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Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Geological Survey Ireland Research Roadmap



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ABOVE Sea Cave at Rinoe Beach,
County Mayo © M. McPherson

FRONT COVER Glencarbury Barytes Mine
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Foreword

The Geological Survey of Ireland has been engaged in geoscience research since it was founded in 1845 and research continues to underpin our activities today. The nature and pace of this research has waxed and waned considerably, and moved from the basic understanding of Irish geology, as the country was geologically mapped in detail, to targeted studies and increasingly applied projects. In the 1980s the Geological Survey was reconfigured to move away from basic research, ceasing publication of its own Bulletin and instead concentrating on completion of modern mapping and development of more stakeholder services. The mapping programme required a great deal of research targeted at specific issues and map sheets, and a number of internal programmes provided considerable funding for this. A step change in geoscience research funding was achieved in 2007, when our parent government Department recognised geoscience as one of three key areas of interest that was not attracting adequate national funding. Thus, the Griffith Geoscience Research Awards were developed, which provided €10m to build capacity in the third level sector on the island of Ireland.

More recently the Geological Survey has made a further transition with the development of major new data gathering initiatives and stakeholder driven projects, all of which lead to research questions which need to be addressed if our outputs are to be of the highest quality. In 2012 the Geological Survey, along with the Royal Irish Academy, Geological Survey of Northern Ireland and Institute of Geologists of Ireland, was successful in having *“Geoscience underpinning the economy”* included as a topic in the Science Foundation Ireland Research Centres call. This led to the creation of the new Irish Centre for Research in Applied Geosciences (iCRAG). iCRAG which commenced operation in 2014, with

SFI funding of €18m along with an additional €8m from industry partners, is on schedule to engage up to 100 researchers across key applied geoscience themes. The Geological Survey Ireland is delighted to be involved in many areas of iCRAG’s operations from the Executive Management to Technical Advisory Committees and project co-supervision. This exciting new development is a game changer for Irish geoscience research with government funding from SFI and additional support from industry partners and European Regional Development Funds. The Geological Survey has now taken the opportunity to reassess how best we can fulfil our research role as data provider, funder and active partner, both nationally and internationally in this new research landscape. We have therefore developed a new Research Roadmap which takes stock of our position to date and sets out a new Research Programme for the coming years. In recognition of our previous initiatives, the new Research Programme will include a biennial Griffith Geoscience Award; an individual award to an excellent scientist to advance pioneering geoscientific discoveries at an international level.

This Research Roadmap sets out how we see our role in further developing geoscience research and I welcome your views on our proposals. Our goal is to improve our research services and develop our key role as the national geoscience agency.

Finally I wish to thank all of those who have contributed to this document already, in particular our close contacts in other research organisations and funders, our own staff and in particular our Research Manager Aoife Braiden who reviewed and compiled the sometimes diverse views into a single whole!

Koen Verbruggen, Director
November, 2016

Background and context

The Geological Survey Ireland was established in 1845 to facilitate the completion of a Geological Survey of Great Britain and Ireland. Since then it has evolved to act as the Irish national geoscience agency and provides geological advice and information to government, industry and the public, and to acquire data for this purpose. The 1970s and 1980s was a period of active research by our staff before an organisational review led us to refocus on mapping, mineral exploration support and data acquisition from the early 1990s. However, since the mid-2000s, we have again included research to underpin the key objectives of the organisation. In addition to the research activities now undertaken by staff of the Geological Survey, we have supported geoscience research in Ireland through direct research funding to, and collaborations with, external research partners. Much of the day-to-day work of several sections of the Geological Survey involves research activities (e.g. publishing academic articles, presenting at research conferences and generating data and data products used directly for research purposes both in-house and externally). These activities benefit the organisation through better understanding of the geological problems being addressed by the Geological Survey but also contribute to the wider research community. It is envisaged that these activities will grow and strengthen through strategic planning internally and further development of external collaborations.

The aim of the Geological Survey's Research Roadmap is to define our vision for the sector and create a cohesive geoscience research programme of work to maximise the impact of investments in this area. This Roadmap encompasses all current Geological Survey Ireland research activities while reflecting the changing research landscape in Ireland and internationally. It will complement and support our internal applied geoscience and mapping programmes as well as external related research programmes. It will also support the delivery of Action 4.21-4.24 from Innovation 2020¹, Ireland's Strategy for Research and Development, Science and Technology.

Geoscience Research Internationally

The geoscience sector is essential to all aspects of our world today including groundwater resources, raw materials for construction and technology industries, secure energy supplies, environmental monitoring and risk mitigation. Only by improving our understanding of Earth's resources and Earth systems can we improve resources management, help reduce environmental impact and risk, develop efficient and clean energy systems and improve our quality of life. To achieve this, geoscience researchers must actively engage in all areas of society including academia, industry and policy development.

The recent United Nations Agenda for Sustainable Development outlines 17 goals in their action plan for 'people, planet and prosperity'². These goals include;

- Ensuring sustainable consumption and production patterns (Goal 12)
- Taking urgent action to combat climate change and its impacts (Goal 13), and
- Conservation and sustainable use of the oceans, seas and marine resources for sustainable development (Goal 14)

Along with other goals focussing on food production, protection of ecosystems and safer and resilient societies, achieving these goals requires a better understanding of our natural systems and increased investment in geoscience research, not just to the benefit of Irish citizens but to address global issues.

As stated by the American Geological Institute's report on Critical Needs for the 21st Century, "strategic and prudent investments in the geosciences are essential to integrate scientific understanding into effective national policies"³. To help realise this, the primary research funding body in the US, the National Science Foundation, has allocated over 20% of their \$7.7bn 2016 budget to its Geosciences Directorate and Earth Sciences Division. The geoscience budget includes \$14.8m for Innovations at the Nexus of Food, Energy,

The Geological Survey Ireland will position itself on the global geoscience research stage by engaging at the highest level through its contribution to public, social and economic policy, and increasing the impact of its research outputs

and Water Systems (INFEWS)⁴, emphasising the need for interdisciplinary research in Earth resources, food and energy production.

Europe is also striving to improve its economy and quality of life for its citizens through greater knowledge and understanding of the Earth; geological surveys across Europe have a vital role to play in this work. Internationally, geological survey organisations range from dedicated research institutes to regulatory bodies providing essential information to users and stakeholders. In addition, they support industry and enterprises through the provision of geological data, maps and derived products. For example, the economic value to the EU of raw materials (excluding tobacco, textiles, printing and wood) is estimated to be €1.5bn and over 30million jobs are directly reliant on access to raw materials^{5,6}. EuroGeoSurveys (EGS, the umbrella organisation representing 37 National and regional Geological Surveys in Europe) has recognised the need for joint research programmes to support industry and EU policy and tackle social challenges that require knowledge of Earth systems. Members of EGS contribute significantly to geoscience research through direct outputs such as peer reviewed publication and derived products (maps, datasets) and indirectly through wider support mechanisms⁷.

Members of EGS and their regional/national funding agencies also support geoscience research through external funding programmes and/or pan-European programmes such as Horizon2020. The European Commission's Horizon2020 programme is supporting research under three key pillars; *Scientific Excellence*, *Industrial Innovation* and seven *Societal Challenges*, and across four cross-cutting themes including *Science with and for Society* and *Joint Research Centres*. Under this structure, geoscience research underpins all pillars and themes with specific relevance to energy, raw materials, spatial planning and land use, food production, water resources, Earth observation, cultural heritage and the marine environment. Of the

€80bn funding available across the Horizon2020 programme, Ireland has set an ambitious target to drawn down over €1.25bn⁸. The Geological Survey Ireland intends to be a key collaborator and leader in this programme.

Geoscience Research in Ireland

Value of geoscience to the economy

A study carried out on behalf of the Geological Survey Ireland estimated that in 2006 the geoscience sector in Ireland employed 1.4% of the working population (over 30,000 people) but accounted for 3% of GNP (€4.6bn) to the economy⁹ (this excluded the considerable local and national economic value of the Geoparks geotourism and educational programmes).

In 2012, from mining activities alone, it is estimated that the exchequer received over €54m¹⁰. The direct economic value of mining activities (measured by sales turnover) amounted to €426 million across all regions of the country. This does not include indirect support services; the combined direct, indirect and induced impact of expenditure in the mining sector is estimated to be approximately €810 million per annum.

Estimates from 2014 indicate that the value of the offshore oil and gas exploration and production sector to the economy was approximately €144m¹¹. A PWC study of oil and gas potential in Ireland¹² investigated possible barriers to foreign direct investment. After appropriate tax incentives and infrastructure, one of the primary recommendations was the provision of excellent data sets. Specifically, geological and geophysical data, and related research, is required to inform key investment decisions.

In 2012 it was estimated that the marine sector was worth approximately €1.4bn (Gross Value Added) to the Irish economy. This accounts for 0.8% GDP and almost 18,500 jobs (FTEs)¹¹ and includes established industries (e.g. fisheries, hydrocarbon exploration) and

Geological Survey Ireland will help develop and maintain focussed, impactful investment in geoscience research in Ireland

emerging industries (e.g. marine renewable energy, high-tech marine products and services), all of which require high level research and development skills and investment in research infrastructure.

In Ireland, between one quarter and one half of all water supplies come from groundwater, with up to 100% of public supplies fed by groundwater systems in some counties. These sources are essential in providing plentiful, clean water not only to homes, but also large scale industries and services. To be able to attract foreign direct investment, expand our existing ecosystem services and provide employment in areas such as the bottled water industry, stakeholders must be able to access high quality data and derived products in relation to our groundwater systems.

Further growth in these sectors will rely on significant investment in geoscience research to strengthen the industries and support the development of expert technical and academic groups working in these sectors. As stated by the 2013 PWC¹² report the context of the hydrocarbons industry (though this could be applied to all areas of geoscience);

“Ireland should aspire to developing niche knowledge-based specialties and capabilities to enhance its attractiveness to multinationals for Research and Development”

Partnerships for Society and Policy Development

Geoscience research in Ireland spans a wide range of sub-topics and commonly necessitates multi-disciplinary research. For example, EU Directives such as the Framework for Maritime Spatial Planning¹³, the Marine Strategy Framework Directive¹⁴ (MSFD) and the Water Framework Directive¹⁵ (WFD) rely on robust multidisciplinary research and long-term monitoring of natural systems. These Directives were established to help protect and develop our natural resources for the benefit of our economy and society. Identifying potential resources, and managing the use of those



resources, requires excellent research in areas such as geology, mapping and monitoring techniques, environmental science and remote and *in situ* earth observation along with fisheries management, transport, infrastructure and security. Such research informs local and national policy within the scope of the EU Directives and national legislation.

Geohazards and the Environment

The Geological Survey is engaged in assessment, monitoring and management of geohazards. This includes research into understanding both the underlying hazards and the associated risks and requires input from experts in risk mitigation and vulnerability. For example research into landslides in Ireland instigated and coordinated by the Geological Survey, has proven invaluable in relation to landslide hazard estimation, geotechnical engineering solutions and environmental impact and planning regulations. The national landslides database and Landslides Susceptibility Map for Ireland have been produced in collaboration with research partners from geology, geotechnical engineering, agriculture and Government.

As the lead agency for tsunami hazard response for the Office of Emergency Planning, and a member of the response committee for volcanic hazard response, the Geological Survey is engaged in research supporting the understanding, and improving



Marble Arch Caves,
County Fermanagh

forecasting, of tsunami risk. In particular, this research is undertaken in collaboration with academic experts in the areas of mathematics, oceanography, marine geology, marine geophysics and volcanology.

Mapping and monitoring of groundwater resources (and potential associated hazards in relation to flooding) is a significant part of the Geological Survey's work. This includes collaborations with the Environmental Protection Agency, local government and the public to ensure the availability of clean groundwater resources. Research into hydrogeological systems, including karst and sand and gravel aquifers, is essential for characterising groundwater resources and developing appropriate protection schemes.

Geoheritage and Geotourism

Complementary to legislative and policy development, protection of geological heritage and public perception of geoscience activities are increasingly becoming key elements of social, economic and infrastructure development projects¹⁶. Research undertaken in these areas allows us to more fully understand the significance of our geological past while planning for our future. Ireland currently hosts three UNESCO Global Geoparks developed in collaboration with the Geological Survey Ireland (The Burren and Cliffs of Moher Geopark, Marble Arch Caves & Cuilcagh Mountain Park and the

Copper Coast Geopark) with potential for further development of additional locations to this status. Geoparks are defined as

'...areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education and sustainable development. A UNESCO Global Geopark uses its geological heritage ... to enhance awareness and understanding of key issues facing society, such as using our Earth's resources sustainably, mitigating the effects of climate change and reducing the impact of natural disasters.'

UNESCO Global Geoparks; Celebrating Earth Heritage, Sustaining local Communities 2016¹⁷

The aim is to raise awareness of our geological heritage, connect people-to-place and provide opportunities for communities to benefit from their local resources through sustainable geotourism. The Geoparks also provide excellent natural laboratories for local schools, educators and researchers.

Government, Academic and Enterprise Partnerships

One of the key visions for Ireland is the role enterprises can play in addressing grand challenges through partnerships in research and innovation. In response to calls for investment in geoscience research, the Geological Survey and academic partners identified key areas of national interest. From this groundwork, the Irish Centre for Research in Applied Geoscience (iCRAG) was established in 2015 providing a €26m investment over six years for a range of applied topics including hydrocarbons, raw materials, marine geology, groundwater and big data processing. In parallel to these applied themes, iCRAG will also develop methodologies in geochemistry, geophysics, 3D geological mapping and progress the new research area of Public Perception and Understanding. The Centre is co-funded by

Science Foundation Ireland, the European Regional Development Fund and industry partners. This is the largest single investment in geoscience research in Ireland and has raised the profile of this sector. It has provided a platform for researchers to highlight their contribution to topics relevant to our society, environment, energy, economic growth and resource sustainability.

Through centres such as iCrag and partnerships with industry clusters such as Geoscience Ireland, the Geological Survey can ensure geoscience research in Ireland is high quality, relevant and impactful. The benefits to society will be evident through job creation, informing public policy and legislation and development of research skills for long term sustainability of the geoscience sector.

The Geological Survey Ireland in the Irish geoscience research funding landscape

In Ireland, the annual combined spend by Science Foundation Ireland (SFI) and the Irish Research Council (IRC) on Earth science/geoscience research is less than €5.5m¹⁸, approximately 0.03% of total annual funding available from the two primary research funders. Given the global and national need for geoscience information to underpin all aspects of social and economic development, the annual investment must be increased while remaining focussed and effective. The Irish Petroleum Infrastructure Programme (PIP) contributes a further €600,000 on average per annum through petroleum industry sponsored research; this funding is focussed on onshore and offshore research to primarily support the hydrocarbons industry.

The Geological Survey funding schemes currently support geoscience research through approximately €1m per annum in direct funding to researchers in academia and industry each year. Both applied and basic research activities are funded across all areas of geoscience. A proportion of this funding is used to co-fund research with external partners such as Science Foundation Ireland, the Irish Research Council and other national and international agencies.

In addition to research supported through the provision of data and derived products to the research community, we have directly funded academic

researchers via programmes such as the Griffith Geoscience Awards (GGA). This programme was launched in 2007 and aimed to build capacity on the island of Ireland in a number of specific areas of geoscience. The awards focussed on supporting excellent geoscience research groups to generate expertise and to help senior postdoctoral researchers to develop their careers. The programme concluded in 2015 with over €9m awarded to nine projects ranging from basic research to outreach and education.

In 2008, 2009 and 2011 the INFOMAR marine mapping programme provided funding for small scale, short term projects (approximately €300k in total per call). An independent review of INFOMAR in 2013¹² reported that researchers funded under the applied research programme rated the programme “very highly” including the excellent data available for research purposes. The report also estimated EU funding leveraged through INFOMAR to be approximately €2.2m (between 2008 and 2013).

Similarly, the Tellus Border Project (funded by INTERREG IVA) provided a total of approximately €890k funding between 2010 and 2013 for short term research projects and postdoctoral research fellowships. The research added value to the Tellus Border Project and directly benefited the researchers and their stakeholders¹⁹. Tellus and INFOMAR research projects, and the Griffith Geoscience Awards, have been utilised effectively by the research community (both in academia and industry) and in many cases have leveraged additional, larger scale funding from exchequer and non-exchequer sources; the Griffith Geoscience Programme alone allowed participating universities to leverage 5 times the initial €9m investment²⁰.

Although the projects and programmes highlighted were largely successful, in light of the significant changes to the geoscience research landscape in Ireland, and following a recent review of the Griffith Geoscience Awards²⁰, it is recognised that new areas of interest and changes to funding mechanisms will enhance future geoscience research in Ireland. This will include further development of internal Geological Survey Ireland research programmes and active involvement with external partners and large scale research programmes such as iCrag and Horizon2020.

Geological Survey Ireland vision and goals

The Geological Survey Ireland is focussed on supporting and leading excellent research across a range of topics relevant to our evolving society and economy.

Strategic Vision

The Geological Survey Ireland, as the national geological agency, contributes to sustainable national development and environmental protection by providing decision-makers and stakeholders with geological information from comprehensive and up-to-date national geological databases²¹. We also provide outreach and educational information to increase the public's appreciation and awareness of geology, geological processes and the role they play in influencing and enhancing our everyday lives.

This vision is supported by the Principal Goals²²:

- To support sustainable development of Ireland's natural resources
- To provide reliable geoscience support for environmental protection and effective spatial planning
- Complete geological surveys and mapping in priority areas in response to the needs of specific sectors and customers
- To support the knowledge economy through the provision of access to geoscience databases and supporting business development, priority research and education services.

The Geological Survey Ireland Research Roadmap will underpin each of these goals through supporting the development of new knowledge and improving our understanding of the natural world.

The Geological Survey Ireland, acting as the national geological agency, contributes to sustainable national development and environmental protection by providing decision-makers and stakeholders with geological information from comprehensive and up-to-date national geological databases and derived products.

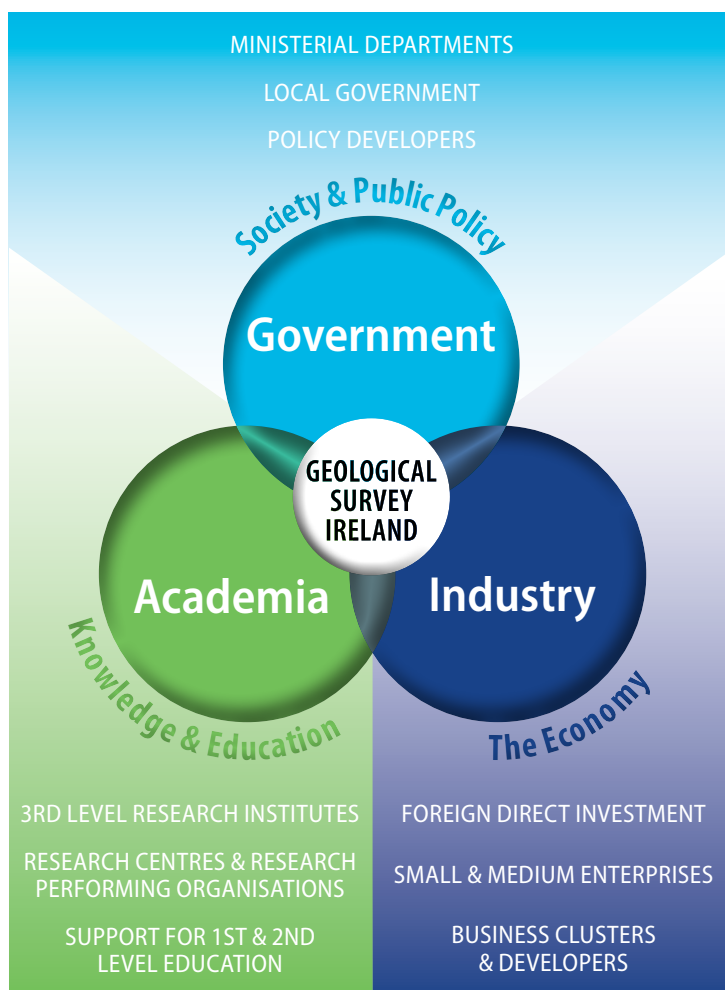


Gurteen, Connemara
© M. Fleming

Key stakeholders

The Geological Survey supports geoscience research across both the private and public sectors with key stakeholders ranging from government to industry and academia. These represent consumers of its data, advice and research outputs, research collaborators, or may have an oversight role in its activities. Our derived products and research results are used by external stakeholders to inform policy and economic decisions and to underpin basic and applied research (in some cases, individual stakeholders may fulfil more than one role).

The benefits of academic-industry collaborations have been recognised in the UK by the Dowling Report, 2015²³. This report shows that private sector organisations that invested consistently in research and development (R&D) (usually with academic partners) reported productivity 13% higher on average than firms that did not invest in R&D. These companies also reported greater labour productivity growth; 51% of growth was attributed to research and innovation activities.



The Geological Survey Ireland Research Roadmap aims to interconnect our external stakeholders to maximise the impact of basic and applied geoscience research outputs.

In a wider context, the Dowling Report recognised that academic-industry collaborations contribute significantly to general economic development. Evidence has shown that private sector R&D investment is greater where government funded research is greater^{24,25}. This is reiterated in Ireland's National Enterprise Policy 2015-2025²⁶, which states that it is the responsibility of Government, and its agents, to support and strengthen these collaborations to ensure greater impact and benefit to society and our economy. The Enterprise Policy includes goals such as:

- (i) increasing the number of higher skilled workers with tertiary education,
- (ii) increasing economic competitiveness, employment and foreign direct investment, and
- (iii) increasing R&D activity in firms of all scales and academic-industry interactions.

Fig. 1 Geological Survey Ireland's key stakeholders

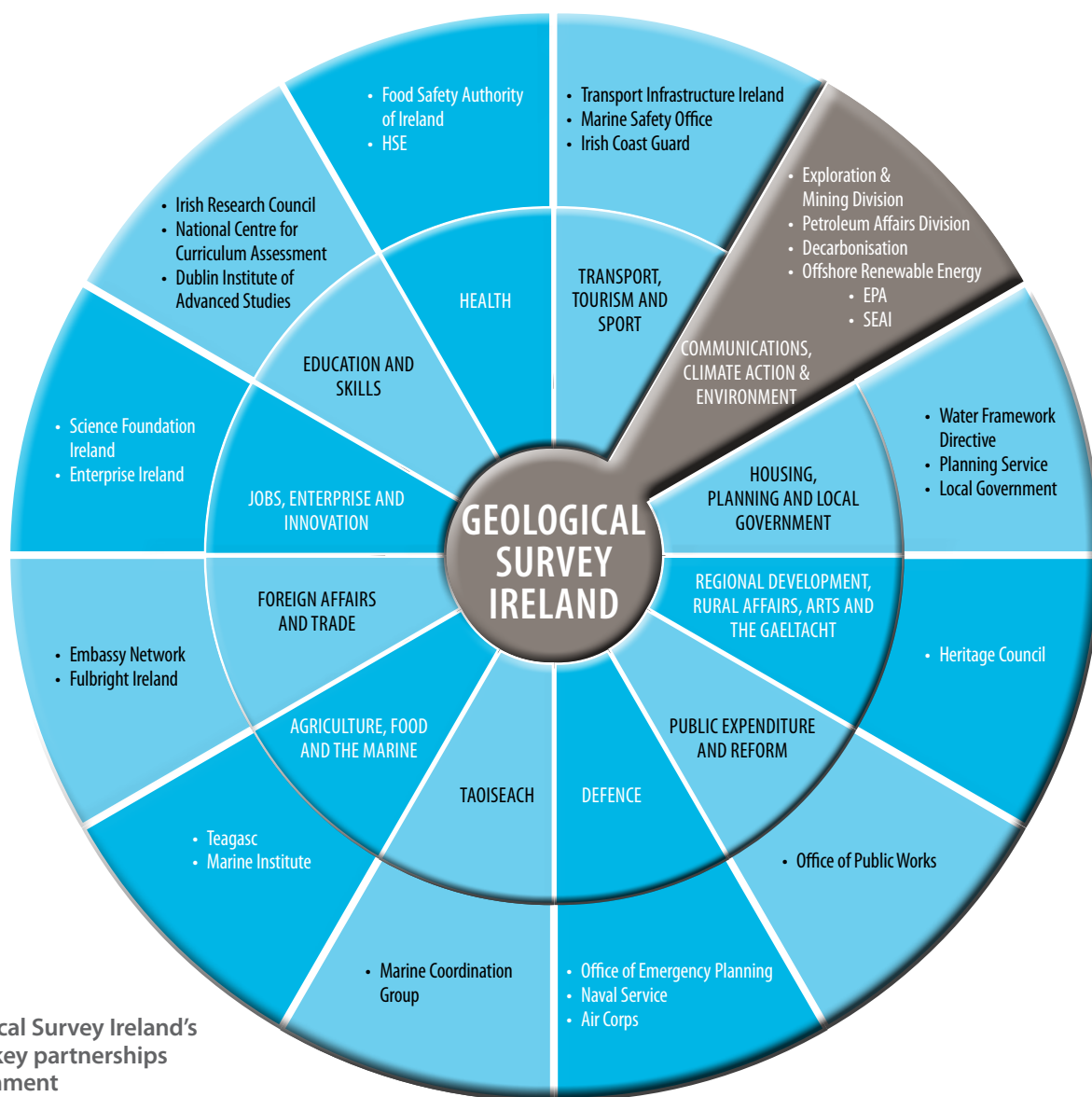


Fig. 2 Geological Survey Ireland's position and key partnerships within Government

Increasingly multi-agency collaborations are required to tackle widespread and devastating hazards such as flooding; understanding the subsurface and interaction with climate variations is essential. Similarly, mapping programmes such as INFOMAR and Tellus support not only better resource management but also provide vital information enabling economic development in multiple sectors (e.g. agriculture, marine transport, fisheries, tourism, mineral resources, energy etc).

International legislation and policies such as the European Water Framework Directive and Marine Strategy Framework Directive require high resolution,

high quality data, derived products and research outputs. The incorporation of data, methodological expertise and systematic investigations informs national and international policy decisions. The translation of research results for the benefit of society is essential. Combined with public debate and dissemination of knowledge, geoscience research can underpin multiple aspects of modern society and support the development of public policy, legislation and national strategies. Through working with partner agencies, government departments and the wider geoscience community, research can help to inform government and international policy.

Scope of Geological Survey Ireland Research Roadmap

In line with our vision and goals, we will support national economic and social development and environmental protection through its Research Roadmap. This will be achieved through three key challenges that society faces today:

1. Sustainability of Earth Resources
2. Risk Mitigation for Geological Hazards
3. Public Perception of Geosciences & Citizen Science.

By addressing these challenges, we can deliver greater benefits to society, improve the economic impact of geoscience research and increase our knowledge of Earth systems, thus improving management of our natural resources. These three challenges provide the Geological Survey with significant scope to strengthen national and international partnerships with research outputs relevant to the geoscience sector across the globe.

Challenge 1: Sustainability and Management of Earth Resources

Ireland is a significant producer of base metals, with a large aggregate extraction industry and prospective producer of hydrocarbons. However, numerous studies have investigated the current strain on our planet's natural resources. Though society's aim must be to reduce and reuse as much as possible, there is still a need to identify and exploit natural resources (e.g. critical elements for the production of green energy technologies, water resources, geo-energy etc.). The global population is expected to reach 8 billion by 2025²⁷. Therefore it is essential that society addresses the challenge of sustainability and management of our Earth's natural resources.

For extractive industries the focus must be on the whole 'value chain' within the Circular Economy (i.e. exploration, exploitation, processing/refining, recycling and reducing waste, and substitution) with particular attention paid to Critical Raw Materials and Rare Earth Elements²⁸.

For non-extractive industries (e.g. geotourism and in this context groundwater) the emphasis must be on sustainability and protection of the resources. These should be supported by high impact, relevant outreach programmes and engagement with society.

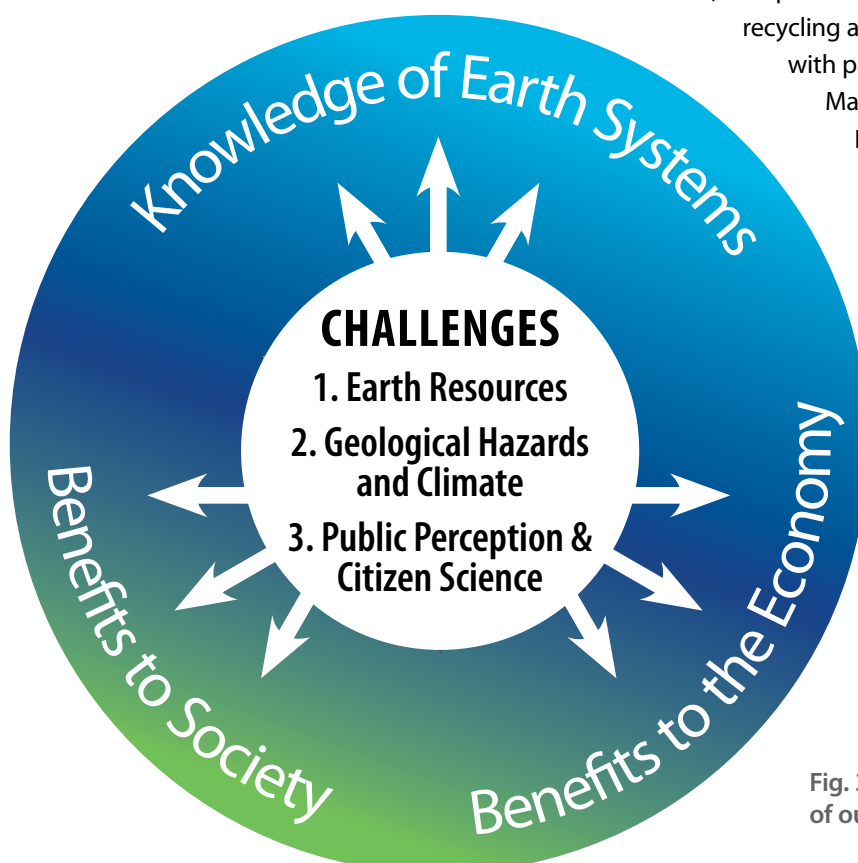


Fig. 3 Key challenges and impacts of our research activities

Lough Nahanagan, County Wicklow © N. M. Noller;
Landslide, Connemara © James Barry;
Oughtmama, The Burren © S. Tomkins

Challenge 2: Risk Mitigation for Geological Hazards

The term *geological hazard* is used in this context in the broadest sense. It includes not only extreme and sudden events such as tsunamis, earthquakes, volcanic ash etc. but also geological effects on infrastructure and the environment over longer time scales. These may include the effects of climate change on coastal or geologically vulnerable areas, environmental pollution interacting with geological systems (such as complex groundwater flow pathways), or changes in the geo-engineering properties of natural materials leading to long term problems with large scale infrastructure projects.

The key to reducing our vulnerability to geological hazards is to more fully understand both the hazard (i.e. the geological processes involved) and the risk (the potential effects of the hazard). Research in this area should be interdisciplinary and across the spectrum of hazard, susceptibility, risk and vulnerability.

Challenge 3: Public Perception of Geosciences & Citizen Science

As part of the Government Department with responsibility for natural resources, we are well positioned to translate research in this area into public policy. Addressing this challenge will be critical to the success of all other activities in the geoscience sector. From developing our energy assets to promoting basic geoscience research, it is vital that the Geological Survey supports and develops multidisciplinary teams to help understand the perception of geoscience in the community and increase public support for geoscience activities. Research in this area should stimulate citizen science programmes to improve public engagement and participation in managing natural resources. Research within this challenge should include expertise beyond the physical sciences (e.g. from social sciences, economics, public policy, psychology, education etc.)



Structure of Geological Survey Ireland's Research Programme

The Research Roadmap will be delivered through a structured Research Programme. The aim of this programme is to create a framework and schedule to implement the strategy and to outline the expected impact and outputs of the planned investment. The Programme will comprise three complementary strands;

- (i) Research Funding
- (ii) Research Collaborations
- (iii) Research Outputs

(i) Research Funding

The Geological Survey will continue to provide funding for geoscience research in Ireland through a number of mechanisms. The aim of this funding is to identify and support excellent research within the areas of the three Challenges that will benefit society and/or the Irish economy. It is intended that the funding will also help build capacity in key areas and ensure that we can meet the needs of our stakeholders in the longer term.

To do this, we will continue to provide direct funding to Research Performing Organisations (RPOs) and will also partner with a number of external agencies, not only to increase the support available but to build and strengthen collaborations with related disciplines such as environmental science, agriculture and land use and the marine sector.

We will also continue to support established funding opportunities through joint programmes with national funding agencies such as Science Foundation Ireland, the Irish Research Council, and the Fulbright Commission of Ireland. This will help to ensure that geoscience is included as a national priority in the knowledge economy.

Objective of Strand 1: To directly support geoscience research in Ireland through flexible and effective funding mechanisms

Mechanisms for funding geoscience research in Ireland:

Based on feedback from stakeholders in industry, academia and government agencies, our Geoscience Research Programme will comprise a number of funding mechanisms to ensure greatest impact and development of skills and knowledge at all career stages and across both public and private sectors. These will include:

- Project awards (small to medium)
- Individual awards including PhD Scholarships, Postdoctoral Fellowships and Griffith Awards to provide academic teaching support
- Funding opportunities for SMEs and industry partners
- Joint funding with national partners (SFI, IRC, EPA, Teagasc etc.)
- Joint funding with international partners (ERA Nets, Horizon2020, EGS etc.)
- Individual project grants for focused areas; these will be narrow in scope and aim to support specific areas of interest to the Geological Survey Ireland (as defined in specific calls)



Fig. 4 Key elements of the Geological Survey Research Programme

(ii) Research Collaborations

The Geological Survey Ireland has built close research collaborations with corresponding agencies and departments in other areas of national and local government, academic institutes and research centres, (e.g. Higher Education Institutes; iCRAG, MaREI and Amber research centres), industry partners and associated representative bodies (Geoscience Ireland, Enterprise Ireland, IDA) and agencies and research funding bodies (EPA, Teagasc, Marine Institute, SFI, IRC, Sustainable Energy Authority of Ireland, Fulbright Commission of Ireland). In addition, further development of partnerships with external representative bodies (e.g. Geosciences and Geographical Science Committee of the Royal Irish Academy; professional bodies) will help consolidate and focus the Geoscience Research Programme. At an international level collaborations include closely related organisations such as EuroGeoSurveys, International Ocean Discovery Programme (IODP) and other national or regional geoscience bodies.

Such collaborations will benefit both the Geological Survey and wider research community in Ireland through greater influence in designing future research programmes. It will also provide access to complementary skills and data available in other sectors in Ireland and abroad.

Objective of Strand 2: to build collaborations with corresponding and related organisations to ensure the development of connected and efficient research programmes

(iii) Research Outputs

Increasingly members of the Geological Survey Ireland scientific and technical staff are engaged directly in research activities and are consistently producing quality research outputs. These are delivered through national and international research programmes including peer reviewed publications and robust data products for the research community. As a provider and user of high quality geoscience data, we are well positioned to increase participation in excellent international projects and programmes. Essential to our role as a research performer will be strong links with academic stakeholders and other RPOs.

Objective of Strand 3: To increase the impact of Geological Survey Ireland based research

As the Government department with responsibility to coordinate national geoscience programmes (e.g. marine and land mapping, groundwater, raw materials), we can provide channels through which research results can directly inform national and local policy. In tandem, we will support the implementation of national and international legislation and directives through its research activities.

Expected impact of Geological Survey Ireland's Research Programme

In line with Innovation 2020, our Research Programme is designed to help increase competitiveness, attract foreign direct investment, build a cohort of excellent researchers and provide the high quality information needed to support evidence-based decisions and policy development. The Geological Survey Research Programme will support the activities of our stakeholders and generate maximum impact in three key areas.

"Investments in scientific excellence; in developing highly qualified researchers that meet the needs of our innovative enterprises; in driving collaborations and linkages between our research centres and enterprise are key ingredients for Ireland's future economic development and growth²⁵."

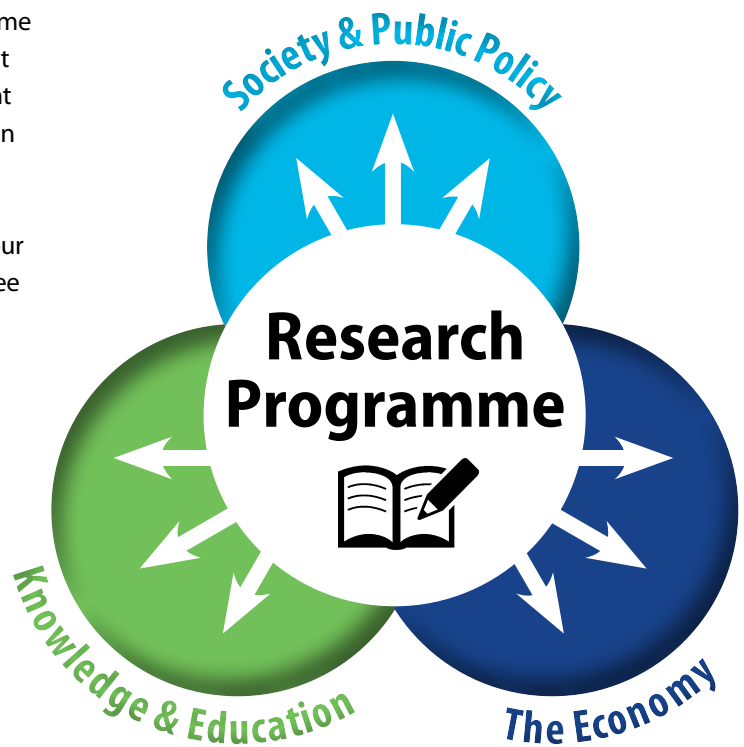


Fig. 5 Expected impact of the Geological Survey Research Programme



The Economy

The Geological Survey Ireland Geoscience Research Programme will support:

- An increase in economic impact through the direct provision of research outputs to the private sector. Indirectly this will support delivery of vital support services (energy, water, geotechnical information for transport and communications infrastructure etc.)
- An increase and strengthening of industry-industry partnerships and industry-academic partnerships to support members of business clusters such as Geoscience Ireland²⁹ and Enterprise Ireland initiatives. This 'clustering' has recently been highlighted as an effective tool for economic development through which grand challenges can be met²⁵. In addition, this will increase mobility of researchers across perceived boundaries^{25,30}
- Connections with initiatives such as the Small Business and Innovation Research network (SBIR) and the Small Business Act to support geoscience research in the private sector. Small and Medium Enterprises (SMEs) and young businesses benefit from research networks due to their limited resources^{26,30}
- Investment in the extraction and mining sector; employment in this sector increased in 2014³². With improved data and data products, further growth and activity in this sector (along the whole value chain) is expected.
- Increase the proportion of geoscience related research and technical jobs within *Professional, Scientific and Technical Activities*
- Development of additional geotourism projects

Knowledge and Education

The Geological Survey Ireland Geoscience Research Programme will:

- Support all levels of education and training from informing Primary and Secondary teaching curricula to direct investment in Tertiary education, training and research
- Supporting basic research in geosciences will improve our understanding of Earth systems
- Invest in applied research for science and technology know-how. Development of geoscience research programmes that will complement applied research centres (e.g. iCrag) will increase the impact and visibility of the sector, thereby attracting further non-exchequer investment
- Support the national strategy to increase the number of research personnel and excellent research

Society and Public Policy

The Geological Survey Ireland Geoscience Research Programme will:

- Increase our knowledge of Earth resources (onshore and offshore), thereby increasing efficiency and decreasing our impact on the planet
- Help to mitigate geological risks and potential anthropogenic hazards effects on natural systems (e.g. energy, infrastructure)
- Increase our national expertise and skill levels to ensure we have the capability to manage our national natural resources and the global impact of our actions
- Increase our awareness of our world-class geology in Ireland through further development of our heritage and Geoparks network. Further research in this area will strengthen our position and provide information for development of additional geotourism resources

Implementation & Key Performance Indicators

The Geological Survey Ireland Research Roadmap will be implemented and carefully monitored through our multi-annual and annual planning and reporting procedures. The three strands of the Research Programme will be used to benchmark success of the programme and to inform future planning.

Key Performance Indicators

The Geological Research Ireland Research Programme will be incorporated into the DCCAE Three year Statement of Strategy, Annual Business Plans and related national strategies. Specific key performance indicators are described in Tables 1-3 for the period to end of 2020.

(i) Geological Survey Ireland as a Research Funder

- Regular and careful monitoring of projects funded by the Geological Survey including regular activity reports and finance reports
- One contact point for funded investigators
- Regular communication and dissemination of Geological Survey funded research activities via the new Geological Survey Ireland website and research webpages

(ii) Geological Survey Ireland as a Research Collaborator

- Strengthening of existing partnerships and development of new collaborations
- Increasing impact of external collaborations, nationally and internationally

(iii) Geological Survey Ireland as a Research Performing Organisation

- Analysis of activities in relation to externally funded projects involving the Geological Survey Ireland
- Increase of international collaborations and partnerships in Europe and beyond
- Development of new projects and new targets set each year – these will need to be beyond the traditional research outputs to account for Geological Survey Ireland structures and funding opportunities

Table 1: Funder

Objective	Output Target	Key Performance Indicators
Effective research programme management	Clear management structures and procedures	Annual management & implementation plan
Effective research project management	Geological Survey funded research projects delivered on time and within budget; Clear and simple procedures for applicants to funding programmes; Comprehensive records of all outputs from funded research	Up to date Research webpage including all information regarding research calls and outputs
Further develop Research Programme to include a number of funding mechanisms	A range of funding structures to support a variety of researcher profiles	At least one funding call launched and coordinated per year
Further develop Research Programme to cover a wider range of geoscience topics	Identification of geoscience topics requiring focussed support	Increase number of research themes covered
Regular reviews of the research funding mechanisms	Updated implementation plan each year	Annual survey to assess the suitability, impact and success of new structures launched/ amendments to existing structures and programmes
Leverage additional funding from partners through co-funded research programmes	Leverage funds through external collaborations	Leveraged funding doubled
Utilise established research funding organisations to raise the profile of Geological Survey Ireland Research Programme	Further development of established collaborations	Fund at least one incoming and one outgoing Fulbright geoscience scholar per year; increase research profile through collaborations with external organisations (e.g. RIA)
Improved communication with research performing organisations	Feedback from researchers about geoscience research in Ireland and supports required	Open channels of communication through website, surveys and attendance at research meetings

Table 2: Collaborator

Objective	Output Target	Key Performance Indicators
Develop stronger research collaborations with HEIs in Ireland	Involvement in academic research activities such as iCrag, IGRM etc.	Increased number of applications for funding including members of Geological Survey Ireland staff; Geological Survey staff as named collaborators; increased requests for Geological Survey research expertise
Develop research collaborations with SMEs and industry partners	Regular meetings with groups such as EI, Geoscience Ireland etc. to identify and reduce barriers to industry involvement in research	Increased number of SME/industry applicants for Geological Survey Ireland (and other) research funding
Improve collaborations with external partners/agencies with responsibility for environmental research and hazard mitigation	Formal links with agents in relation to environmental hazard research	Direct involvement in consultation on environmental and geohazard/ risk mitigation; co-funding or joint contributions to research projects related to these areas
Ensure relevant Geological Survey Ireland contribution to research in terms of legislation and policy	Maintain and improve relationships with agencies responsible for geoscience related legislation	Active co-operation and support between agencies, government and stakeholders
Improve collaborations and communications with professional representative organisations to increase impact	Develop channels of communication with relevant organisations	Greater engagement by professional organisations; increased collaborations between these organisations and Geological Survey Ireland in relation to research activities
Increase the opportunities to build collaborations with, and between, researchers	Increased connectivity between researchers in all areas of the geoscience community	Greater interactions between geoscience researchers in Ireland

Table 3: Researcher

Objective	Output Target	Key Performance Indicators
Establishment of a research inventory and improved recording of geoscience research activities	Development of Research Website content	Up to date Research Webpages
Increased research activity by Geological Survey Ireland staff	Direct involvement of Geological Survey Ireland staff in research activities	Increased number of applications for funding including members of Geological Survey Ireland staff/ Geological Survey Ireland as named collaborators
Increase research output from staff (publications)	Research publications	Number of publications in peer review journals
Increase research output from Geological Survey Ireland staff (conference presentations)	Research conference presentations	Number of conference presentations at leading national and international geoscience conferences
Further development of Public Perception/Public acceptance research theme	In-house research on public acceptance of geoscience activities	Academic publications/ presentations on this topic including Geological Survey Ireland staff; increased involvement in this area of research nationally

Appendix 1: Partnerships with Government offices and programmes

Department of State	Agency/Partner	Geological Survey Ireland activities
Agriculture, Food and the Marine	Teagasc Marine Institute	Tellus/Soil geochemistry and environmental mapping Groundwater Protection and Nitrates Marine mapping / INFOMAR
Foreign Affairs and Trade	Embassy Network Fulbright Ireland	Attracting FDI & Economic development in geoscience Geoscience Ireland cluster Research (Fulbright Scholarships)
Jobs, Enterprise and Innovation	Science Foundation Ireland Enterprise Ireland	Supporting SME & FDI growth Research & Development Geoscience Ireland
Education and Skills	HEIs Irish Research Council National Centre for Curriculum Assessment Dublin Institute of Advanced Studies	Research collaborations/funding Education & Training Research & Development Geothermal Energy Geohazards (seismics)
Health	Food Safety Authority of Ireland HSE	Environmental Health Groundwater
Transport, Tourism and Sport	Transport Infrastructure Ireland Marine Safety Office Irish Coast Guard	Geotourism, Geoheritage & Geoparks Geoengineering for infrastructure Marine mapping/INFOMAR
Communications, Climate Action and Environment	Exploration & Mining Division Petroleum Affairs Division Decarbonisation/Offshore Renewable Energy EPA SEAI	Renewable & non-renewable energy Minerals and mining Mine Heritage Groundwater Tellus/Geological hazards/ Radon Geothermal energy Marine mapping/INFOMAR
Housing, Planning and Local Government	Water Framework Directive Planning Service Local Government	Groundwater Protection Aggregate Potential Mapping Landslide Susceptibility Mapping Planning and Environmental Assessment Geological Heritage
Regional Development, Rural Affairs, Arts and the Gaeltacht	Heritage Council	Infrastructure development Geological Heritage
Public Expenditure and Reform	Office of Public Works	Marine Mapping/INFOMAR Groundwater & Turlough flooding
Defence	Office of Emergency Planning Naval Service Air Corps	Tsunami & Ash Cloud Risk Marine mapping/INFOMAR Baseline mapping
Taoiseach	Marine Coordination Group	Marine mapping/INFOMAR

Notes

- 1 Innovation 2020
- 2 United Nations, 2015 Transforming our world: the Agenda for Sustainable Development
- 3 Critical needs for the Twenty First Century; the role of geosciences; American Geological Institute
- 4 <http://www.aas.org/fy16budget/geosciences-fy-2016-budget>. It should be noted that this NSF budget excludes funding allocated to US Geological Survey, NASA and the US Department of Energy who also conduct geoscience research.
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- 6 EuroGeoSurveys; A Vision towards a Geological Service for Europe
- 7 *Personal communication*, EGS
- 8 <https://www.enterprise-ireland.com/en/News/PressReleases/2013-Press-Releases/%E2%82%AC79-Billion-Horizon-2020-Europe%E2%80%99s-largest-ever-fund-for-research-and-innovation-comes-to-Ireland.html>
- 9 Geosciences, Gaining Ground, DCENR, 2007 (the most recent figures available)
- 10 Assessment of Economic Contribution of Mineral Exploration and Mining in Ireland, Indecon Report 2013
- 11 Vega et al., 2015
- 12 PWC INFOMAR External Evaluation
- 13 <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0089&from=EN>
- 14 <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0056&from=EN>
- 15 <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32000L0060&from=EN>
- 16 Review of Key Issues around Social Acceptance of Geoscience Activities & Earth Resources in Ireland
- 17 UNESCO Global Geoparks Celebrating Earth Heritage, Sustaining local Communities 2016
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- 26 Hughes, J. A. & Bascavusoglu-Moreau, E., 2014. Estimating the effect of UK direct public support for innovation, Department for Business, Innovation and Skills, 2014
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- 29 http://ec.europa.eu/growth/sectors/raw-materials/policy-strategy/index_en.htm
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