policy implementation	Sustainable development
Time & cost savings	Knowledge sharing	Policy targeting	Damage avoided
	Accessible data & innovation		The Ecosystem Approach
			Environmental Reporting & accounting

Figure 9: Benefits of the national LCHM programme (economic value added)

Interactions exist between each of these areas of economic benefit.

5.2.1 Efficiency

High accuracy

The low resolution of CORINE and its limited number of land cover classes is a consequence of its development for pan-European activities. However, in a national context, this low resolution is very constraining as explained in section 2. Consequently, most Member States have now developed, or are in the process of developing, more detailed land cover databases (a selection of which are referred to Section 2.0). The 2011 EPA Land Use Land Cover Review⁵⁵ identified that all the main prospective users of a LULC database in Ireland needed a much higher resolution than could be offered by CORINE, in many cases of less than one hectare. Low resolutions imply inaccurate estimates of the area occupied by any one class of land cover; this undermines good land management and spatial planning. The immediate economic consequences might involve back-up actions such as retrospective assessment of aerial photographs, or additional land-based survey work where features cannot properly be identified.

Time and cost savings

Time and cost savings are closely related to the issues of accuracy and avoidance of duplication. **Savings are evident in comparison with conventional airborne or ground-based surveys.** According to the Eurisy study Satellites for Society (2016), savings on airborne survey-based costs for the European Clean Seas programme were €22m, or 2.75 times those of system development. The cost of satellite-based data, including land cover, for a soil resilience assessment in the Netherlands (City of Diemen, 2013) was one tenth that of alternative survey methods. Although not strictly transferable to a comparison of satellite land cover versus ground-based or airborne data in Ireland, the example helps to illustrate the scale of potential cost savings. The savings in time and labour costs from a reduction in the need for ground-based survey work amount to days or weeks of work for one or more individuals.

⁵⁵ Environmental Protection Agency (2011) 'Land Cover & Habitat Review'. Available at: http://www.epa.ie/pubs/reports/biodiversity/EPA%20Bio%20AP_final.pdf. Accessed 27.04.2016

Closer to home, the use of land cover data within a risk modelling approach of the 335km² catchment of the River Ugie in north-east Scotland indicated savings of over €30,000 per year on ground-based surveys⁵⁶. Similarly, Natural Resources Wales (NRW) has been able to use satellite-based LCHM to identify potential corridors between habitats that allow for species movement and to do so at less than 25% of the cost of field survey work. These habitats are small or of a linear nature and would typically be missed at the CORINE resolution. Survey works account for €100,000 per year, or around 20% of the NRW'S budget.

For the most part, in environmental impact assessment, remote survey data does not replace the need for ecological ground-truthing as this will still be needed to discriminate subtle differences between land cover and habitats. Moreover, where Annex 1 habitats are thought to be present and Appropriate Assessment is needed, it will be incumbent on project ecologists to undertake field work to ensure that such features are recorded and typically identified at up to Fossit Level 3 classification. Rather, higher resolution land cover data will allow the exercise to become more efficient, for instance by identifying, in combination with aerial photographs, areas that need sampling or verification. It will allow for high standards in reporting and interpretation to be maintained even where resources are constrained.

Where small features are overlooked, projects or programmes can be delayed, adding to costs while other complementary activities are kept in limbo. In a worst case scenario, features could be missed altogether. For example, a new road or pipeline route option could fail to identify a feature that may require a realignment of several kilometres with the result that new surveying work is required in all disciplines. A realignment of just one kilometre of road, even at a preliminary design stage, could require new surveying and specialist input resulting in a delay of a month at a cost of €100,000 or more in staff time and specialist services.

Other time and cost savings result from procedures being implemented far more efficiently and to plan. Time and costs savings were one of the key benefits recognised by the stakeholders interviewed as part of this study. The Indecon survey for the OSi, found that 68% of respondents believed that geospatial data had provided “significant savings” in administrative costs. Other international surveys referenced in the Indecon report identified cost savings in the public sector of between 0.2%-0.5%. Even the lower estimate applied to Ireland would suggest savings of €82m per year in the public sector alone.

5.2.2 Productivity

Reducing overlaps in data collection

The Eurisy survey⁵⁷ reports that 63% of European public authorities now use earth observation systems with the same proportion using satellite-based data at the regional and local level. However, 75% of respondents reported economic and technical challenges to more extensive use of this data, principally skills availability.

LCHM data collection and processing is a costly and time intensive undertaking that is currently spread across several public sector agencies in Ireland. The 2011 EPA Land Use Land Cover Review (2011) revealed that considerable resources have been invested in individual land cover and habitat mapping projects. Of the agencies surveyed, five invested in excess of €100,000 per year in LCLU activities. In the case of the National Soils Information, around €5 million was invested by Teagasc and the EPA in a system which has a resolution of 1:250,000 compared with the 1:575,000 available at present⁵⁸.

⁵⁶ Bloodworth, J. Holman, I. and Burgess, P. (2015) 'Spatial Targeting of Catchment Management Interventions to Improve Raw Drinking Water Quality Using the Carpow Framework'. XVth World Water Congress, 25 - 29 May, Edinburgh, Scotland.

⁵⁷ Eurisy (European Association of Remote Sensing Companies) (2016) 'Satellites for Society – Survey Report'. Eurisy, Brussels.

⁵⁸ Daly, K. & Fealy, R. (2007) 'Digital Soil Information System for Ireland. Environmental RTDI Programme 2000-2006'. Environmental Protection Agency.

There are economic benefits to having **common data standards**. Substantial resources have been invested by various government departments and agencies in mapping activities to meet their own needs when, in fact, similar work is being carried out elsewhere. The EPA review was based on survey returns from seventeen organisations including four county councils for which the cumulative LULC budget amounted to over €1m per year. If this expenditure were representative of the local authorities as a whole, then this figure could be increased by a further €1.1m per year.

Land cover represents a principal spatial dataset that should be provided as a public good for standardised base mapping. Public and private organisations can then overlay other spatial data onto this base map, for example and linear or point data such as overhead electivity lines, wells, septic tanks, etc. Having a common land cover resource avoids the need for users to duplicate existing maps. Common standards will allow data to be shared and exchanged, developed and then returned or updated for use by the original organisation or by others. This will enable the integration of compatible datasets so that they have wider application and relevancy across the public and private sectors.

Similarly, common standards will also permit more cross-comparisons and transparency. The avoidance of duplication will allow for more efficient exchange of information and the potential for cost savings. Within organisations too, the exchange of data will permit work to progress more efficiently as complementary skills can be applied to a project at the appropriate time. Work programmes can be more closely adhered to and information and outputs received on time when they have the opportunity to be most effective. Resources freed from one task can be productively reinvested in other areas or in the more detailed analysis of the data leading to better policy or project delivery. By reducing the burden of data collection, public agencies and private bodies will be able to direct resources more efficiently to focus on specialised data gathering, project analysis, policy development or other activities central to their remit.

Knowledge sharing

Closely related to the need to remove data overlaps, is the benefit of promoting knowledge sharing. Many organisations in Ireland already have first-hand experience of the problem of incompatible spatial data with respect to the spatial units and descriptors used in the Republic and Northern Ireland. This has restricted the momentum behind **cross-border** activities and led to calls for an all-Ireland spatial planning initiative. Incompatibility extends to awareness too. Even within the state, organisations are not always aware of the LCHM information generated by other public agencies or of the potential uses this data can have for their own work. For example, Bat Conservation Ireland (BCI) did not know about a Teagasc/Sligo IT project which mapped linear features as one indicator of High Nature Value Farmland.

A centralised programme of land cover data collection and its **integration with other spatial data** will bring greater clarity to the full range of current applications for LCHM data and make it easier to identify opportunities for information sharing across sectors. Methodological and geometric consistency will make it possible to join up compatible or cross-boundary land cover information. The use case examples included in this report have shown the extent to which land cover and land uses interact with each other and how changes in one can often impact on another.

Agglomeration economies are a recognised benefit of complementary activities being performed within the same geographical space. Indeed, they have been described as the driving force behind cities⁵⁹ with productivity gains as high as 20% commonly assumed for the financial sector. Benefits arise from companies being located close to one another with the opportunity this provides for sharing in innovation, networking or complementary activities. In the modern age of the “smart city”, agglomeration similarly occurs with digital data of which spatial data is a key element. Similarly, with greater access to different

⁵⁹ Graham, D. (2007) ‘Efficient road congestion’, *Journal of Urban Economics*. 62, pp. 103-113.

datasets and an enhanced capacity to analyse across these datasets, public and private sector agencies will become more aware of the value of national LCHM information. Improvements in **networking** will arise with a stronger culture of knowledge sharing across sectors and identification of compatible work areas or new work opportunities. Multi-sectoral collaborations should be common where LCHM data is a base element of a project. This in turn can result in value creation by meeting user needs, matching supply and demand.

Just as a reduced overlap in data collection will free up resources and working time, the exchange of data will facilitate coordination within organisations and between public sector, local authority and private sector entities. It will be more feasible to identify internal and external working strategies that are cross-departmental and cross-disciplinary. This will strengthen the **management of competing objectives** and permit more of the **joined-up thinking** needed to address complex issues such as climate change.

Open Data and innovation

The EC has estimated that the re-use of public sector **open data** in Europe is growing at an annual rate of 7% and was worth €28 billion in 2008 in direct terms while contributing to applications worth €240 billion⁶⁰. The report estimated that an expansion of open data would deliver a further economic contribution of €40 billion per year. Using a similar methodology, the UK has estimated open data to have an economic value of €16 billion (HM Government, 2011). By comparison of relative GNP, this could imply benefits of €1.2 billion in Ireland. Behind these estimates of productivity gain are benefits in terms of increased efficiency, convenience, cost savings, job creation⁶¹, new and better quality products, transparency, and societal benefits such as having better informed citizen.⁶²

For spatial data specifically, the UK Ordnance Survey⁶³ has estimated the economic benefits at between £13m and £28.5m per year, most of which have been achieved through productivity gains (63%) and increased tax revenue (3.5%). Although OSi makes data available for research purposes, much spatial or boundary data such as the GeoDirectory has to be purchased, including by public bodies. By comparison, the GeoPortal has been made available in line with the Public Sector Reform Plan 2014-2016 and it is possible that Prime2 could follow⁶⁴.

Land cover data is an example of a dataset that should be open access (where possible) and which has the capacity to contribute to varied economic sectors and activities, providing opportunities for **collaboration** between the public sector, private sector and research institutions. The availability of detailed national LCHM data will also support the development of **novel applications** in planning, environmental resource management, infrastructure, and asset and property management. In turn this will open up new opportunities for the ICT sector, increasing competitiveness and helping to create new jobs.

5.2.3 Policy effectiveness

Improved policy implementation

The availability of a common land cover dataset will provide a **baseline which can be regularly updated** as new survey and remote sensing data becomes available. The higher resolution will enable **greater accuracy** in activities in the domains of land use planning, water management, climate change, air quality,

⁶⁰ Vickery, G. (2011) 'Review of Recent Studies on PSI Re-use and related Market Developments', Information Economics, Paris.

⁶¹ Manyika, J. Chui, M. Groves, P. Farrell, D., Van Kuiken, S. and Almasi Doshi, E. (2013) 'Open Data: Unlocking innovation and performance with liquid information', McKinsey and Company.

⁶² Tinholy, D. (2013) 'The Open Data Economy: Unlocking Economic Value by Opening Government and Public data'. CapGemini Consulting.

⁶³ UK Ordnance Survey (2013) 'Assessing the value of OS Open data to the economy of Great Britain – Synopsis'

⁶⁴ Lee, D., Cyganiak, R. & Decker, S. (2014) 'Open Data Ireland: Best Practice handbook'. NUI Galway: Insight Centre for Data Analytics.

recreation and tourism, flood risk management and many other sectors. Common standards, the **exchange of data** and opportunities for **collaboration** within and between organisations will all contribute to improved policy implementation. The quality and integrity of decision making is essential to an effective public service and reliable data will make for informed choices. The opportunity for more efficient delivery of public services will also boost the competitiveness of Irish businesses involved in any aspect of land planning or management.

In addition, robust land cover data offers an opportunity to **evaluate the effectiveness** of policies relative both to baseline conditions and policy objectives. Software packages can calculate the area occupied by different land cover types so that a **quantitative analysis** can be undertaken of the relative proportions or changes in the proportions. The quantitative data makes possible the application of methods such as **cost-effectiveness analysis** or **cost benefit analysis**. The combination of baseline and regularly updated land cover information, monitoring and statistical data allows policy to be properly evaluated and for future policies to be informed by an **evidence base**, providing efficiencies and avoiding unnecessary expenditure on righting past mistakes.

Policy targeting

Improved spatial targeting allows resources to be **focused** on areas or activities that are most likely to respond well to policy measures. For example, future flood management will require the identification of locations that could be used for percolation areas (SUDs), or for the retention of water using upstream catchment management or wetland creation. Environmental management can be targeted at those areas most in need of protection or to areas where biodiversity would respond best to policy measures. If, on the other hand, policy was to be applied more broadly, resources will be used less efficiently. Policies might achieve certain positive outcomes, for example as social transfers of funding in the case of agri-environment schemes, but would be less effective at addressing key outputs.

For pollution control and nutrient management, the EPA routinely collects data on water quality, but the sources of diffuse pollution are often poorly understood. Having information on land cover will help the EPA to identify agricultural or forestry activities that present a potential risk of pollution, for instance from poor livestock management, fertiliser/slurry application or timber harvesting. This would allow the agency to design the most effective, least disruptive and most cost-effective catchment management planning. The agency will be able to target measures for those locations at greatest risk, taking into account the respective effectiveness and implementation costs.

EXAMPLE - LCHM in practice: Environmental and habitat management

Objective = the identification and protection of environmental assets.

a) Efficiency

High resolution data means that the location of valued habitat and species can be identified, reducing the risk that expensive corrective actions may be necessary should these are overlooked.

b) Productivity

Successful management will depend on the best allocation of resources helped by an understanding of the land cover context. A common platform will facilitate planning authorities or private consultancies in undertaking Appropriate Assessment to account fully for habitats and species distribution and condition in both strategic and environmental impact assessment. There will be a reduced prospect of delay and more targeted use of costly ground-based assessment of development options that could quickly be ruled out in favour of alternatives through the preliminary use of LULC data.

c) Policy effectiveness

Cost-effective strategies can be targeted to protect priority habitats or species. In addition, information on land cover and habitat quality change over time can be used to allocate resources most efficiently to address the most significant threats first. Making informed choices at an early stage means resources are invested most efficiently, avoiding future damage costs and any need for costly environmental restoration.

d) Sustainable policies

Green infrastructure strategies can be used to meet common objectives for nature protection, amenity and the minimisation of environmental risk to human beings. Where liability issues arise, e.g. pollution, penalty levels can be calculated that provide for the most appropriate rehabilitation measures including, if necessary, complementary habitat that adequately compensates for the original damage. The risk of the State incurring these costs in the absence of such information is reduced.

5.2.4 Sustainability

Sustainable development

That economic development proceeds without any deterioration of the natural resource base is central to sustainable development. Maintaining options for future generations is a fundamental obligation and, in this context, informed choices are essential. Sustainable development, as reiterated in Ireland's own *Framework for Sustainable Development* (2012)⁶⁵, allows for different development and conservation strategies to be compared in order to identify strategies which result in significant economic or social benefits without any net loss of the aggregate natural resource base.⁶⁶

For infrastructure planning, baseline information, especially land cover data, is required to assess the potential impacts associated with new development and to ensure that these do not compromise sustainability objectives. Mitigation measures inevitably involve costs or compromises in project design, but need to be effective if they are to minimise potentially costly environmental or social impacts. In practice, a considerable amount of scoping work and options analysis may be necessary, including substantial ground-based survey work or site assessment. Various alternative options may need to be investigated, particularly in the case of linear infrastructure such as roads, electricity transmission or pipelines. In many cases, one or more of these options could be discounted at an early stage if good land cover data were to be available. National land cover data may not eliminate the need for ground-based survey, but it will allow these surveys to be undertaken more efficiently. This will result in substantial time and resource savings on ground-based survey work.

Planning invariably involves making choices and trade-offs between competing land uses for which good data, including spatial data, is necessary for the accurate estimation of the respective costs and benefits. **Green infrastructure** is one area in which spatial data can contribute to sustainable development. It provides a common template for different disciplines in local authorities to work together. **Process efficiencies** can be achieved where standardised LCHM data is available and can be shared between departments. In this context, LCHM becomes a tool to implement green infrastructure which in turn forms the basis for sustainable development.

⁶⁵ Department of Environment, Community and Local Government (2012) 'Our Sustainable Future – A Framework for Sustainable Development in Ireland'. Ireland, Dublin

⁶⁶ The *weak sustainability* criterion

Damage avoided

High quality LCHM provides the basis for informed policies to protect from potential environmental impacts, along with the targeting of appropriate measures. As a result, environmental quality can be protected, people's security, utility and quality of life are enhanced, and homes can be safe-guarded from the direct negative impacts of flooding, groundwater pollution or storm damage. As a consequence, future economic and social costs can be avoided.

One example is poor **nutrient management**. Where water quality is poor, costs are incurred in terms of additional spending on wastewater treatment to ensure that discharges do not raise the pollutant content of sensitive receiving waters above acceptable thresholds. Based on figures estimated by Irish Water⁶⁷, the additional operating and capital cost in moving from primary to tertiary treatment for a wastewater treatment plants serving 50,000 people could be €636,000 and €7.87 million per year respectively. Further costs might be incurred in terms of the additional treatment required for water abstracted downstream for human consumption. Other economic costs include potential damage to fisheries and the consequent loss of utility to anglers and other river users along with the potential loss of visitor or tourism-related expenditure on fishing permits, boat hire or accommodation. The avoidance of these costs through the use of LCHM data to inform and target **catchment management** represents an economic benefit.

Another example is the area of **flood management**. Flash floods pose a particular risk of erosion and significant damage to property and infrastructure due both to the elevated force of flow and the lack of time available for people to take evasive action. Emergency expenditure accounts for an average of 37% of the total costs of a flood event and is more likely to be realised if lives are at risk and if people or livestock need to be transferred to safe areas⁶⁸. However, these impacts and expenditure can be minimised if homes and infrastructure are well protected through policies and measures. The availability of up-stream land cover data strengthens the authorities' ability to predict the likelihood or imminence of events. Downstream land cover data can be combined with information on the location of sensitive receptors or vulnerable community facilities or infrastructure such as schools, retirement homes, medical centres, workplaces, roads and telecommunications. Economic benefits are realised in terms of *damage avoided*.

Reduced costs, or **avoided costs**, are possible where decision making is better informed. The 2009 floods in Cork City were especially damaging because they impacted on a central urban area. The cost to the civic authorities was in the region of €35m with a wider cost to homes and businesses estimated at between €80m and €100m. Additional economic losses were realised in terms of disruption to transportation and commercial activity. Every flood event is different, but in the UK it has been estimated that the average cost of damage to agriculture land is £1,207 (€1,387) per hectare or £612 (€703) per hectare⁶⁹. Domestic properties with an annual 1% risk of flooding have been estimated to have an annual equivalent damage risk of £100 (€84)⁷⁰. Therefore, for properties at risk every 20 years, this figure rises to €420 per year. Multiplied by the number of hectares or properties, these estimates are transformed into substantial figures. Nine hundred homes were flooded by Storm Desmond in December 2015. Repair costs per property in the UK were believed to average £50,000 (€57,470) (Association of British Insurers, 2016)⁷¹. The social impact and cost of flooding can be equally severe and includes temporary relocation, stress and anxiety. LCHM data cannot prevent all such damage, but can inform catchment management, reducing the risk from inappropriate land uses or targeting areas where run-off can be intercepted.

⁶⁷ Personal communication in context of EPA ESManage Project.

⁶⁸ Meyer, V. Becker, N. Markantonis, V. Schwarze R. (2012) 'Costs of Natural Hazards – A Sythesis'. European Community's Seventh Framework Programme Integrated Project CONHAZ, Contract 244159.

⁶⁹ Posthumus, H. Morris, J. Hess, T. Neville, D. Phillips, E. & Baylis, A. (2009) 'Impacts of the summer 2007 floods on agriculture' in England Journal of Flood Risk Management, 2, pp. 182-189.

⁷⁰ Penning-Rowsell, E. Viavattene, C. Pardoe, J. Chatterton, J. Parker, D. and Morris, J. (2010) 'The Benefits of Flood and Coastal Risk Management: A Handbook of Assessment Techniques 2010'. Flood Hazard Research Centre, Middlesex University.

⁷¹ Association of British Insurers. www.abi.org.uk (January 2016).

EXAMPLE- LCHM in practice: Flood management

Objective = to reduce exposure to flood risk and the economic and social costs.

a) Efficiency

Physical catchment descriptors are used by the OPW to describe the water flow and flood risk characteristics of river catchments. The poor resolution of CORINE means the OPW's CFRAM programme remains ignorant of the location of smaller features that could have a significant impact in terms of both the speed and volume of run-off.

b) Productivity

Common LCHM data means that information can be shared with local authorities, landowner's/land managers and the emergency services providing for better coordination.

c). Policy effectiveness

More hydrological information on catchment descriptors can be added to the CFRAM models. Policies can be targeted at particular land uses and locations that have the best potential to alleviate flood risk. Vulnerable receptors (people, infrastructure, ecology and economic activities) can be identified.

d). Sustainable policies

Catchment management can be used to lessen flood risk. Planning authorities can proceed with more confidence when it comes to the siting of new development, including infrastructure such as roads and bridges. Ultimately, this will reduce costs in terms of exacerbated flood damage or the retrofitting of structures.

The Ecosystem Approach

In a similar vein to the "avoided costs" outlined in the previous section, is the ability to take appropriate preparatory actions to provide for improved policy implementation in the future. The Ecosystem Approach provides for such preparation by making best use of **ecosystem services**. Ecosystem services are ecological functions provided by the natural environment, on which human beings depend. These include *provisioning services* such as food production, *regulating services* such as pollination, water quality, storm and flood protection and *cultural services* such as the benefits of natural environment for amenity and well-being. The national LCHM datasets can be used to identify the sources of these services and to determine how the natural environment can be best managed to maximise such services.

An example can be provided for **climate change**. The UK Stern report⁷² argued that without preparatory actions, climate change could impose significant costs equivalent to 5% of GDP each year (€6bn), increasing thereafter. Short term costs are already being realised in terms of insurance premiums which have been rising at 2% per year since the 1970s. Long term costs could involve major land use and relocation of people. This has significant consequences for future planning and infrastructure. Preparatory action calls on the collective benefits available from a national LCHM programme as identified above. Better land cover data will allow for more informed choices by applying an Ecosystems Approach to the mitigation of CO2 emissions by selecting and siting different land uses, for example to maximise carbon sequestration by peatlands. Making the right decisions will provide significant economic benefits in

⁷² Stern, N. H. & Great Britain (2007) 'The economics of climate change: The Stern review'. Cambridge, UK: Cambridge University Press.

allowing Ireland to meet its emissions targets at least cost. Reducing the risk through the appropriate management of land cover and land use emissions at source is cost-effectiveness. Other forms of abatement result in costs per tonne of carbon of around €39⁷³.

Secondly, *adaptation* to climate change will require cross-departmental cooperation and coordination. The Ecosystem Approach entails the use of regulating services provided by green infrastructure, forests, rivers, wetlands, dunes and salt marsh to reduce run-off and fluvial flood risk, to contribute to high water quality, to provide coastal protection and to sequester and store carbon. Management of these ecosystems can typically deliver benefits at lower cost than built defences. For example, on average, whole life costs for green space SUDs features in Scotland have been estimated at half those of conventional drainage.⁷⁴

The ecosystem approach is already being actively evaluated by local authorities, Irish Water and the OPW and will require high resolution LCHM data to identify the location of land cover types and the potential for their utilisation or extension. Substantial preparatory planning and investment, including capital investment, will also be needed.

Given the considerable uncertainty attached to climate change projections, adaptation choices will incur substantial costs with less than certain benefits. To preserve options for the future, good land cover data will be needed for **climate modelling**, to **minimise uncertainty** and to identify those areas that are most **vulnerable**. Decisions with major economic and social consequences will need to be properly assessed, including the possibility that some areas will be sacrificed to sea level rise. With such high stakes it will be essential that policy making and political decisions are informed by the best available information.

Figure 7 in Section 2.3 provided an example of how the low resolution of CORINE fails to identify several land cover or habitat types that provide ecosystem service benefits in the area of Knockvicar in Co. Roscommon. This omission is especially true for linear features (e.g. hedgerows, watersides) or small areas of land cover (e.g. heterogeneity in peatlands or forests) as illustrated by Figure 10 which describes the economic or social benefits of ecosystem services that might otherwise be overlooked. The ecosystem services provided by these areas either have a direct economic value or could only be substituted by costly artificial interventions such as flood defences, water treatment, wastewater treatment.

⁷³ Motherway, B. & Walker, N. (2009) 'Ireland's Low-Carbon Opportunity: An analysis of the costs and benefits of reducing greenhouse gas emissions'. Technical appendix, Dublin: Sustainable Energy Ireland.

⁷⁴ Duffy, A. Jeffries, C. Waddel, G. Shanks, G. Blackwood, D. and Watkins, A. (2008) 'A cost comparison of traditional drainage and SUDS in Scotland'. Water Science and Technology, 57, pp. 1451-1459.



Figure 10: Ecosystems services provided by land cover

Environmental reporting and accounting

As well as a resource for identifying baseline environmental conditions, the national LCHM programme will provide long-term monitoring of land cover change into the future. For example, high quality land cover data will allow Ireland to account adequately for both greenhouse gas (GHG) emissions and sequestration in line with international and EU reporting obligations. For example, 40% of the country's forest estate was planted after 1990 which represents the portion most actively growing and sequestering carbon and is taken into consideration for EU reporting purposes. Accurate assessment needs to account for the location of these trees, thereby integrating influential variables on land cover with Forest Service data and soils mapping.

For environmental accounting, ecosystem services such as carbon sequestration by peatlands provide a rationale for the mainstreaming of biodiversity across government departments. A common LCHM dataset would assist with this process and ensure efficient payback from Ireland's investment in the ESA. Furthermore, under the EU 2020 Biodiversity Strategy, Ireland is required to map and account for the state of ecosystem services. As well as being a legal obligation, the Mapping and Assessment of Ecosystems and their Services (MAES) can be used to demonstrate the economic and social value of the natural environment. As illustrated above, natural ecosystems have the capacity to save the State resources given their contribution to food and forest production, water quality, flood mitigation, storm protection, biodiversity and quality of life. MAES will identify where ecosystem services are most valuable and can most practically contribute to human wellbeing. The NLCHMP can be used to communicate the benefits and to allocate responsibility for their management.

5.3 Risks of maintaining the status quo

A summary overview of the main risks associated with maintaining the status quo, i.e., not establishing a national LCHM programme, is provided below:

Failure to meet national policy commitments for public sector reform:

Absence of a viable delivery mechanism to achieve national policy commitments for information sharing, open and accessible data initiatives, increased transparency and public accessibility, as set out in the Government's Public Service Reform plans (referred to in Section 3.1). This will have the following adverse impacts on the effectiveness of the public sector:

- A lack of joined-up thinking and a compromised ability to deliver a national solution to the current data gap in land cover and habitats;
- Inefficiencies in information sharing within the public sector as individual public agencies continue to invest in their own mapping programmes. As well as the cost inefficiencies associated with this, the potential multi-sectoral applications of land cover and land use data will be inhibited as a result;
- Ongoing overlaps in the data collation and analysis activities of some public sector agencies representing a wasteful use of resources;
- Issues associated with the costs and ownership of data and the constraints on the use-ability of data arising from incompatible data standards.

A sub-optimal knowledge base for EU and national legislative obligations:

Ongoing constraints on thematic and spatial resolution increases the risk of inadequate monitoring and reporting in response to EU legislative requirements arising from the Water Framework Directive, the

Habitats Directive, the Air Quality Standards Regulations, the Floods Directive, Environmental Liability Regulations and others described in Section 3.2.

Inaccuracies and misleading information leading to poorly informed decision making:

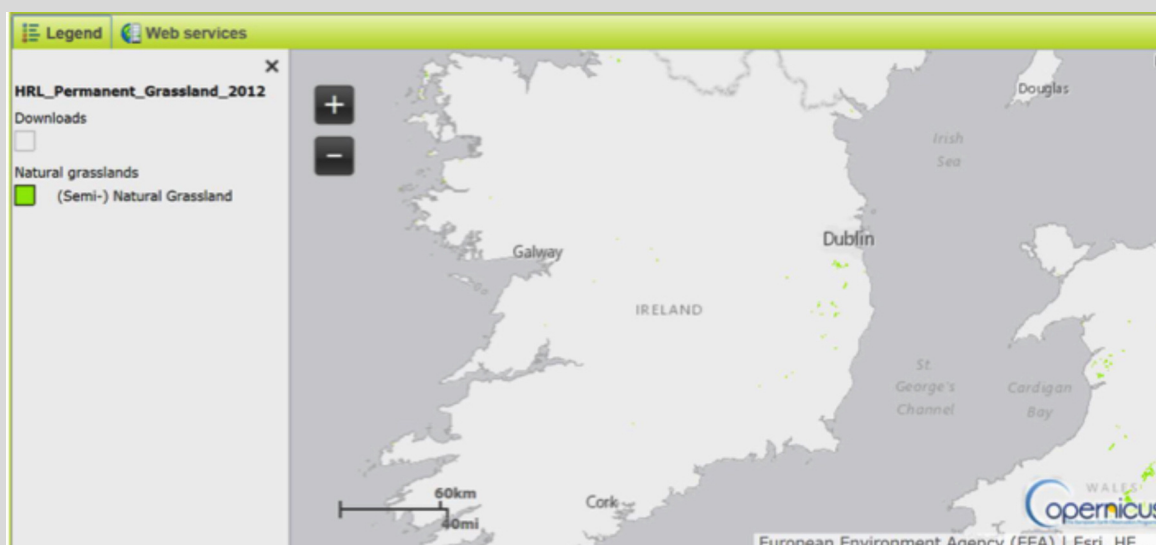
- Risk of inaccuracies in the description of baseline environmental conditions compromise the integrity of the plan making process (such as Strategic Environmental Assessment) and present a risk that potential impacts will not be recognised or appropriately managed;
- Misrepresentation of areas or the extent of a land cover arising from a reliance on low resolution datasets in the absence of more detailed and complete LCHM datasets;
- Continuing reliance by professionals on existing land cover datasets that may not be fit for purpose depending on the nature of a project. The inappropriate use of existing national datasets (in the absence of an alternative) increases the risk of poorly informed decision making which can have adverse consequences for the environment, economy and society;
- Continuing reliance on pan-European data models and products that are derived from medium to low spatial resolution satellite imagery which are not capable of capturing finer details on the characteristics or extent of land cover (please refer to the example set out in Tables 3 and 4 below);
- A missed opportunity to maximise the use and value of satellite data and Ireland's contribution to the ESA earth observation systems;
- A poor understanding of the rate, extent and nature of change in the landscape and associated implications for environmental quality on a local, regional and national level;
- A limited capacity to benchmark land cover change against trends occurring in Europe and on an international level;
- Poor land use management and a failure to recognise competing land uses. Examples include developments permitted in flood risk areas, biodiversity loss arising some types or intensities of land use;
- Failure to recognise conflicts between development proposals and the natural environment, leading to delays in the planning and implementation of vital infrastructural projects which can have negative impacts on quality of life and the economy;
- Failure to recognise or fully appreciate the interactions and interdependencies of land cover features within and across county, regional or national boundaries. This compromises the ability of the Irish planning system and other systems responsible for environmental management to safeguard the environment and ensure sustainable development and land management practices;
- Inability to manage and mitigate environmental risks such as climate change adequately including the impact of storm and flood events of property and livelihoods, the effect of rising temperatures on food production and water quality, or the threat of coastal communities, beaches and coastlines being submerged by rising sea levels;
- Failure to inform climate change policy Ireland with adverse implications for climate change adaptation and mitigation targets;
- Failure to recognise the nature of risks to the integrity of habitats or species arising from the effects of climate change or development pressures.

The European Commission's Forest Type Map (FMAP) 2006 map is a 25m spatial resolution raster Pan-European Forest/Non Forest Map with target year 2006 derived from LISS III, SPOT4/5 and MODIS satellite imagery and CORINE Land Cover (CLC) 2006 data. The FMAP 2006 has reported overall classification accuracy on a pan-European level of 88.0%. However, for countries such as Ireland which have a low proportion of forest, there is a strong under-estimation of forest cover. This is due to the minimum mapping unit of 25 ha of the CLC2006 which was used to train the classifier. As the mean forest size in Ireland is significantly less than > 25 ha, many forest areas were not included in the training dataset used to produce the FMAP 2006. Similar difficulties in reporting Irish forest-related land-cover changes in using CORINE data were noted by Black et. al (2010). In the absence of other compatible or readily utilisable datasets there is a risk that these pan-European products produced by the European Commission would be used as a basis for reporting and or policy formulation in areas such as land use change, climate accounting or agricultural policy which would impact negatively on the national interest.



Table 3: Example 1 of the risks arising from the use of pan-European data models - European Commission's Forest Type Map (FMAP) 2006 map

The European Environment Agency (EEA) produced a 100m resolution permanent grassland map for Europe. It was poorly reviewed and discontinued but a “semi-natural grassland” map was extracted from it to produce the map below for Ireland.



The definition of natural grasslands set out below is not consistent with that which might be used by a national agency such as Teagasc and the produced map is not a good representation of the distribution or extent of natural grassland in Ireland. Nevertheless, in the absence of any other mapped data this is the “official” map of semi-natural grassland in Europe according to Copernicus, CORINE and the EEA.

*“Natural grasslands are areas with herbaceous vegetation (maximum height is 150 cm and gramineous species are prevailing) which cover at least 75 % of the surface covered by vegetation which developed under a minimum human interference (not mowed, fertilized or stimulated by chemicals which might influence production of biomass)”.*⁷⁵

Table 4: Example 2 of the risks arising from the use of pan-European data models - European Environment Agency (EEA) - Permanent Grassland Map

Lack of awareness of the value of land cover and habitat information:

- A general lack of awareness of the potential value of land cover information for multi-sectoral applications;
- A lack of freely available and accessible information on land cover and habitats for the public, hence limiting capacity to engage in public participatory processes.

Inhibited research and innovation capacity of sectors that rely on quality land cover information:

- A lack of freely available LCHM data in Ireland places a severe constraint on the value of this information to land use planning, climate research, flood risk management and many more areas;
- The absence of a robust evidence base for scientific research on climate change, flooding, biodiversity etc.;

⁷⁵ European Environment Agency (2016) 'GIO land (GMES/Copernicus initial operations land) High Resolution Layers (HRLs) – summary of product specifications'. Available at: https://cws-download.eea.europa.eu/pan-european/hrl/HRL_Summary_for_publication_v14.pdf Accessed 19/09/16

- A loss of competitiveness at European and international level for both the geospatial industry and research funding programmes relevant to the built and natural environment. The absence of complete land cover data means that many sectors are not operating at an optimal capacity in terms of research and innovation. Novel approaches to tackling critical issues of national importance such as climate change may not be explored in full as key baseline information on the characteristics of land cover are not available;
- Opportunities for rural diversification may not be recognised as a full body of information on land cover attributes is not be available.

5.4 Risk Mitigation for the State

The National Risk Assessment 2015 – Overview of Strategic Risks⁷⁶ presents the key strategic risks facing Ireland and proposes measures to mitigate these risks. These risks span the economic, environmental, technological, social and geo-political domains. The national LCHM programme has strong potential to contribute to mitigation measures for national risks identified for at least two of these domains: economy and environment, as described below.

⁷⁶ Department of the Taoiseach (2015) 'National Risk Assessment 2015- Overview of Strategic Risks'. Available at: http://www.taoiseach.gov.ie/eng/News/Government_Press_Releases/Draft_National_Risk_Assessment_2015_%E2%80%93_Overview_of_Strategic_Risks.html. Accessed 16.06.16

Themes	National Strategic Risk	Contribution to risk mitigation
Economy	<p>Loss of competitiveness</p> <p>Ireland's national competitiveness refers to the ability of enterprises in Ireland to compete in international markets.</p> <p>The more extensive use of technology, developing Ireland's skills base, and rebuilding public trust in the capability of private and public bodies to adhere to the highest standards, are recognised as important measures for supporting competitiveness gains.</p>	<p>The national LCHM programme will advance the research and innovative capacity of public and private organisations across a range of sectors. The freely accessible data framework adopted will increase the transparency of public sector information helping to build trust in the public sector and its capacity to comply with environmental standards and obligations.</p>
Environment	<p>Climate change & extreme weather events:</p> <p>Recognised as a key risk area for Ireland with impacts on the environment, society, and the economy and associated sectors, including water resources, agriculture and food security, human health, terrestrial environments, critical infrastructure, biodiversity, and coastal zones.</p> <p>A risk of failing to invest effectively or sufficiently in adaptation measures is also set out, as are the potential compliance costs associated with emission and renewable energy targets.</p>	<p>Accurate land cover, habitat and land use data is essential for effective climate mitigation and adaption and will support efforts for reduction of GHG emissions and carbon balancing (as described in earlier sections).</p>
	<p>Infrastructural development:</p> <p>The timely provision of infrastructure in the right locations is recognised as crucial to economic growth.</p>	<p>Improved land cover and habitat information has strong potential to support efficiencies in the planning and delivery of infrastructural developments.</p>
	<p>Other:</p> <p>Other national strategic risks identified include food safety and the potential for an outbreak of a major disease in farmed animals, and misalignments in the property market.</p>	<p>The national LCHM programme has potential to support mitigation actions to address both of these challenges by helping the spatial targeting of policy supports in these areas.</p>

Table 4: Mitigating national strategic risks

6.0 Recommendations

A national LCHM programme for Ireland has been widely endorsed by public and private sector agencies⁷⁷ as the most promising and cost effective mechanism by which to address the current shortfalls in the availability of high quality land cover data in Ireland.

The wide ranging applications for a national land cover and habitat mapping product, and the wealth of environmental and economic benefits to be derived from the programme have been documented throughout this report. Collectively, the potential for multi-sectoral applications, the contribution to risk mitigation, and the benefits for efficiency, productivity, policy effectiveness and sustainability, present a compelling case in support of its establishment. Recommendations to further advance the proposal for a national programme are outlined below:

A national mandate from Government to establish and invest in the national LCHM Programme

This study has identified a wide range of administrative and economic benefits that will arise from the proposed national LCHM programme. As such, it is the view of the project team that the initial funding of €4 million sought over a six-year period will result in a strong return on investment given the efficiency and productivity that will arise, and the benefits for policy implementation, policy targeting, and sustainability.

Identify a lead agency to manage the national LCHM Programme

A lead agency with responsibility for overall coordination and data collation for the programme should be identified. OSi, on behalf of Tailte Éireann (the Government body to be formed through a merger of OSi, PRA and the Valuation Office), has been identified by the Working Group as the preferred organisation to provide and maintain the technical systems for dissemination of the data outputs to the wider public service and citizen. As the national mapping agency, OSi is ideally placed to act as the data publisher to disseminate the outputs of a national LULC programme of this magnitude and importance. Furthermore, the existing data reserves and collation mechanisms of the Property Registration Authority and the Valuations Office can potentially provide, in the longer term, valuable input to the eventual land cover data product in terms of commercial and private land uses. The relationship of OSi (as part of Tailte Éireann) and the proposed lead agency requires further consideration.

Mechanisms and incentives to capture data in the absence of a centralised system

The establishment of mechanisms and incentives to capture relevant land cover data collated by the private sector, Local Authorities and state agencies in respect of Environmental Impact Assessments of development projects, or the Appropriate Assessments of plans or projects. In the absence of a centralised land cover data management system, this information is currently being lost, but can be retained within the planning system where it could be of value as an efficient mechanism by which land cover data gaps can be filled. For instance, a requirement should be explored by which planning permission applicants submit the spatial data files associated with a development proposal and any ecological survey and follow-on monitoring results.

Further recommendations in supporting the effective delivery of the national LCHM programme are as follows:

⁷⁷ The public sector agencies that form the national LCHM Programme working group and the range of public and private stakeholders consulted with as part of this study.

Public sector partnership and licensing agreements

- A collaborative partnership agreement with a commitment from all public sector agencies to make available datasets that will help complete the national land cover data product;
- A mandatory requirement for public agencies to provide data in accordance with the common standards framework of the national LCHM. Integration with EU standards should be central to this;
- Absolute clarity on licensing agreements and the potential cost implications to enable the integration of existing land cover datasets. Easily accessible data is a central component of the capacity for this programme to add value to the range of application areas described in Section 4.0, and ultimately for its use as a public resource. Clear access protocols should be set out if some datasets are subject to specific licensing agreements.

Integration of datasets

- While land cover and habitat will be the key focus area initially, the capacity to integrate a range of existing datasets on land use and human activities will greatly expand the scope for application of the product;
- The programme should seek to identify opportunities to extend the scope of existing data collection surveys where it can be demonstrated that there are clear cost efficiencies to be gained in doing so;
- In the longer term, the potential to add data such as CSO data on demographics compiled at ED level would bring enormous benefits in terms of analysing the impacts of human beings on land cover. With the potential addition of socio-economic data, the capacity to contextualise land cover, habitats and land use attributes, will further extend the value of the national LCHM programme with the possibility for wider societal and economic benefits.

Technical Requirements

This study has focused on the potential application areas for a national LCHM data product, and the economic value of a national programme. The technical requirements for such a data product were not a core consideration of this study. Nevertheless, high level technical requirements that emerged during the stakeholder consultation are set out below:

- Greater accuracy, higher resolution and diverse land cover data is preferable to optimise the application areas for a national data set;
- The inclusion of time series data will greatly strengthen the capacity for analysis and monitoring of land cover changes;
- A nationally coordinated ground truthed dataset for a base year would be very valuable;
- Freely available datasets such as the Earth Observation data from satellite systems (including those from the European Space Agency (ESA) Sentinel programme) provide a hugely valuable resource but are currently not being exploited to their full potential in Ireland. A mechanism for the downloading and archiving of Earth Observation data available through the European Space Agency (ESA) Sentinel programme should be explored;
- Ability to upload data and metadata;
- Features that will permit map viewing at oblique angles;
- Measurement tools for environmental resource accounting;
- Guidance material in support of the data product to support its use for training and educational purposes.

Appendix 1: The proposed draft National LCHM Programme Schema compatible with the Fossitt Level 2B dataset

Fossitt Level 1		Fossitt Level 2B (Landcover)	
F	Freshwater	FL	Freshwater lakes
		FR	Reservoirs & artificial water bodies
		FW	Freshwater courses
		FS	Freshwater swamp
G	Grassland and Marsh	GI	Improved grassland
		GS	Semi-improved grassland
		GN	Semi-natural grassland
		GM	Marsh
H	Heath and dense bracken	HH	Heath
		HD	Dense bracken
P	Peatlands	PR	Raised bog
		PB	Blanket bog
		PD	Degraded and cutover bog
		PF	Fens and flushes
W	Woodland and scrub	WB	Broadleaved forest
		WC	Coniferous forest
		WM	Mixed forest
		WT	Clearfelled and transitional coniferous forest
		WS	Scrub
E	Exposed rock and disturbed ground	ER	Exposed rock
		EG	Exposed sand, gravel or till
		EB	Bare soil and disturbed ground
		EQ	Open quarries and mines
		ER	Refuse and civic amenity facilities
B	Cultivated and built land	BC	Arable land
		BH	Horticulture and flower beds
		BL	Buildings
		BS	Open sealed surfaces
		BG	Artificial green surfaces
		BI	Roads, ways and other infrastructure
C	Coastland	CS	Sea cliffs and islets
		CW	Inter-tidal water bodies
		CM	Salt marshes
		CB	Shingle and gravel
		CD	Sand dune systems
L	Littoral	LR	Intertidal rocky shores
		LG	Shingle and gravel shores
		LS	Sandy shores
		LM	Muddy shores
		LX	Mixed sediment shores
S	Sublittoral (subtidal)	MW	Marine water body
M	Marine water body		

Appendix 2: List of Consultees

Organisation	Representative
Bat Conservation Ireland	Dr. Tina Aughney
	Siobhan Egan
Central Statistics Office (CSO)	Gerry Brady, Environment Division
	Nova Sharkey, Environment Division
Compass Informatics	Gearóid Ó Riain
Department of Agriculture, Food and the Marine	Jerome Walsh
	Frank Barrett
	Katherine Duff, Forest Service
Department of Housing, Planning, Community and Local Government (DHPCLG)	David Dodd Environment Advisory Unit
	Julian Aherne Environment Advisory Unit
	Stuart Logan Planning Adviser, Water and Planning Division
Dublin Institute of Technology	Dr. Henk van der Kamp, School of Spatial Planning
Enterprise Ireland	Conor Sheehan, Irish Delegation to the European Space Agency (ESA)
Environmental Protection Agency (EPA)	Kevin Lydon
	Gavin Smith
Fingal County Council	Gerry Clabby,
Independent Researcher - Climate Change	Professor John Sweeney
Independent Research – Geoinformatics and Environmental Resources	Dr. Fiona Cawkwell
Irish Environmental Network	Micheal Ewing
Irish Water	Katie Harrington, Ecology Specialist
	Bryan Deegan, Ecology Specialist
Laois County Council	Catherine Casey, Heritage Officer
National Parks and Wildlife Service of the Department of Arts, Heritage, Regional, Rural and the Gaeltacht Affairs (DAHRRG)	Gemma Weir
National University of Ireland Maynooth	Dr. Conor Murphy, Department of Geography
Office of Public Works (OPW)	Oliver Nicholson
Teagasc	Dr. John Finn
	Stuart Green
The Heritage Council	Beatrice Kelly
University College Cork	Dr. Margaret Desmond, Environment Research Institute
	Barry O'Dwyer, Environment Research Institute
University College Dublin	Dr. Mark Scott, School of Geography, Planning and Environmental Policy
	Prof. Zorica Nedovic-Budic, School of Geography, Planning and Environmental Policy
	Dr. Gerald Mills, School of Geography
	Dr. Tamara Hochstrasser, School of Biology and Environmental Science
Waterways Ireland	Dr. Paula Treacy, Senior Environmental Officer

Appendix 3: Sectoral hypothetical scenarios to demonstrate potential uses for a national LCHM programme

Hypothetical scenarios demonstrating the potential applications of the national LCHM programme across a range of sectors are described below. The sectors include the following:

- Biodiversity
- Agriculture
- Forestry
- Land Use Planning and Water Resource Management
- Air Quality

Scenario 1

A Use Case for Biodiversity

The User

Local Authority Heritage Office

The user in this hypothetical use case is a Local Authority Heritage Officer.

The Scenario

This use case demonstrates the use of national LCHM programme to the local authority in the formulation of a county *Biodiversity Action Plan*. The purpose of the Biodiversity Action Plan is to strengthen the knowledge base for the conservation and management of biodiversity, and protect species and habitats of conservation value within the county. National and international guidance, such as Ireland's National Biodiversity Plan (*Actions for Biodiversity 2011-2016*) directs that successful biodiversity conservation requires actions to be taken at a local level. In assessing biodiversity and areas of ecological diversity and value in the county, consistent land cover, land use and habitat mapping is an important support tool.

The Biodiversity Action Plan will address conservation sites (SACs and SPAs) that form part of the Natura 2000 network arising from the Habitats Directives. Regular monitoring of protected sites is important to safeguard their protection, and to identify any potential adverse influences, which may pose a threat. However, habitats which are not legally-protected can also have a high conservation value in supporting locally important species and in acting as ecological corridors for the movement of species. Article 10 of the Habitats Directive and the Habitats Regulations 2011 place a high level of importance on non-Natura 2000 areas. The condition of annexed habitats both inside and outside the Natura 2000 network is also important in terms of the Environmental Liabilities Directive. In many cases, these habitats have not been comprehensively mapped.

This hypothetical use case demonstrates the benefits of the national LCHM programme to users at a county level and its contribution to enhanced biodiversity identification and management.

How the NLCHMP supports the users in undertaking the project tasks:

The availability of national habitat data will not replace the requirement for field surveys by ecologists. Field surveying will continue to be essential in many cases as it will not be possible to discriminate certain habitats using semi-automated methods, nor to assess the condition of many habitats (including for annex habitats). However, the value of having national landcover map or habitat maps is in informing local sampling programmes (and in feeding into regional and national sampling programmes). This will significantly reduce the time required to carry out current manual methods of analysis. For the local heritage officer, the national habitat data (and wider datasets that will be made available through the programme) can be utilised to illustrate the current status of biodiversity in the county, capture change in land cover, land use and habitat, identify county priorities and visually communicate key biodiversity issues.

The availability of high quality land cover and habitat data will also assist the heritage officer in evaluating the extent of existing habitats at a local level within the county and will facilitate the monitoring of habitat changes through regular-interval time series spatial mapping. In doing so, it will facilitate enhanced habitat management and conservation decision making at local level. This will have a significant impact on local and region biodiversity, and ultimately benefit national biodiversity expansion.

It will also support greater integration with biodiversity plans of neighbouring counties so that management plans can provide for transboundary protection of important habitat and species.

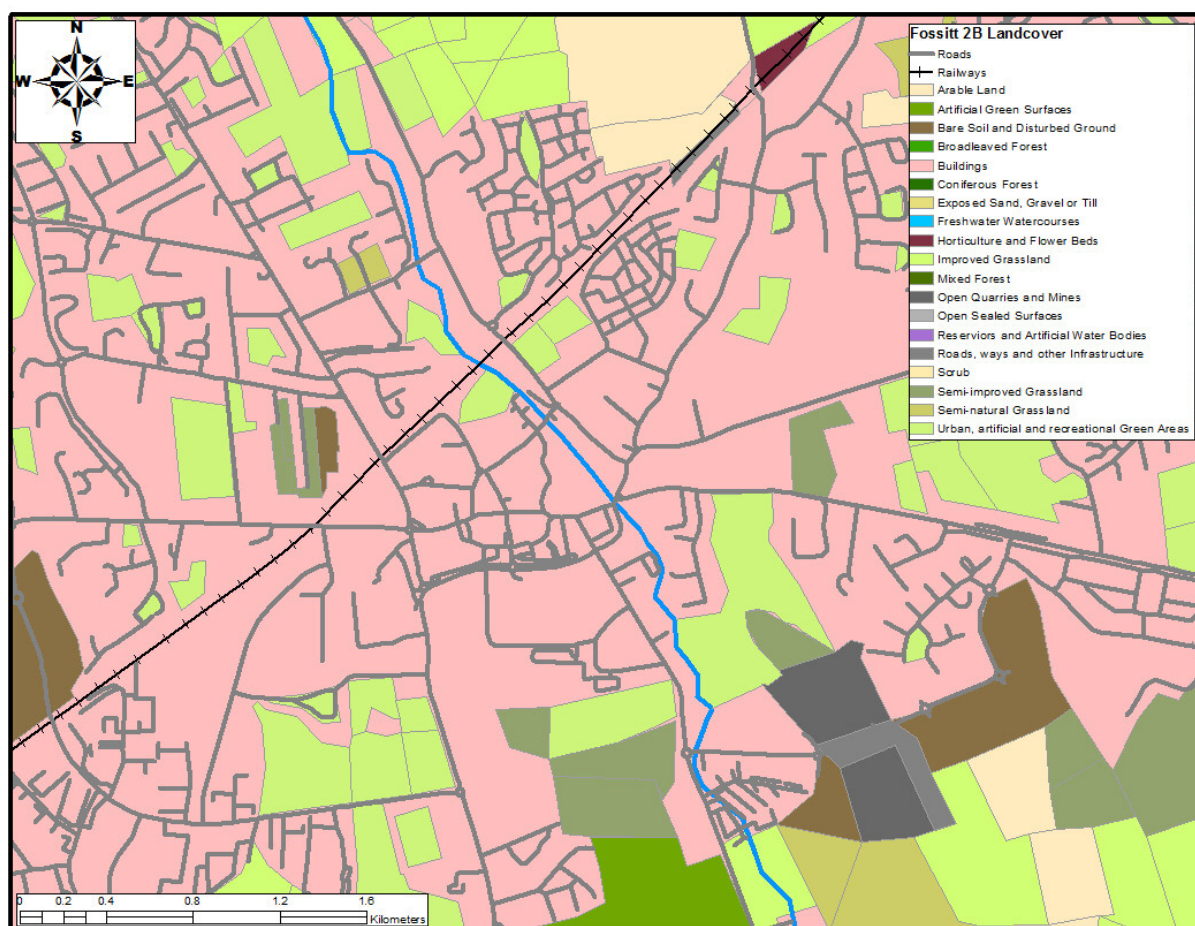


Figure 11: Example of spatial mapping using the level Fossitt 2b land cover classification to demonstrate its application at local level in the development of a Biodiversity Action Plan for a large rural town.

What are the benefits of the NLCHMP?

- The absence of a trusted national data source that shows the spatial distribution of habitats and species poses a challenge to biodiversity management and protection. The national LCHM programme will fill the spatial data gap that currently exists for habitat management.
- CORINE does not deliver the spatial resolution accuracy to small scale ecological features that perform important services in supporting the movement of species. Furthermore, the OSi's spatial data storage model, Prime2, has a limited thematic classification of landcover. For example, land cover and habitats comprising peatland, marshy grassland and scrubland are shown as one large boundary unit. The NLCHM programme will seek to break these down into many more classes (possibly using the Fossitt Level 2B for Landcover). Further to this is the Prime 2 spatial delineation of upland areas. These are not subdivided although in reality they may contain multiple landcover classes or habitat classes. The programme aims to subdivide these areas into smaller units.
- The availability of a national, shared information base on habitats will supports greater coordination for biodiversity management across administrative boundaries. At present, inconsistent mapping approaches with different spatial and thematic scales, or that have been prepared at different times (sometimes years apart), can make it difficult to detect changes occurring within habitats, undermining the integrity of biodiversity management plans.
- The provision of enhanced data on the location and extent of ecological corridors within

settlements and rural areas, which function as crucial linkages in facilitating migration of species and dispersal of flora and fauna.

- The time series recordings will support the monitoring of ecological corridors over time, allowing for potential fragmentation of regional and local corridors to be detected and mitigated.
- Time series detection nature of the national LCHM programme will capture potential degradation of locally important habitats within the county.
- The availability of the national LCHM programme will facilitate other competent authorities, NGOs, researchers and private users working within the county who need to consider habitat location and biodiversity in the course of screening and assessment (Appropriate Assessment) of projects and plans.
- The national LCHM programme will facilitate more informed decision-making and policy development.

What are the risks associated with maintaining the status quo?

- Existing land cover datasets such as CORINE and Prime2 do not offer sufficient classifications to reflect the full range of land cover, land use and habitat classifications on the ground, constraining their application for biodiversity management purposes at regional and local level. Consequently, the protection and management of habitats, particularly non-designated, locally important habitats are being compromised.
- The use of CORINE land cover data in the assessment of ecological corridors does not facilitate the detection of areas below 25 hectares, and as such, potential habitat fragmentation and the isolation of small fragmented populations cannot be captured at local level.
- While habitat mapping is being undertaken at local authority level, there is no consistent approach to data collation and mapping processes. This makes it difficult to detect changes occurring within habitats or ecological networks that cross administrative boundaries. This leads to habitat degradation and loss, and threatens the capacity of habitats to perform essential ecosystem services.
- CORINE land cover is not suitable for the detection of small scale habitats such as small woodland areas, due to the coarse nature of its resolution quality, thereby; the existence of important local habitats is not represented.
- CORINE and Prime2 do not facilitate long term monitoring. Conversely, the national LCHM programme database will facilitate time series detection of land cover, land use and habitats significantly enhancing local habitat and biodiversity management.

Scenario 2

A Use Case for Agriculture

The User

The user in this scenario is the **Department of Agriculture, Food and the Marine (DAFM)** in its capacity as the managing authority for the implementation of the Green Low Carbon Agri-environment Scheme *GLAS*, a part of the Rural Development Programme 2014-2020.

GLAS sets out to achieve the objectives of Articles 28 (Agri-environment climate) and 30 Natura 2000 and Water Framework Directive) of the Rural Development Regulation and ties in with the 'green' vision for Irish agriculture, as contained in Food Wise 2025, and as promoted by An Bord Bia in the *Origin Green* campaign. The GLAS seeks to harness sustainable agricultural practices; promote low-carbon emissions; and, support and promote agricultural production methods that are compatible with the protection of the biodiversity, water quality and climate change mitigation measures.

The Scenario

The DAFM wishes to monitor the application of spatially targeted actions under the GLAS scheme and to spatially reference the relationships of the subject lands with other elements in the rural environment, such as historical structures, watercourses and existing areas of environmental sensitivity such as Natura lands.

How the NLCHMP supports the users in undertaking the project tasks:

The national LCHM programme will support the DAFM in collating data in relation to the expansion and reduction of agricultural land classes, habitat and other land uses of interest. It will enable the DAFM to target certain land classes/habitats for agri-environment interventions and subsequently to assess the impact of such spatially targeting at a high level. For example, proportion of funding can be targeted at certain habitat types and the uptake can be used as a high level indicator of success.

The national LCHM programme will have land cover classification layer to enable the assessment of GLAS Commonage Plans in tandem with the DAFM's online submission platform for Commonage Plans. The conservation and sustainable management of commonages is a key aim of the GLAS scheme, therefore the accurate quantification of this type of land use in rural environments is key in terms of promoting environmental sustainability. Sub-classification of commonage type habitats, which can be extensive in nature, has the potential to assist commonage advisors in the drawing up appropriately tailored environmental plans at the early planning stage.

The national LCHM programme can assist in the assessment of the GLAS scheme by equipping DAFM with higher resolution data allowing the capacity to review the impact of targeted measures on the habitats and classifications of particular interest. Tracking progress in this way will enable better assessments on the efficacy of the use of funding, thereby, optimising supports for the development/preservation of habitats of greatest environmental value in the rural environment.

The programme will enable the DAFM to provide greater detail to Commonage Management Plan advisors, when drawing up environmental plans, thus should lead to higher quality of plans which can be better mapped and tailored to local needs. The high resolution quality of the programme will enable decision makers to accurately determine the classification of the habitats in the specific area concerned.

The programme may also be used as a tool to monitor the spatial distribution of other GLAS actions, for example the area of lands selected as Wild Bird Cover (WBC), and their respective relationship to adjacent habitats in the landscape, and hence their strategic value at a spatial level.

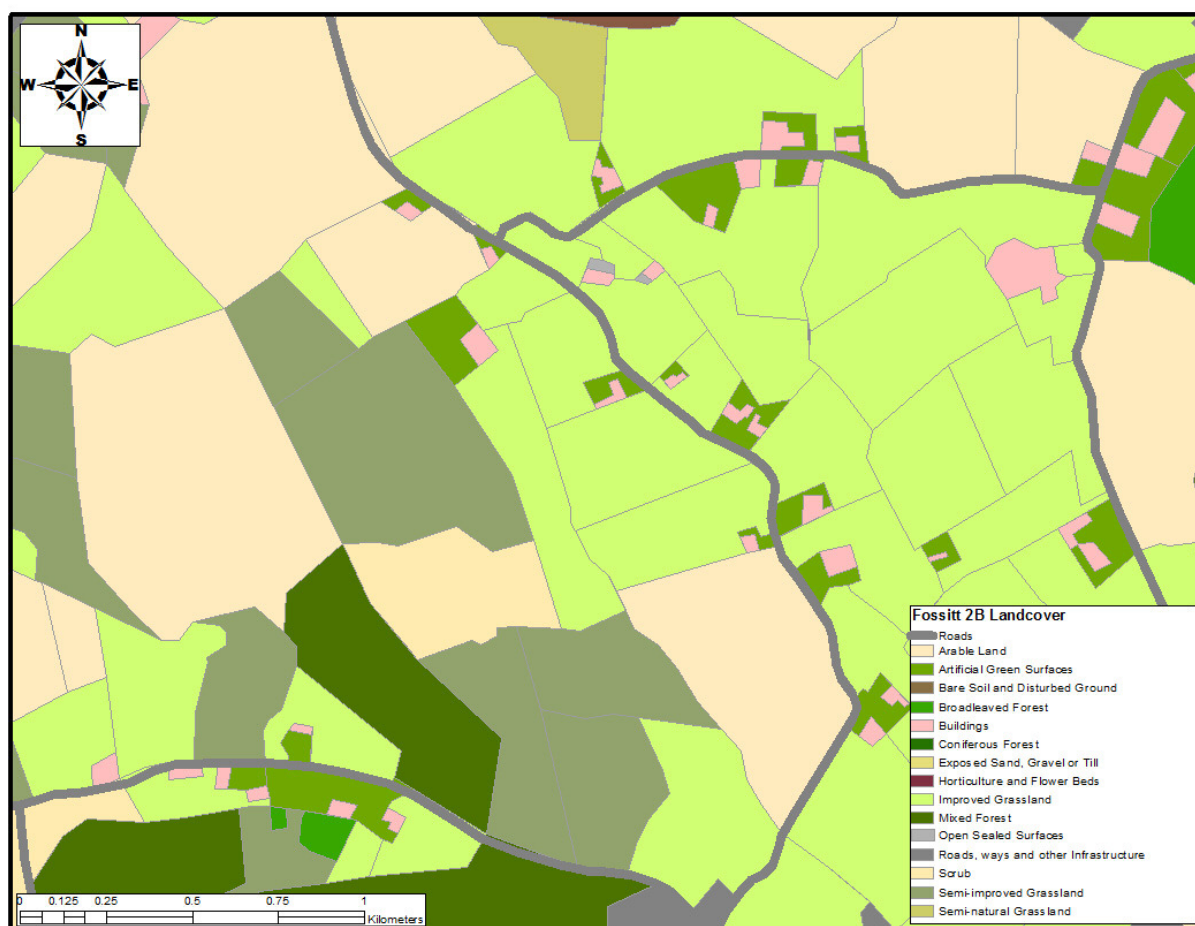


Figure 12: Example of spatial mapping using the level Fossitt 2b land cover classification to demonstrate its application as a support tool in the identification of agriculture lands, and in particular small field parcels. The enhanced spatial resolution at regional level will support enhanced agri-environmental environmental practices and policy making.

What are the benefits of the NLCHMP?

- Facilitates spatial level assessments of agri-environment measures such as: traditional hay meadows and low-input pastures, promoting habitat preservation and practices such as minimum tillage; and, promoting sustainable agricultural actions which are compatible with
 - Enables the study of boundary dynamics between the above and other land use and habitat types as well as habitat connectivity in the wider landscape.
- Provides a baseline characterisation upon which a variety of monitoring programmes can be informed (e.g. expansion of commercial plantations).
- Assists users in quantifying constraints for different GLAS activities and the location of potential additional areas of lands of environmental interest.
- It will provide a tool to support analysis for the suitable siting of different agricultural activities, crop diversification and potentially identify less productive areas; this will be crucial in developing the concept of Functional Land Management at a national scale.
- Supports agricultural related land management applications such as quantification of impervious land cover for storm water runoff modelling, identification of flood attenuation areas, catchment scale drainage requirements and nutrient management plans.
- Facilitates improved management of agricultural lands and Natura 2000 sites by displaying the sites within the surrounding land cover context, thus aiding advisors in the planning of agri-environment actions.

- May help with the strategic assessment of the impact of GLAS in terms of habitat and wildlife conservation.
- The availability of more precise knowledge of land characterisation thereby providing policy makers, regulatory agencies and land use planners with a better evidence base to make informed decisions.
- May be used to aid the identification of high nature value farmland, especially outside Natura areas.
- May facilitate the effective determination of compatible agrarian practices on lands which border the lands designated under the GLAS scheme.

What are the risks associated with maintaining the status quo?

- Insufficient characterisation (resolution) which may lead to inappropriate measures

Scenario 3

A Use Case for Forestry

The User

Forest Service of the Department of Agriculture, Food and the Marine (DAFM). The Forest Service is responsible for the development forestry in Ireland, and its role encompasses forest policy and the promotion of the forest sector; the administration of forestry grants schemes; forest protection; the control of felling and the promotion and support of forest research.

The Scenario

Ireland remains the least forested country in the European Union, with forestry comprising an estimated 10.5% of the land cover, compared to an average EU rate of 35%. Forestry possesses significant national socio-economic and environmental benefits. As such, it is the policy of the Forest Service, under the direction of Sustainable Forest Management (SFM), to increase the cover of forestry nationwide, while ensuring the protection of the environment, and complementary to existing surrounding land uses. The effective deployment of SFM will benefit hugely from enhanced monitoring of forestry land cover change.

There are a variety of spatial data tools currently used within the forestry sector, including the pan-European Forest Map and pan-European High Resolution Layers (HRL), both of which provide data on land cover characteristics, and are complementary to other existing spatial datasets such as CORINE land cover. However, these tend to lack the spatial resolution accuracy at a national (or regional) level to generate appropriately scaled spatial information that facilitates precise land use change monitoring. Thereby, the existing spatial datasets are not effective in providing sufficiently accurate high quality land cover data, and are resulting in the over-estimation of forest area. Furthermore, they fail to adequately monitor time series change, by which to effectively capture forestry land use change.

How the NLCHMP supports the users in undertaking the project tasks:

Currently in Ireland, forest change is not satisfactorily captured by current spatial datasets in use. This is where the national LCHM programme will be of most benefit to the forestry sector. The Forest Service will benefit significantly from the development of national LCHM programme as it will improve the monitoring of forestry land use change, through the provision of consistent time series data for change detection. The programme will also facilitate the Forest Service in a range of other responsibilities, including the implementation and monitoring of legislative and policy requirements.

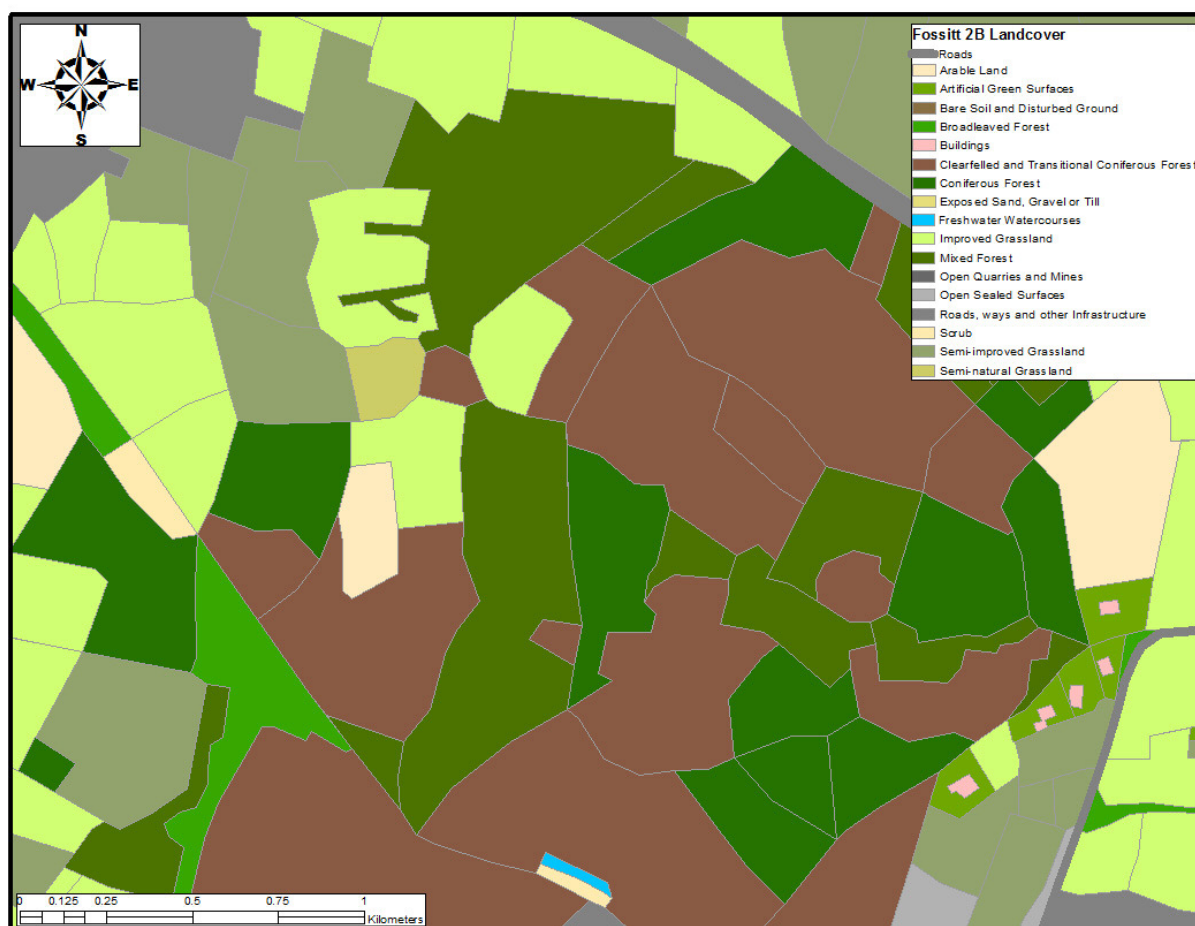


Figure 13: Example of spatial mapping using the level Fossitt 2b land cover classification to demonstrate its application as a support tool in the enhanced identification of forestry lands. The temporal characteristics of the proposed national LCHMP database will facilitate enhanced forestry land cover change detection and support Sustainable Forest Management.

What are the benefits of the NLCHMP?

- The availability of higher resolution data will facilitate the Forest Service in the evaluation of forestry and landscape patterns, and the identification of the availability of suitable lands for future afforestation. It will also assist in the detection of potential land use conflicts, such as new or increased afforestation in proximity to designated sites or sensitive watercourses and help with the implementation of SFM.
- Assists the Forest Service in meeting legislative requirements (for example, the Wildlife Act 1976 as amended, Water Framework Directive (WFD), Habitats Directive, Birds Directive, and Nitrates Directive), through the provision of more accurate data that will help improved reporting of forestry projects.
- At present in Ireland, the Forest Service's iFORIS GIS-based management system for forestry grants is currently used in monitoring afforestation, felling and forest road building operations. The national LCHM programme database will facilitate improved monitoring and reporting of forestry and forest management measures, through increased accuracy at local level, in addition to the provision of data for forest area change detection. These enhanced tools will serve to assist in the improved development and review of River Basin Management Plans, all of which will facilitate the achievement of legislative compliance requirements, such as those prescribed under the WFD.
- The programme will capture over time changes to forestry cover and will help with improved

monitoring and reporting of carbon accounting.

- Assists in applying enhanced forest design measures to ensure that afforestation is in keeping with surrounding landscape, and this will there facilitate a more consistent national and regional landscape approach.
- Supports the Forest Service in the identification of deforestation, both legal and illegal, and with the availability of consistent time series datasets, it will identify the rate at which deforestation is occurring. Existing databases, such as CORINE land cover do not sufficiently detect such level of details to allow deforestation to be sufficiently identified and measured and thus, the national LCHM programme will fill this existing gap in spatial data.
- Forestry plays an important role in water management and subsequently, flood attenuation management. The national LCHM programme will support forestry and agricultural related land management applications such as quantification of impervious land cover for storm water runoff modelling and drainage requirements.
- While the national LCHM programme may not directly detect disease outbreak within forested areas, the availability of spatial time series data will facilitate monitoring the extent of the disease outbreak in forestry plantations, thereby, providing valuable analysis information to the Forest Service.

What are the risks associated with maintaining the status quo?

- While the National Forest Inventory (NFI) provides good national data, it does not provide sufficient resolution at a regional and county level to assess land cover change. This is a significant gap that exists within current spatial mapping datasets whereby incidents of deforestation may proceed undetected.
- Existing databases including CORINE land cover, pan-European Forest Map and HRL do not provide sufficient imagery resolution. This means that smaller field parcels can be difficult to differentiate from the surrounding vegetation.
- Maintaining the status quo means that there is less consistency on a national or indeed regional basis in terms of landscape management planning. Therefore, landscape policy will continue to operate on a county by county basis, with limited cross boundary integration.
- Inefficient land cover and land use mapping datasets may potentially inhibit forestry, agriculture and rural development policies and result in lost investment opportunities.

Scenario 4

A Use Case for Land Use Planning and Water Resource Management

The User

In this use case, potential applications for the National LCHM Programme are described from the perspective of one selected user, **Waterways Ireland**. Waterways Ireland is mandated to manage, maintain, develop, and restore inland navigable waterways primarily for recreational purposes. These waterways are subject to numerous natural and built heritage designations, something Waterways Ireland has to keep in mind when monitoring developments near its waterways and when carrying out its own operations. Additionally, Waterways Ireland is responsible for implementing the Water Framework Directive on their waterways, meaning they must protect the environment in the areas they manage.

Waterways Ireland have to be aware of all developments near their waterways, including the Royal Canal,

so that any impacts arising from these developments on the management, maintenance, development, and restoration can be assessed. Of particular importance to Waterways Ireland is whether a development will affect the drainage system around their waterways, as any changes in the amount or quality of water entering or leaving these waterways will affect how Waterways Ireland manages them.

The Scenario

A construction firm is proposing to build a new residential development in the peri-urban area of Leixlip. The proposed development will comprise a large scale residential development on the eastern periphery of Leixlip, in the land currently zoned for new residential developments under the Leixlip Local Area Plan. This area is near to the Royal Canal. Waterways Ireland is examining the recently submitted planning application for this development to assess if it will:

- Change the water drainage systems into, and out of, the Royal Canal
- Either directly or indirectly damage the habitats along the Canal
- Have any influence of Waterways Ireland's planned future development (e.g. cycleways, recreation sites) or activities (e.g. landscape character assessment)

How the NLCHMP supports the user

Waterways Ireland can use the National LCHM Programme to examine the potential of the development proposal to impact on the Royal Canal. Their ability to quickly determine whether to make a submission to the competent planning authority will be facilitated by the programme.

Firstly, Waterways Ireland is concerned with any implications the proposed development will have on the drainage regime of the canal, as this affects how they manage water levels in the canal. The National LCHM Programme will assist them in this, by allowing them to see how the proposed development fits into the wider landscape, beyond areas for which they may have information.

Secondly, Waterways Ireland has a responsibility to protect the water quality in the canal under the Water Framework Directive. As with drainage, the programme can be used to see how the proposed development might affect water quality, by examining the water flowing into, and out of, the canal might change. Additionally, the Water Framework Directive is concerned not just with water course in isolation, but with the habitats surrounding them as well. Thus, any habitats near the canal that might be impacted by the proposed development must be taken into account, and again the programme will aid Waterways Ireland in assessing this.

Thirdly, Waterways Ireland is concerned with fish stocks within the canal to preserve the angling potential of the canal⁷⁸. Using the National LCHM Programme to help assess how the proposed development will affect the drainage and water quality of the canal, Waterways Ireland will be able to determine if their fish stocks will be impacted by the proposed development.

Finally, as the National LCHM Programme will generate nationwide maps of natural heritage (i.e. habitats) it will allow Waterways Ireland to pursue many of its heritage goals up to 2020¹-. These include updating all its current habitat maps, carrying out Landscape Character Assessments and identifying clusters of heritage feature. Once in place, Waterways Ireland will be able to determine if this proposed development, or any other, will negatively affect the visual and natural heritage along the Royal Canal.

Based on the analysis conducted using the National LCHM Programme and other sources, Waterways Ireland will be able to decide whether submissions are needed to the planning authority to protect their mandate.

⁷⁸ Waterways Ireland (2016) 'Angling on the Royal Canal Hotspots', Available at: <http://www.waterwaysireland.org/Pages/Angling/angling-on-the-royal-Canal-hotspots.aspx>. Accessed 17.05.2016

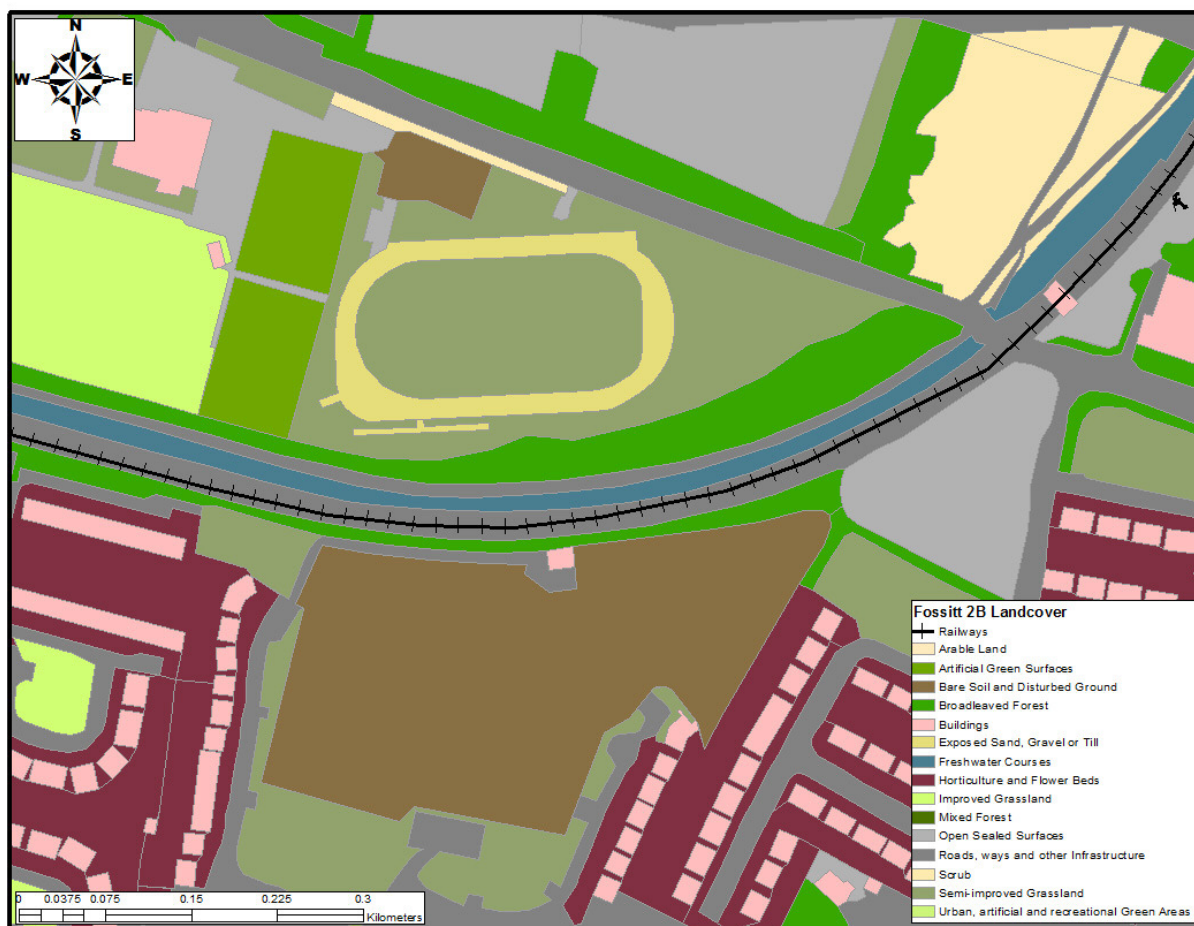


Figure 14: Example of spatial mapping using the level Fossitt 2b land cover classification to demonstrate its application as a support tool for enhanced land use planning. The enhanced resolution and temporal characteristics of the proposed national LCHMP database facilitates improved land cover and land use assessment.

What are the benefits of the NLCHM product?

The availability of accurate spatial data to support the effective and strategic planning of developments is a key element of the area's planning scheme. In contrast to existing land cover data and tools (e.g. CORINE land cover, Myplan.ie, GeoDirectory), the National LCHM Programme allows any proposed development to be placed in the wider land cover context, with the identification of non-protected (but still important) habitats on or near these developments. In summary, the benefits to Waterways Ireland for this use case are:

- Helps assess the impacts from proposed developments on the drainage and water quality of waterways they manage.
- Aids the implementation of the Water Framework Directive on their waterways.
- Allows determination of whether submission to planning authority is necessary.
- More broadly, it helps to achieve the goals of their Heritage 2020 strategic plan.

What are the risks associated with maintaining the status quo?

- Failure to meet the goals of their Heritage 2020 strategic plan, as this requires Waterways Ireland to conduct habitat surveys along the 1000 km of waterways they manage.
- Maintaining the status quo risks compromising on the quality of data available to users such as Waterways Ireland and their ability to make more informed decisions on the impacts of

development proposals within the context of surrounding habitats and land cover.

- The existing individual datasets have varying levels of resolution and without integration (i.e. within the National LCHM Programme), it is probable that different submissions for the same location will result in varied outputs.
- Varying levels of spatial accuracy, and the availability of a comprehensive data base, particularly in rapidly developing peri-urban areas where these issues are critical.
- Mixed reliability of spatial datasets in terms of age, quality and comprehensiveness.

Scenario 5

A Use Case for Air Quality

The User

The hypothetical user is **an academic research team based at a national university**. The team specialises in air pollutant assessment and modelling.

The Scenario

The project focuses on using critical loads for pollutants, in particular nutrient nitrogen, to assess the threat from pollutant deposition to habitats. In the study of air pollution, a **critical load** is defined as “A quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge”. (Nilsson and Grennfelt 1988). The team is interested in studying the impact on the conservation status of sensitive species and habitats listed in the Annexes of the EC Habitats Directive (92/43/EEC) – i.e. SACs and SPAs that form part of the Natura 2000 network. The impact on non-annexed habitats or annexed habitats that fall outside the network, located throughout the country is also of interest.

Air borne pollutants such as nutrient nitrogen can have considerable adverse impacts on human health and the environment, in particular sensitive ecosystems and biodiversity. It can lead to acidification of soils and surface waters, to ground-level ozone formation and to nitrogen loading in terrestrial ecosystems. Nitrogen deposition is recognised as a threat to biodiversity in Europe. It is listed as a ‘potential pressure and threat’ to conservation status in the Commission guidance⁷⁹.

The concept of critical loads is being used across Europe to assess and manage habitats that are sensitive to this type of pollution, and the team wishes to apply this concept in their research. The conservation status of sensitive habitats can be affected if atmospheric pollutant inputs reach their ‘critical load’⁸⁰. This means that if a habitat receives more than a certain amount of pollution (e.g. from agricultural activities such as pig, poultry and dairy facilities and/or other industrial sources), then damage to the habitat is possible.

How the NLCHMP supports the user

The team uses the national LCHM outputs, in combination with other data sources to, i) estimate the extent of nitrogen emissions deposited; ii) locate which habitats will receive these depositions, and; iii) identify habitats that will exceed their ‘critical load’ of pollutants.

⁷⁹ European Commission (2011) Assessment, monitoring and reporting under Article 17 of the Habitats Directive: Explanatory Notes & Guidelines. Available at: https://www.bfn.de/fileadmin/MDB/documents/themen/natura2000/Nat_Bericht_2013/Art17_-_Guidelines-final.pdf/. Accessed 18.05.2016

⁸⁰ EPA (2012) ‘Ireland’s Environment. An Assessment.’ Johnstown Castle, Wexford. Available at: <http://www.epa.ie/about/org/oea/>. Accessed 18.05.2016

The team studies the national habitat data (which includes newly collated habitat information for areas around the country which were not previously mapped) in combination with data on the location of licensed facilities (such as pig and poultry facilities), sourced from the EPA's Pollutant Release and Transfer Register (PRTR). Where available, the team will also use air quality monitoring data from the EPA's Ambient Air Quality Monitoring network⁸¹. Wider land cover and land use data available from the national LCHM programme is also referenced for wider contextual purposes.

The team is then able to apply calculated emissions from the licensed facilities, and model the pollutant dispersal over the landscape, having particular regard to the habitat composition of the area. As pollutants disperse in the atmosphere, they will interact with the surrounding landscape through a combination of wet (rainfall) and dry deposition (e.g. fallout and impaction). Typically, the vegetation in habitats acts as a pollutant sink, removing harmful gases and particles⁸², with some vegetation types acting as large sinks (e.g. trees, forests and hedgerows) and others less so (e.g. grassland, crops). While this results in improved air quality, if the volume of removed pollutants is above the habitat's critical load, that habitat will suffer damage. The National LCHM Programme supports the team in determining habitat-specific estimates of pollutant deposition and identifying the location of particularly sensitive habitats. This allows the team to be spatially explicit in identifying habitats under threat from pollutants generated from the current industrial activity.

CL_{nut}N (5th percentile)

eq ha⁻¹ a⁻¹

- < 200
- 200–400
- 400–600
- 600–800
- 800–1000
- > 1000

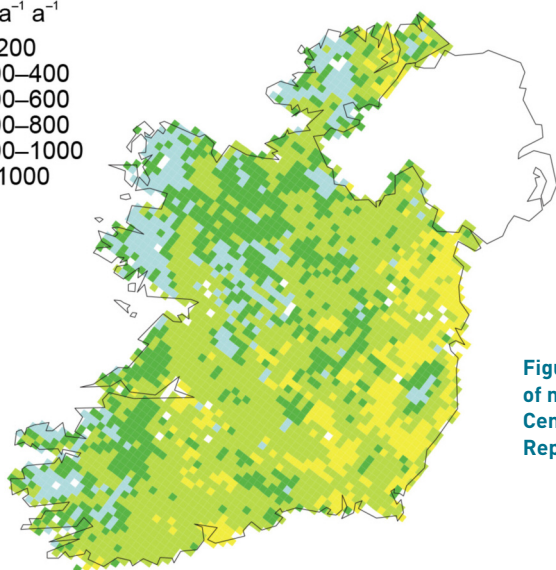


Figure 15: Shows the 5th percentile of the maximum critical loads of nutrient nitrogen (CL_{nut}N) submitted to the Coordination Centre for Effects (CCE) during 2012 (URL: wge-cce.org > Status Report 2012). Critical load units: eq ha⁻¹ a⁻¹.

What are the benefits of the NLCHM product?

- The National LCHM Programme provides full coverage data on all habitats present in Ireland, not just designated sites (SACs and SPAs). It will also bring improvements in the delineation of habitats on a national scale i.e. the location of acid grassland, dry heathland etc. This will make it easier to identify habitats located in areas where pollutants, such as nutrient nitrogen, are reaching their maximum critical load, and to design mitigation action that specifically targets these areas.

⁸¹ Environmental protection agency (2014) 'Air Quality'. Available at: <http://www.epa.ie/air/quality/monitor/>. Accessed 17.05.2016

⁸² Alonso, Rocío, et al. (2011) 'Modelling the influence of peri-urban trees in the air quality of Madrid region (Spain)'. Environmental pollution 159.8, pp.2138-2147. Available at: http://iacenter.ir/uploads/Modelling_the_influence_of_peri-urban.pdf. Accessed 19.05.2016

- It will support the ongoing monitoring of habitats for which critical loads of air pollution are being exceeded and will enhance understanding of how changes in air quality impact on designated and non-designated habitats.
- This information can be used to revise and update critical load maps, i.e. to identify the location of sensitive habitat and set new critical loads and will assist and support the EPA, the DAHRRG and other national actors in the reporting of National Critical Load data to the Convention on Long Range Transboundary Air Pollution (CLRTAP)
- It will support greater coordination in approaches to deposition and sensitive ecosystem mapping.
- The National LCHM Programme improves on the Prime2 data by expanding the number of land cover classes to thirty-two, allowing a much more detailed examination of evaluation of the land cover context. It also offers a much higher spatial resolution than CORINE land cover. This facilitates examination of the interaction of air pollutants with the surrounding environment at a much more detailed level than is currently possible. This allows users to identify precisely which habitats and populations are vulnerable to air pollution from wider land use activities.
- There is potential to use this information to also reduce social impacts and expenditure on public health care, agricultural losses and water treatment and to more accurately identify sources and establish the extent of environmental liability.
- It will support scientific researchers in the evaluation of potential air emissions impacts, facilitating more informed decision making in respect of pollution abatement, and the protection of the environment and human health.

What are the risks associated with maintaining the status quo?

- The absence of a comprehensive national habitat dataset undermines the quality of research on the interactions between air quality, land cover and habitats.
- Existing land cover datasets either have extremely coarse spatial resolution (CORINE) or poor land cover discrimination (Prime2). National scale assessments on habitats vulnerable to air quality pressures and threats are currently not possible.
- Risks to the quality and ecosystem functions provided by non-designated, but important habitats, as potential air pollution impacts on these habitats fail to be detected (as these habitats are less likely to be mapped than those falling within the Natura 2000 network).
- A risk of failing to identify sensitive environmental or human receptors within the vicinity of a potential air pollution source and consequently not imposing adequate control and abatement measures may compromise environmental quality and public health.

Scenario 6

A Use Case for Land Use Planning

The Users

A privately owned Irish property development company with substantial experience in developing high quality business parks and residential developments throughout the Greater Dublin Area.

The Project

The developer is interested in new investment opportunities in the Dublin Docklands. The company

recognises the value of this strategically located area and plans to acquire a site in the Docklands area that would be suitable for a new mixed use development scheme. The proposed development will comprise a commercial and residential development on the south side of the River Liffey which will provide in excess of 18,000 square meters of office and commercial space, in addition to 80 residential apartments. There are two main stages to the project:

- Site Acquisition
- Planning and Design

How the NLCHMP supports the users in undertaking the project tasks:

- Site Acquisition

The developer is reviewing potential development sites within the docklands. Following a comprehensive review of the area, a short list of three suitable sites is agreed. Due diligence assessments are carried out to help determine the preferred site. As part of this process and due to the proximity of the three sites to the River Liffey and a series of other waterways including the Grand Canal, River Dodder, the Royal Canal, and Dublin Bay, the vulnerability of each site in terms of flood risk is of interest. The national datasets are referred to identify the locations of watercourses in the vicinity of the docklands area, the proximity to existing buildings, roads and other infrastructure, and the location and extent of open artificial surfaces and urban green areas in the area of interest.

The sites are also assessed in terms of land use zoning, proximity and access to surrounding road networks, location of public transport access points, nature and character of surrounding land uses, proximity of waterways, and any sensitive habitats etc. In doing this, the national LCHM data programme proves beneficial in providing a strong information base from which to make an informed decision, as it provides many of the land cover data sets required for this aspect of the project.

- Planning and Design Stage:

Compatibility with surrounding land cover and land uses is essential to the success of this development application. Careful regard is afforded to the character of the surrounding area, including features of the natural environment, and land uses. Information on sensitive habitats obtained from the data product indicated that there are several Natura 2000 designated sites within the vicinity of the site. Consequently, **screening for Appropriate Assessment** is undertaken to determine the effects, if any, of the proposed development and associated features on European sites and to assess the potential for significant effects on the qualifying interests or on the conservation objectives of these sites. By considering the location of the designated sites in context with surrounding land cover, the datasets assist in making an informed judgement as to the potential impacts of the proposed development on the qualifying interests of European sites.

Due to the nature of the planning application and the scale of the development, **an Environmental Impact Assessment (EIA)** is required to accompany the planning application for the proposal. The availability of the datasets proves a supportive tool for the applicant in undertaking various EIS chapters. For example, the data product is utilised as part of the Roads and Transportation section to determine baseline information on existing roads, junctions and other infrastructure such as bridges in the immediate vicinity of the site and surrounding access routes.

What are the benefits of the NLCHMP to this project?

The convenient availability of accurate land cover, habitats and land use data can support a private developer in the following ways:

- Supports due diligence assessments on the characteristics of sites under consideration for acquisition;

- Facilitating more efficient integration of environmental impacts considerations the development application process;
- Supports the AA and EIA processes by providing an easily accessible information base that can be referred to by the many different professionals involved in the preparation of these assessments, including planners, engineers and ecologists. This promotes consistency in assessment and report writing processes, and helps to identify interdependencies between key areas, saving time and money;
- Efficiencies gained in planning and design timescale and costs;
- Facilitates the identification of potential land use planning conflicts at an early stage in the planning and design scheme.
- Acts as a support tool in the integration of new developments with elements of green infrastructure, an important feature in a rapidly growing urban environment such as the Dublin Docklands.

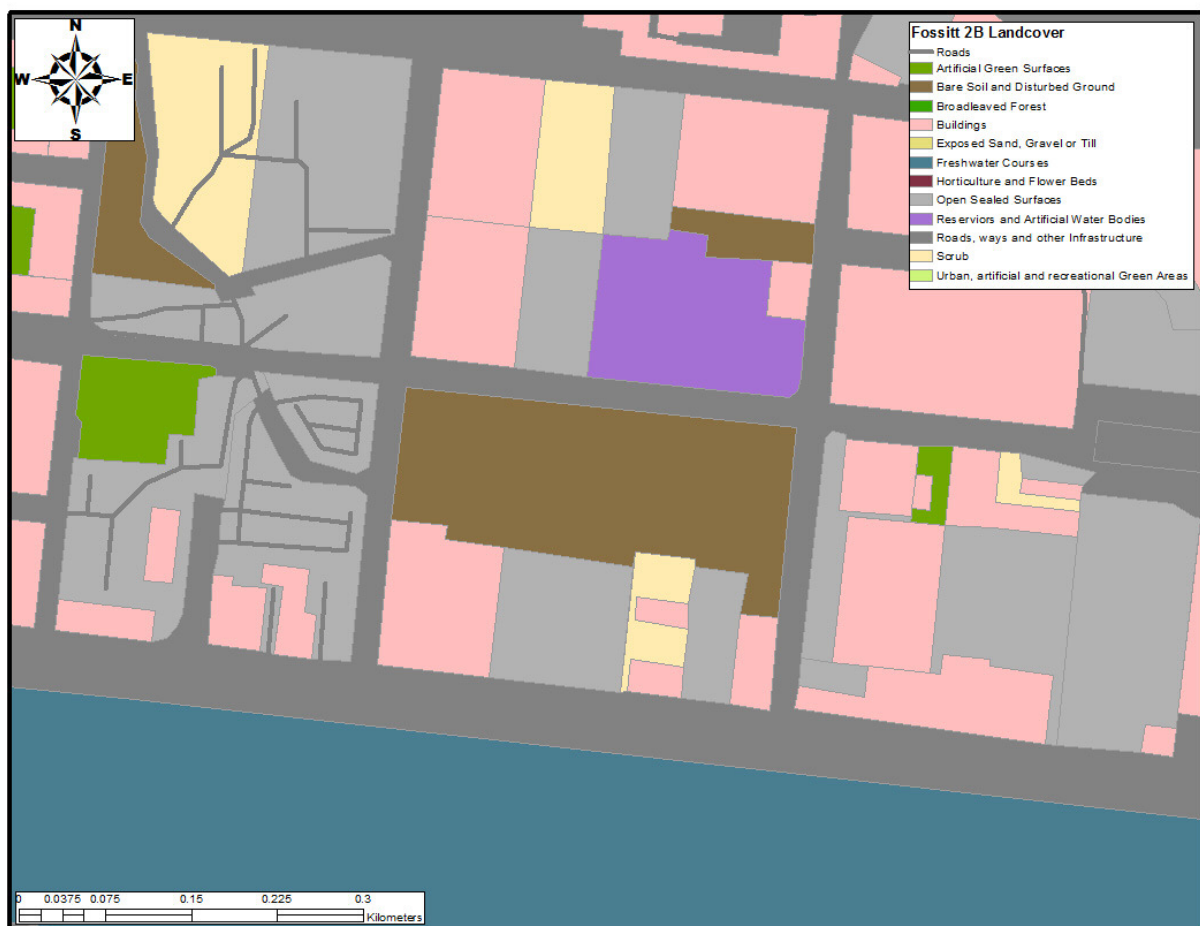


Figure 16: Example of spatial mapping using the level Fossitt 2b land cover classification to demonstrate its application as a support tool in urban land cover and land use planning.

What are the risks associated with maintaining the status quo?

- Maintaining the status quo risks compromises on the quality of data available to users (e.g. policy makers, planners, developers) and the ability to make more informed decisions at all stages of land use planning.

- Developers may not be aware of the land cover, habitats and land use datasets available to them that could support them in the planning and design of new developments. In turn, this may give rise to the delays in the planning process which can incur unexpected costs and compromise the capacity to deliver in demand development types such as housing or office space.
- Many existing individual datasets provide varying levels of resolution making it harder to gain a complete overview of the characteristics of an area, particularly a high density urban area such as the Dublin Docklands.
- Access to relevant spatial data and data sharing agreements vary significantly depending on organisational permissions which can impede efficient decision making process.
- Varying levels of spatial accuracy will remain, resulting in continued mixed reliability of spatial datasets in terms of age, quality and comprehensiveness.

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