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Climate Adaptation Research – Horizon Scan

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Acronyms

CCAC	Climate Change Advisory Council
DAFM	Department of Agriculture, Food and the Marine
DECC	Department of Environment, Climate and Communications
DHLGH	Department of Housing, Local Government and Heritage
DT	Department of Transport
EC	European Commission
EI	Enterprise Ireland
EIT	European Institute of Innovation and Technology
EPA	Environmental Protection Agency
EU	European Union
IPCC	Inter-Governmental Panel on Climate Change
JPI	Joint Programme Initiative
KIC	Knowledge and Innovation Community
MAFF	EU Multi-Annual financial Framework
MI	Marine Institute
MÉ	Met Éireann
NAF	National Adaptation Framework
OPW	Office of Public Works
SFI	Science Foundation Ireland
5YAR	EPA Five-Year Assessment Report on Climate Research

Executive Summary

The Irish government has made a strong policy commitment to climate action with a clearly stated National Climate Objective to achieve resilience and carbon neutrality by 2050. To achieve this research must play its part. Several organisations have identified research gaps and priorities for the future. Change in this area will not only require further investment in pure research, but also strengthening of research systems, capacity and improvements in knowledge transfer and research uptake, among other things.

This report used a literature review and a series of nine key informant interviews to present a short summary of research priorities, and research funding structures in both Ireland and Europe. It concludes that Irish researchers and research institutions are well-regarded in the wider research community and are reasonably well-integrated intro European research funding and collaboration structures. It notes that there are good opportunities to participate more at the leadership level in research projects which may be facilitated by further reform of the domestic research funding architecture. This may include changes to the reporting of research activities in Ireland to better demonstrate areas of collaboration between Irish researchers and their European counterparts. While there are undoubtedly gaps and unmet research needs for adaptation, there are many well-known, understood and thoroughly tested adaptive interventions in multiple sectors that can be implemented with confidence and at some scale. Gaps and unmet needs should not be a reason for delay in implementing adaptation at different scales at this point.

The report makes four recommendations for the consolidation and streamlining of the Irish research funding architecture, a reduction of the reliance on short-term competitive funding and a corresponding increase in longer-term core funding for research institutions, greater alignment of climate adaptation practitioner needs, such as related to implementation processes, participation and governance at the community level among others, and research output, and the harmonisation of Irish and European research reporting standards.

Limitations

This is a rapidly moving area of work with a major research study (the EPA's Ireland's Climate Change Assessment) expected to be published over Q3-4 in 2023. A limited number of informants were interviewed to add depth to the desk-based review. No industry representatives were interviewed to expand on applied research needs. This is a small-scale study and by definition focused on a narrow study remit.

Methodology

This small-scale study is a desk-based literature review. Nine key informant interviews were also conducted to compliment the desk-based review with additional qualitative expert respondent insights. Unattributed feedback from the key informant interviews is presented in some of the chapters where it was most relevant to further elaboration of the opportunities and constraints for Irish researchers and research institutions. A full list of key informants is included at Annex 1.

Definitions and goal of climate change adaptation in Ireland

The amended Climate Action and Low Carbon Development Act of 2021 (Irish Government, 2023) clarifies the State's climate change ambitions through the establishment of the National Climate Objective, which states:

The State shall, so as to reduce the extent of further global warming, pursue and achieve, by no later than the end of the year 2050, the transition to a climate resilient, biodiversity rich, environmentally sustainable and climate neutral economy.

The legal definition of climate change adaptation described in the Act's precursor, the Climate Action and Low Carbon Development Act of 2015 (Irish Government, 2015) is described as:

Any adjustment to a) any system designed or operated by human beings, including an economic, agricultural or technical system, or b) and naturally occurring system, including an ecosystem, that is intended to counteract the effects (whether actual or anticipated) of climatic stimuli, prevent or moderate environmental damage resulting from climate change or confer environmental benefits.

Ireland's National Adaptation Framework (NAF) (DCCE, 2018) further elaborates the definition and places it in the context of resilience-building. It defines adaptation as "the approach for addressing the current and future risks posed by a changing climate. The aim of adaptation is to reduce the vulnerability of our environment, society and economy and increase resilience. Adaptation also brings opportunity through green growth, innovation, jobs and ecosystem enhancement as well as improvements in areas such as water and air quality".

Ireland's definition is wholly consistent with that of the Inter-Governmental Panel on Climate Change (IPCC), among those of other international bodies, which describes adaptation as the "process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects" (IPCC, 2014).

The effect of building adaptive capacity for resilience to climate change can be considered the goal of adaptation in Ireland. The NAF considers resilience to mean "the capacity of a system, whether physical, social or ecological, to absorb and respond to climate change and by implementing effective adaptation planning and sustainable development (including governance and institutional design) to reduce the negative climate impacts while also taking advantage of any positive outcomes. This will allow the system to either return to its previous state or to adapt to a new state as quickly as possible" (DECC, 2018).

Scope of climate change adaptation in Ireland

Successful adaptation to both the positive and negative impacts of climate change requires action at all levels of society, by public and private actors, and individuals, working in a coordinated manner across multiple sectors. The NAF states "Adaptation not only depends on action by all levels of government but also on the active and sustained engagement of all stakeholders, including sectoral interests, the private sector, communities, and individuals. Everybody has a role to play in making sure Ireland is taking appropriate adaptation action to achieve a climate resilient future. This is a joint responsibility where "climate proofing" our country is an undertaking for which all of society is responsible and everyone has a role to play" and where the concept of a just transition is consistently applied to ensure the burdens do not negatively affect the most vulnerable in society.

The NAF anticipated adaptation occurring in three ways:

- Soft adaptation – e.g., regulation, behaviour change.
- Green adaptation – e.g., nature-based solutions to climate-induced risks.
- Grey adaptation – e.g., technical, engineering-based solutions to climate-induced risks.

The NAF set out the guiding principles, roles, responsibilities, financing, governance, research, and planning processes to be used by a range of stakeholders including national and local government, the private sector, and civil society. It further established a themed approach to adaptation that considered four main subjects – natural and cultural capital, critical infrastructure, water resource and flood risk management, and public health.

Clear, long-term quantitative targets for adaptation have not been established. This recognizes the iterative nature of the challenge. As time goes on the potential impact of climate change will vary according to a complex and fluid range of risk, exposure, and vulnerability patterns, requiring further adaptative responses. The adequacy, or current lack thereof, of robust indicators for the measurement of adaptation and resilience relative to risk also makes quantitative goal-setting difficult.

The need for research into climate change adaptation

Irish and European policy instruments for adaptation, climate and environmental strategies and assessments, highlight the need for research, knowledge creation and dissemination as important steps towards the achievement of climate resilience. The EU Adaptation Strategy (EU, 2021) describes the need for "smarter adaptation" that will contribute to "a climate resilient society by improving knowledge of climate impacts and adaptation solutions" (Climate-Adapt, 2021). This will be achieved through, among other things:

- Pushing the frontiers of adaptation knowledge.
- More and better climate loss data.
- Enhancing and expanding Climate-ADAPT as the European platform for adaptation knowledge.

The NAF noted the significant progress made in Ireland on advancing the adaptation research agenda in four main areas – observations, monitoring and analysis; modelling of future climate; impacts, risk, and vulnerability assessment; and adaptation information and responses. It further noted the important contributions of European research funding and collaboration through Horizon 2020 and the Joint Programme Initiatives, such as that for oceans. Moreover, it states that it is "essential that this work is maintained and enhanced so as to target specific policy areas, but also new areas of research informed by international best practice". It goes on to identify a range of research priorities under the headings mentioned above. In general terms research contributes to a more sustainable economy and better society and, more specifically, "climate research and modelling programmes should support climate adaptation by delivering climate services at a local level across all sectors of the economy, including emergency management" (DECC,2018).

The EPA's 2020 report on Ireland's Environment – An Integrated Assessment (EPA, 2020) acknowledges the impact of climate change in Ireland in line with global trends and the country's demonstrated vulnerability to extreme events. The report states that "rapid and deep cuts to GHG emissions are essential to avoid the most dangerous impacts of climate change, but we still need to respond to the known expected impacts". The report goes on to outline how both national and international research and data from systematic observations made in the atmosphere, in the oceans and on land are "central to informing actions on climate change".

Climate Change Advisory Council (CCAC) Annual Reviews have summarised the state of adaptation knowledge in Ireland and identified research gaps. The CCAC noted, in its annual review 2021 (Climate Change Advisory Council, 2021), the "need for a strategy to address any data and knowledge gaps necessary for the preparation and implementation of the next National Adaptation framework", adding that it was not clear that this was in place. The annual review of 2022 (Climate Change Advisory Council, 2022) noted that "despite considerable research investment, adaptation skill sets, and capacities are still seen as being in short supply". These observations highlight both gaps in the knowledge base for adaptation and its application, through dissemination and capacity building, to ensure that knowledge helps practitioners to achieve adaptation objectives on the ground.

The EPA's forthcoming Five-Year Assessment Report on Climate Research (5YAR), to be published (over four volumes) in 2023, recognises the need for further granularity in the research agenda to reduce the risk of critical sectors being left behind. In its third volume (Being prepared for Ireland's Future Climate) the sectoral breakdown focuses on a wider

range of sectors and domains (beyond those considered in the NAF) where further research is needed. These are:

1. Marine, terrestrial and freshwater ecosystems.
2. Agriculture, forestry and land use.
3. Coastal environments.
4. Water.
5. Built environment, heritage and rural communities.
6. Critical infrastructure and interdependencies.
7. Health and wellbeing.
8. Business, industry and tourism.

Each of these categories incorporate multiple specialist subjects and will require a high degree of coordination and integration, across research institutions and disciplines. Not only must they address policy-relevant questions about what should be done, they must be oriented to how practitioners can deliver evidence-based adaptation in their service sectors and settings.

Informants interviewed for this report agreed that a key need in Ireland was to address the critical question of how to implement effective adaptation approaches in a wide range of sectors and settings where services are provided. A strong relationship between research commissioners, implementers and end users is needed to ensure that capacity to deliver adaptation is built in the right places. A common critique of the current approach to climate change research was that it was not contributing to capacity development to the extent necessary. Ireland lacks a singular national entity with responsibility for the implementation of climate change adaptation, distinct from monitoring or policy development functions. This is a systemic weakness.

Adaptation research funding structures in Ireland and Europe

Climate change adaptation research in Ireland and in the European Union is organised and funded through a wide range of institutions and taxonomy. A simplified mapping of research funding pathways is shown below in Figure 1.

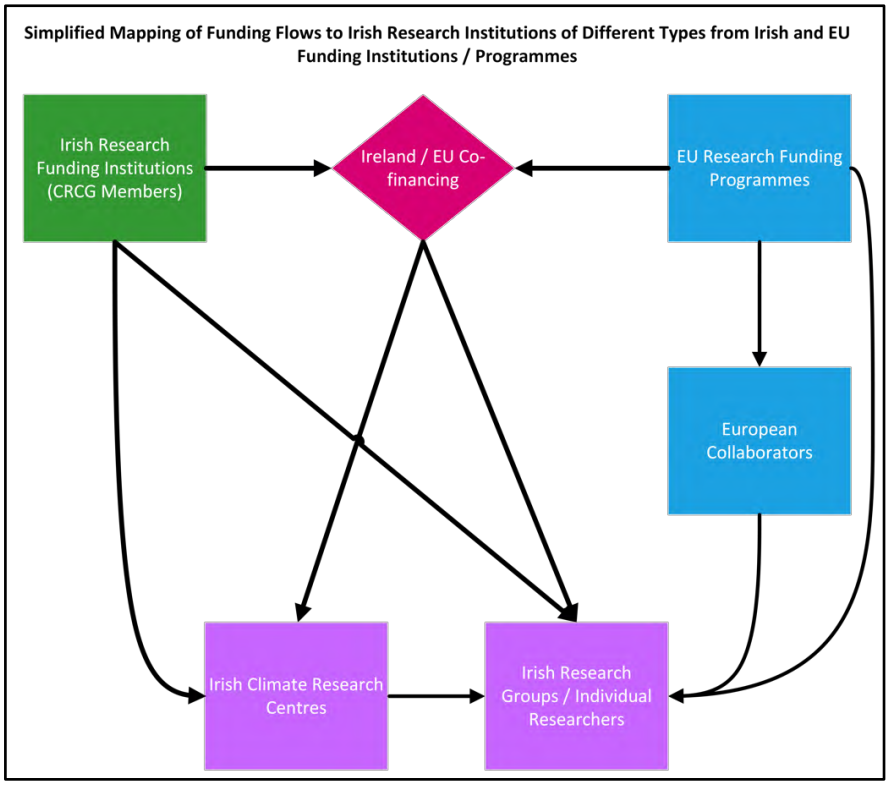

Figure 1: Research funding pathways, Ireland and European Union

Ireland

In Ireland, climate change adaptation research is primarily funded by national government departments, state agencies and statutory bodies, augmented by the private sector and national and international philanthropic organisations and individuals. In recent years the Climate Research Coordination Group (CRCG) has coordinated the research funding activities of its now 31 member organisations. It is a sub-set of the larger National Environmental Research Coordination Group. This working paper focuses on publicly funded research.

CRCG membership, comprising most if not all those research funders, stands at 31. Among the state organisations funding climate change research are the Environmental Protection Agency (EPA), Science Foundation Ireland (SFI), the Marine Institute (MI), Teagasc, Enterprise Ireland (EI), MÉ, and the Office of Public Works (OPW). Among departmental funders are the Department of Housing, Local Government and Heritage (DHLGH), the Department of Transport (DT) and the Department of Agriculture, Food, and the Marine (DAFM). The full list of CRCG members is included in its annual reports.
Many of these funding organisations have multiple research programmes at different scales, targeting different questions and types of researchers, e.g., young researchers, innovation, or research centres, among others. The EPA is one example with 8 different funding programmes in 2021 (EPA, 2021) that cover, among others, short-term evidence-based

studies, project-based awards, strategic national partnerships, collaborative awards, research fellowships and PhD funding.

The CRCG 2019 Annual Report (EPA, 2020) describes the funding landscape for climate change research in Ireland. It notes the priorities included in the Department of Business, Enterprise, and Innovation (DBEI) research priority areas for 2018-2023, under the Innovation 2020 Strategy for research and development, science, and technology. This strategy incorporates an energy, climate action and sustainability theme, with two priority areas for a) decarbonising the energy system and b) sustainable living. Impact 2030 (DFHERIS, 2022), Ireland's new Research and Innovation Strategy, sets out several important objectives to improve the funding and capacity of Ireland's research institutions and the uptake / application of research findings, by policy makers and enterprises. It identifies the climate emergency as one of two fundamental transitions for Irish society, alongside the digital transition, where research and innovation are critical enablers.

The CRCG / EPA has set out four thematic research areas for climate action, Pillar II of its overall research programme. They are:

1. Carbon stocks, GHG emissions, sinks and management options.
2. Ireland's future climate, its impacts and adaptation options.
3. Socio-economic and technological solutions: transition management and opportunities.
4. Air science (air pollution and short-lived climate forcers).

There are several important questions related to the effectiveness of the Irish research funding environment as currently structured in meeting the various expectations on it.

Firstly, it is striking to see climate change research funding distributed across, at least, 31 state institutions and agencies in a country the size of Ireland. There is a well-established rationale for a range of funding opportunities to target different sectors and domains be they, for example, infrastructure, biodiversity, fundamental observations, or health- focused, notwithstanding the need to understand interconnectedness and cascading risks. There is also a well-established rationale for funding that is appropriate for different types of researchers or institutions, be they young, independent, or established. Whether these different aims are achieved most efficiently through the extensive ecosystem of funding organisations in Ireland today, or whether this structure causes undue complexity, fragmentation, duplication, and gaps, should be considered.

Secondly, there is a documented recognition of practitioners' demand for research products that help them to understand how to implement effective adaptation actions. There are several challenges to address in this area. These include, but are not limited to, accessibility and ease of understanding research findings, relevance of research findings to specific operational contexts, and linkages to capacity building and capacity support opportunities. More effective co-creation of research where end users are more involved in research design and implementation may help ensure that practical demands for evidence-based solutions are met. Establishment of a national body for adaptation implementation may also be a consideration. Ireland has a small capacity to monitor the implementation of the Climate Action Plan, established in the Department of the Taoiseach, but no single entity for managing delivery and matching research demand with research supply.

Thirdly, competition-based funding schemes, often for short-term projects, can compromise institutional capacity and undermine job security. The All-Island Climate and Biodiversity Research Network (AICBRN) is a diverse network of climate researchers formed in 2019. The AICBRN was formed to "cooperatively undertake the essential fundamental and challenge-based research to successfully address the climate and biodiversity emergency" (AICBRN, 2019). AICBRN's aim is to help spur the development of innovative and transformative solutions Ireland needs, for both adaptation and mitigation. This will be achieved through a more integrated interdisciplinary ecosystem of researchers and institutions. The AICBRN suggest that Ireland's funding architecture is too complex and is over-reliant on short-term (12-24 month) competitively funded research projects that primarily contribute to the grey literature rather than more authoritative, peer-reviewed findings from large-scale projects conducted over significant medium- to long-term timescales. Consequently, the impact of Ireland's research funding is less than in might be. The AICBRN, and others, including some of the key informants to this paper, call for reform of Ireland's financing of climate change research by supporting established and new research centres over the medium- to long- term, with a greater emphasis on collaboration over competition for funding. Overcoming job insecurity among researchers primarily working on short-term projects and increasing capacity in the system by reducing demand for many small grant competitions, would enable the research community to focus more intently on developing innovative, peer-reviewed solutions to current and future policy challenges. Teagasc appointed 16 new permanent research staff to support their work on mitigation and adaptation, a positive development for core capacity in that organisation that would be welcome to a broad range of academic climate research institutions.

European Union

Ireland's research agenda and capacity is strongly linked to that of the European Union through funding and participation in EU research programmes in partnership with a wide range of European research collaborators. The main EU climate relevant programmes that include research as principal or supporting functions are:

1. Horizon 2020 and its successor Horizon Europe, including its Missions on adaptation, and climate-neutral and smart cities.
2. LIFE.
3. Interreg Europe.
4. European Climate Knowledge and Innovation Community (Climate-KIC).
5. Copernicus.
6. Connecting Climate Knowledge for Europe Joint Programming Initiative.

Horizon 2020 was the EU's research and innovation funding window for the Multi-Annual Financial Framework (MAFF) period from 2014 – 2020. Since expenditure can be committed throughout that period and paid after it there are 25 projects ongoing involving Irish researchers and institutions, until as late as 2026. Horizon 2020 was designed to address the policy priorities set out in Europe 2020. Climate change research was addressed through a challenge-based approach under the heading of societal challenges. This incorporated 7 specific programme areas. While one, climate action, environment, resource efficiency and raw materials, was specifically addressing climate change, all the others addressed climate-relevant subjects such as health, food security, clean energy, and green transport among others. Irish researchers and institutions participated in 42 projects since 2019. Ireland was estimated to have won €1.2 billion in research funding through Horizon 2020 between 2014 – 2020 (Horizon Europe, 2023).

Horizon Europe has now replaced Horizon 2020 for the MAFF period from 2021 – 2027. Its total budget is €95.5 billion. The Specific Programme Implementing Horizon Europe comprises three pillars, the second of which focuses on Global Challenges and European Industrial Competitiveness. It includes six clusters. While several, if not all, of the programmes are climate-relevant, the following clusters are of specific relevance to climate change research:

Cluster 5: Climate, Energy and Mobility. The goal of cluster 5 is to "achieve an advanced knowledge base that will catalyse the transition to a net-zero greenhouse gas emissions economy resilient to the impacts of climate change".
Cluster 6: Food, Bioeconomy, Natural Resources, Agriculture and Environment. The goal of cluster 6 is to" accelerate the transition towards the sustainable management of natural resources with measures for climate neutrality of primary production, circular management of resources, sustainable and healthy food systems, the halt of biodiversity decline and the prevention and removal of pollution".

These clusters are illustrated in the wider context of Horizon Europe in Figure 2, below.

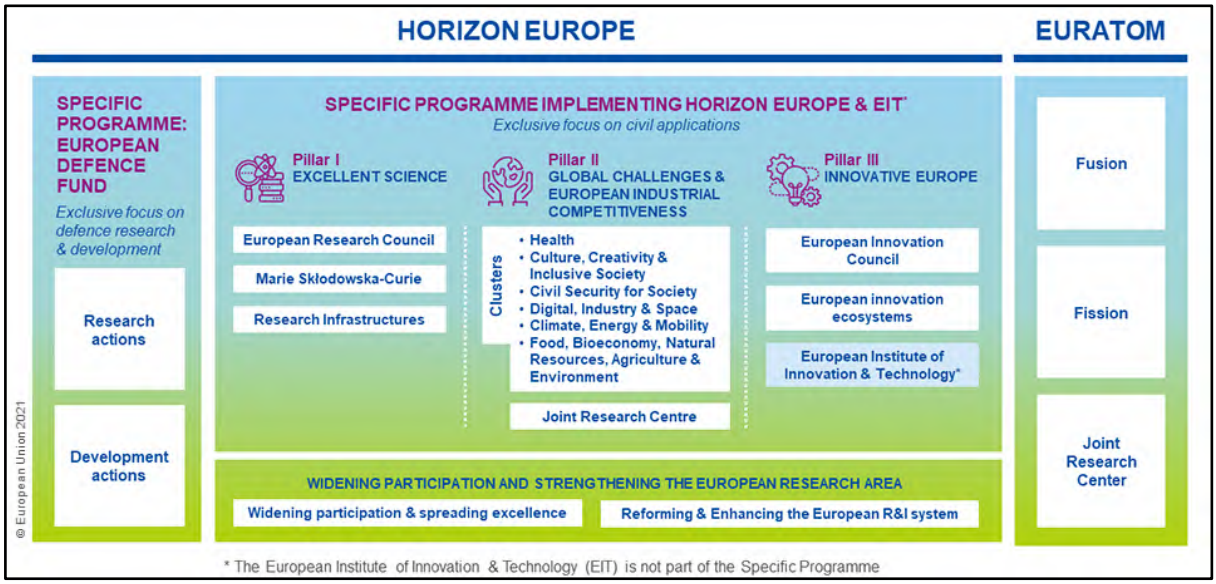

Figure 2: Structure of Horizon Europe 2021-2027

Enterprise Ireland provides the National Support Network for Horizon Europe (Enterprise Ireland, 2022), supporting the work of National Contact Points for each cluster and pillar that draws expertise from a range of Irish institutions including, but not limited to, the Marine Institute, the Environmental Protection Agency, and the Health Research Board. The Enterprise Ireland advisors provide technical guidance to Irish researchers seeking Horizon Europe funding and connect them to a range of financial supports to facilitate successful applications. Given the relatively recent inception of Horizon Europe remains at the early stages of disbursement in accordance with its work programmes.

Horizon Europe has initiated Missions on adaptation, restoring oceans and waters, and climate-neutral and smart cities. The goal of the missions, in broad terms, is to bring concrete solutions to some of the world's biggest challenges, putting research and innovation into a new role, combined with new forms of governance and collaboration, as well as engaging

citizens. EU coordinated missions will pool resources such as funding programmes, policies, and regulations, and will help to mobilise public and private sector actors to contribute to lasting impact and achieve the policy objectives of the European Green Deal and EU Climate Adaptation Strategy.

At least six councils in Ireland (Donegal, Louth, Offaly and Sligo County Councils, and Galway City Council, and Cork City Council) have joined the Adaptation Mission. The CARO Atlantic Seaboard North in Mayo is acting as a Friend of the Mission. Dublin and Cork City Councils have joined the Mission on Climate Neutral and Smart Cities (Ireland Representation to the EC, 2022). The missions aim to bring tangible benefits to people and to involve them in the design, implementation and monitoring of actions taken. Potential benefits include funding, technical assistance, linkages to peers and visibility to funding institutions such as the European Investment Bank.

LIFE, the long-running EU instrument for the environment and climate action, is running through the MAFF period of 2021 – 2027. LIFE co-finances projects in areas including urban adaptation and land use planning, infrastructure resilience, flood, and coastal management, among other areas. LIFE provides grants for best practice, pilot and demonstration projects that contribute to climate change resilience, and for integrated projects that enhance the implementation of EU policy and strategy on adaptation. 9 distinct projects have been funded in Ireland since the 2019 call for proposals, although none of them focus explicitly on climate change adaptation. In the same period LIFE has awarded funding to 8 European projects with a wide focus on a diverse range of adaptation subjects from urban animal feeding, scale-up of a wave energy converter, and mainstreaming adaptation in urban planning through public and private storm water infrastructure.

Interreg Europe aims to jointly tackle common challenges and find shared solutions related to climate change, among other subjects, as one of the goals of the EU Cohesion Policy 2021 - 2027. Project financing often focus on transboundary capacity development, learning and sharing of knowledge, through partnerships that often include municipal authorities and academic institutions. Irish academic institutions led at least three Interreg projects during the 2014 – 2020 MAFF period. No data is yet available about the participation of Irish institutions in the new funding period up to 2027.

The EU has established quite a wide range of initiatives to address climate through, in part, research and its application. Climate Knowledge and Innovation Community (KIC) works to accelerate the transition to a zero-carbon, climate-resilient society, through support from the European Institute of Innovation and Technology (EIT). Climate KIC brings together partners in the worlds of business, academia, and the public and non-profit sectors to create networks of expertise, through which innovative products, services and systems can be developed, brought to market and scaled-up for impact. Copernicus is the EU's earth observation system that provides data to researchers and others to monitor, among other things, climate change, land use, the atmosphere, and marine environments. The Joint Programme Initiative (JPI) for Climate is an inter-governmental initiative to jointly coordinate and fund new transnational research that provide useful climate knowledge and services for post-COP21 climate action. European Research Infrastructures provide resources and services for research communities to conduct research and foster innovation. They aim to reduce fragmentation of the research ecosystem and avoid duplication in European research and innovation. Irish research institutions can and do participate in all these opportunities and collaborations. European Cooperation in Science and Technology (COST) complement national research funds by

covering costs associated with collaborative activities, including workshops and conferences, dissemination, and communication activities. This is an EU funded intergovernmental framework with 41 members, including Ireland.

International collaboration with European and global partners is important for understanding climate change and its diverse impacts. There are many opportunities for Irish researchers and institutions to participate in and lead programmes at scale at the regional and global levels. Since 2019, Irish researchers have participated in at least 42 research programmes funded through Horizon 2020. However, Irish participation can and should be deepened in such collaborative programmes. Most participation is at the level of co-investigator, rather than as lead. The Science Foundation Ireland (SFI) notes "Ireland's position offers a unique opportunity to monitor air quality and atmospheric changes at the boundary of Europe and the North Atlantic. Ireland is also a relatively small country, and so can be a useful testbed for evaluating how effective new approaches and technologies are to address climate change. With this unique geography, industry base and research ecosystem, Ireland is exceptionally positioned to play a strong role in addressing the global challenges of climate change" (SFI, 2023). With these fundamental assets, it is possible for Ireland's contribution to regional research to grow, assuming some structural issues in Ireland's research funding environment can be resolved. Other countries, such as Norway and the UK, not to mention the EU itself, are putting research funding on a more predictable and long-term footing to build capacity in critical areas. Ireland may wish to review and learn from such experiences.

Research priorities for climate change adaptation in Ireland

While the NAF and other research-related publications have recognized the significant contribution of Irish research to climate change adaptation there is a generally recognised need for further work to be done. The extent of knowledge and research gaps are exhibited by the number of proposed actions in national, local authority and sectoral adaptation plans that note that more data or research is needed.

The National Climate Action Plan (NCAP) (Government of Ireland, 2023) sets out a range of priority actions to strengthen processes and structures for research and innovation and identifies some priority areas for research in future. The NCAP notes that "There is also an emerging consensus that the unique and urgent challenge of climate change and sustainability requires the exploration of more responsive modes of knowledge production". These priority areas are summarised in table 1 below.

Table 1: NCAP 2023 research gaps and priorities

Source	**Gap / priority**
NCAP 2023	Improving the use of academic expertise to support better policy making and improvement of knowledge transfer systems.
NCAP 2023	Strengthening Ireland's research infrastructures for climate science and monitoring.
NCAP 2023	Improving systems research and modelling.
NCAP 2023	Better supporting innovation and the development of new technologies.
NCAP 2023	Improving capacity at all levels and strengthening just transition.
NCAP 2023	Improving policy monitoring and evaluation.
NCAP 2023	Strengthening research networks and improving coordination between them.
NCAP 2023	Better mobilisation of the private financial services sector for more innovative climate finance.
NCAP 2023	Making climate communications to the public more effective through research to develop behavioural insights in support of messaging.

Table 2 summarises research gaps and priorities referenced in successive CCAC Annual Reviews from 2019 until 2022.

Table 2: Climate Change Advisory Council Annual Reviews 2019-2022, research gaps and priorities.

Source	**Gap / priority**
CCAC AR 2022	Improved access to climate data and support via, e.g., Climate Ireland.
CCAC AR 2022	Improved communication tools for testing adaptation actions and communicating key risks to diverse audiences, c.f. Met Éireann TRANSLATE storylines.
CCAC AR 2022	Practical, expert guidance on incorporation of uncertainty into adaptation decisions guided by modelling.
CCAC AR 2022	Improved science / policy interface to ensure research better meets the needs of decision makers and planners.
CCAC AR 2022	Improved learning mechanisms to enable Ireland to better benefit from adaptation experience in other countries, including the developing world, on locally led

Source	Gap / priority
	adaptation, coastal adaptation, innovation, M & E, climate and gender justice in adaptation.
CCAC AR 2022	Improved consideration of socioeconomic vulnerability in national, sectoral and local policy and planning.
CCAC AR 2021	Further research needed to support implementation of policies and plans (citing the 2020 EPA State of the Environment Report)
CCAC AR 2021	Capacity building in key areas through long-term, multi-annual approaches, as opposed to short-term, ad hoc approaches, to support ongoing transition and policy evolution.
CCAC AR 2020	Increase private sector research and development for mitigation in Ireland.
CCAC AR 2020	Need for education and training across many sectors and at community level (through non-formal adult and community education approaches) is common to emergency planning and adaptation planning and this should be leveraged to improve societal resilience.
CCAC AR 2019	CRCG research themes: 1) carbon stocks, GHG emissions, sinks and management options; 2) Ireland's future climate, its impacts and adaptation options; 3) socio-economic and technological solutions and transition management opportunities; and 4) air science (air pollution and short-lived climate forcers).

The Climate Research Coordination Group (CRCG) provides a cross-sectoral national strategic coordination forum for climate environmental research in Ireland as shown in table 3, below.

Table 3: CRCG research gaps and priorities

Source	Gap / priority
CRCG AR 2019	Need for more co-funded research across Irish stakeholders is the main priority.
CRCG AR 2019	Hand-in-hand, an urgent need to improve research data management and access to research outputs across all research bodies[1].
SFI Climate Action Workshop November 2019[2]	High-level outputs of the workshop pointed to gaps in coordination and coherence across the system, lack of engagement with communities, lack of systems-level solutions and lack of a defined framework for knowledge sharing.

The Environmental Protection Agency (EPA) set out its Thematic Research Areas Assessment for the period between 2021 and 2023 (EPA, 2021) with the goal of building knowledge and evidence in four areas through the development of interconnected research hubs for each:

- Addressing climate change evidence needs.
- Facilitating a green and circular economy.
- Delivering a healthy environment.
- Protecting and restoring our natural environment.

[1] Highlighted as a recommendation in the Department of Public Expenditure and Reform (DPER)/Irish Government Economic and Evaluation Service (IGEES) climate research funding report

[2] Reported in CRCG AR 2019.

The EPA Assessment 2021 – 2023 is supported with a discussion document. The assessment has informed the EPA Research 2030 – A Framework for EPA Research 2021 – 2030 (EPA, 2021). This high-level framework is intended to, among other things, generate the evidence base that supports decision-making, behaviour change and policy development. The discussion document highlights four key areas for research under the heading of climate change. Some are further explored in the forthcoming Ireland's Climate Change Assessment Report. They are:

- Understanding and measuring fundamental cycles, processes, trends, and drivers of climate change.
- Enabling achievement of climate neutrality by 2050.
- Preparing for Ireland's future climate (i.e., achieving climate resilience).
- Realising the benefits of and opportunities arising from transition and transformation.

The research priorities suggested in the discussion document for preparing for Ireland's future climate, most closely aligned with climate change adaptation, are:

- Measuring climate resilience.
- Assessing the societal, economic, and environmental impacts of extreme events.
- Identifying climate-resilient pathways for Ireland, linked to shared socio-economic pathways and commitments made under the Paris Agreement.
- Generating adaptation decision-making information on decision-making frameworks, such as adaptation pathways, to meet short-, medium-, and long-term resilience goals.
- Detailing the climate vulnerability of each sector and identifying critical thresholds, considering spatial, sectoral, social, and ecological vulnerabilities.
- Achieving coastal resilience by addressing knowledge gaps, erosion, flooding, infrastructure, acceptable levels of risk and role of communities.
- Analysing climate change impacts temporally, spatially and under different emission scenarios (including higher warming) to maintain a state-of-the-art understanding of future climate change at resolutions and over timelines appropriate to national, regional, and local decision-making.
- Exploring the implications for Ireland of global impacts (e.g., large-scale singular events, food security, climate migration) and secondary impacts (knock-on effects) and the interplay between impacts at sectoral level.
- Costing adaptation impacts and actions in the Irish context.

Such research areas are expected to address policy objectives and targets from a range of policy areas including the Programme for Government 2020, the National Peatlands Strategy, the Climate Action Plan, the National Adaptation Framework, the National Planning Framework and various specific targets under SDG 13 on climate action.

The AICBRN have identified several scientific challenges. They are:

- The improved monitoring and analysis of historical records.
- Better understanding of changes in the deep past.
- Quantification of uncertainty in projections.
- Elucidating the role of variability.

Further specific research challenges for adaptation, mitigation, biodiversity and just transition.

For adaptation specifically the challenges noted by the AICBRN are:

- Modelling uncertainty.
- Quantifying and improving resilience of infrastructure.
- Modelling and forecasting of storm surges.
- Development of (Marine, Surface, Airborne) Service and SAR Robotics technology.
- Improve flood risk assessment and management.
- Adapting to changes in critical ecosystem services.

It is expected that the 5YAR will provide some general guidance suggesting that, for adaptation to be successfully implemented, evidence and knowledge support from research is needed to assist and inform climate action in all sectors and levels of society. The assessment will consider the current state of climate knowledge across a range of sectors in Ireland and identify research gaps and priorities. It is expected to identify clear objectives to define what successful adaptation looks like, underpinned by consistent understanding of likely and possible climate impacts across all sectors and levels, based on a consistent set of climate model projections. Researchers must assist policy makers and practitioners to ensure that the social dimensions of vulnerability cross-sectoral and cascading risks are fully integrated into risk assessments in future, and that the root causes of vulnerability and climate justice are addressed in future development and disaster recovery in all sectors. In addition to research-informed technical solutions and ongoing monitoring of climate variables in the oceans and atmosphere, research has an important role to play in developing broad civic participation in adaptation to meet the diverse needs and priorities of different sections of society, incorporating research, planning and implementation of adaptation actions. Policy makers, climate action practitioners and the public should be supported by the research community to have a better understanding of the uncertainty inherent in the projection of climate impacts long into the future and the social dynamics of adaptation, including soft barriers to adaptation such as lack of local inclusion in decision-making, or inappropriate governance structures.

In summary, there is a clear need for further research and associated investment in fundamental observations systems and analysis, a renewed and comprehensive multi-sector risk and vulnerability assessment using common climate change models, and a wide range of sector- and domain-specific research gaps to be addressed. Research of practical solutions to overcoming resistance to adaptation, using insights and techniques from behavioural and social science to better design adaptation programmes that support and achieve changes needed at individual, community, enterprise, and systems levels, in addition to addressing critical policy relevant questions, are also an important need. Further, the demand for evidence-based guidance for practitioner implementing adaptation in all sectors and at all levels, is apparent. Some, if not all, of these needs may benefit from wider collaboration and funding across Europe, and enhanced systems for learning from and uptake of research conducted outside of Ireland. Importantly, consolidation of funding opportunities and support for longer-term, larger-scale funding is recommended by the academic research community. Co-creation of research projects with relevant stakeholder groups e.g., business, community groups, and end-users e.g., local authorities, to increase adaptive capacity by addressing practical questions around application of research findings in operational contexts, accompanied by clear pathways to funding, is a strong need. As public and institutional awareness of climate change adaptation and the need to act grows, the questions of what to adapt and how must be aforethought for the research community.

Irish and European funded climate adaptation research projects from 2019 onwards is presented below at Annex 2.

Conclusions

Our analysis of Irish adaptation research literature and input from key informants suggests:

1. Irish researchers and research institutions are well regarded within the European research community. As the only native English-speaking EU member state and as a small country on the European North-Western Atlantic periphery, Ireland is very well placed to lead and participate in more climate change adaptation related research.
2. Irish research institutions are aware of the research funding, learning and collaboration opportunities at the national and European levels and participate to the extent currently possible.
3. Opportunities exist for Irish researchers and research institutions to extend their participation at the leadership level of research projects funded through European programmes.
4. Irish government research and innovation strategy emphasises the need to build the capacity of Irish research institutions in part to increase participation in research at European and global levels. Further reform of the Irish research funding architecture would facilitate greater Irish participation at these levels.
5. Irish and European reporting of research collaborations is quite different. CRCG reports of its research partnerships with specific institutions do not provide the same level of detail as those of Horizon Europe. This makes it more difficult to determine which research institutions and groups are most engaged on similar issues or are in partnership.

Recommendations

1. Ireland's research funding architecture should be streamlined by substantially reducing the number of bodies responsible for disbursing climate change adaptation research funding.
2. The emphasis of Ireland's research funding should shift from an over-concentration on short-term, competitive grant mechanisms in favour of an increased emphasis on long-term research partnerships with Irish institutions and research groups, supported through core funding. This would provide better retention and development of research capacity and support core research activity unencumbered by uncertainty around security of funding.
3. Improved alignment of research and adaptation practitioner needs for evidence-based guidance on how to achieve adaptation in practice across multiple sectors, supported and guided by the creation of a national body responsible for the implementation of climate change adaptation. Focusing research on the needs of local structures engaged in community-led adaptation could be particularly useful.
4. Harmonise reporting standards regarding the research institutions funded to make for easier comparison with funding from the EU.

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Annex 1: List of key informants

Table 4: List of key informants

Name	**Title**	**Institution**
Sophie Berger	Policy Officer	European Commission, DG Research and Innovation
Veronica Cunningham	Research Funding Office Manager	Marine Institute
Johannes Klumpers	Senior Expert and Head of Secretariat on EU Mission on Climate Adaptation	European Commission, DG Climate Action
Josh Lernihan	Policy Officer (temporary)	DG Climate Action
Dr. Frank McGovern	Chief Climate Scientist, Chair, EU JPI Climate	EPA
Dr. Darragh O'Neill	Senior Manager, Research Strategy	EPA
Dr. Micheál O'Dwyer	Climate Research Hub Lead	EPA
Dr. Conor Quinlan	Senior Manager, Climate Services	Office of Evidence and Assessment, EPA
Professor Peter Thorne	Professor of Physical Geography, Director - Irish Climate Analysis and Research UnitS Group (ICARUS), Chair CCAC Adaptation Committee, AICBRN	Maynooth University
Professor Shane Ward	Professor of Biosystems Engineering, Member of the EU Mission on Climate Adaptation Board	School of Biosystems and Food Engineering, University College Dublin

Annex 2: Recently completed and ongoing Irish research into climate change adaptation

The CRCG annual reports and data from Horizon Europe provide some information about the research projects involving Irish researchers and research groups since 2019. The CRCG reports include summary data of the amount of research funding in the four thematic areas, but do not, in most cases, provide details of the institutions or individuals funded broken down by theme.

Table 5: Summary of CRCG member funding of Irish-led and implemented research for theme 2 projects (Ireland's future climate, its impacts and adaptation options) 2019-2021

Year	**Total funding €**
2019	7,644,781
2020	3,394,770
2021	7,384,509

Table 6: List of Irish funded theme 2 adaptation research projects started between 2019 – 2021

Year	**Project**	**Funder**	**Irish research partner**
2019	Towards an Agricultural Greenhouse Has Research and Innovation Centre (AGGRIC)	DAFM	Teagasc
2019	Response of tree species to climate change	DAFM	
2019	Lowering the carbon and ammonia footprints of pasture-based dairy production (LoCAM-dairy)	DAFM	Teagasc
2019	Built environment resilient futures. Best practice in implementing climate action (BE-Resilient)	EPA	UCD
2019	Enhancing integration of disaster risk and climate change adaptation into Irish emergency planning (EUDRCCAIEP)	EPA	UCC
2019	Climate Change Adaptation: Risks and Opportunities for Irish Businesses (CARIB)	EPA	Sustainability Works Ltd
2019	Cross-sectoral impact assessment of droughts in complex European basins (CROSSDRO)	EPA	Maynooth University
2019	Transboundary Adaptation Learning Exchange (TalX)	EPA	UCC
2019	Climate Change in the Republic of Ireland: Societal health impacts and solutions (CRISIS)	EPA	UCC
2019	High resolution coupled atmosphere-ocean-wave regional climate projections for Ireland	EPA	ICHEC
2019	Soil moisture estimates from satellite-based earth observations (SoMoSAT)	EPA	Maynooth University
2019	Research-based assessment of integrated approaches to nature-based solutions (RainSolutions)	EPA	VESI Environmental

Year	Project	Funder	Irish research partner
2019	Biological tools to measure the impact of flow on ecology in Irish rivers	EPA	Atlantic Technological University
2019	Earth observation for intertidal mapping and monitoring of EO Intertide	GSI	
2019	Irish droughts: Environmental and cultural memories of a neglected hazard	IRC	UCD
2019	Climate smart Ireland" Identifying regulators of aerenchyma, the "snorkel" tissue for survival of waterlogged crops	IRC	UCD
2019	Of land and ocean: Culture and climate on Ireland's islands	IRC	Maynooth University
2019	Thermal biology of Ireland's ocean giants	IRC	
2019	Ocean climate section: South Rockall Trough	MI	
2019	A small waterplane area twin hulled (SWATH) tide buoy with real-time kinetic (RTK) positioning for accurate (centimetre level) tide gauge calibration	MI	
2019	The role of ocean dynamics and ocean-atmosphere interactions in driving climate variations and future projections of impact-relevant extreme events (ROADMAP)	MI	NA (JPI Water)
2019	Downscaling climate and ocean change to services: Thresholds and opportunities (CE2COAST)	MI / JPI Water	MI
2019	Decoding Arctic climate change: From archive to insight (ACCAI)	MI	
2019	Sensitivity of fluvial flood peak flows to a changing climate	OPW	
2019	EirOOS Irish Ocean Observing System: A component of the European Ocean Observing System (EOOS)	SFI	MI

Table 7: List of Horizon 2020 adaptation funding started between 2019 – 2022:

Year	Project	Funder	Irish research partner
2019	Excellence in Simulation of Weather and Climate in Europe, Phase 2 (ESiWACE2)	Horizon 2020	NUI - G
2019	Integrating Environment and Health Research: A Vision for the EU (HERA)	Horizon 2020	TUD
2019	EuroGEO Showcases: Applications Powered by Europe (e-shape)	Horizon 2020	DECC (3rd party)

Year	Project	Funder	Irish research partner
2019	Advancing Resilience of Historic Areas against Climate-related and other Hazards (ARCH)	Horizon 2020	RFSAT Ltd
2019	Tropical and South Atlantic climate-based marine ecosystem predictions for sustainable management (TRIATLAS)	Horizon 2020	NUI - G
2019	Promoting and implementing joint programming to reinforce transnational research at the crossroad between biodiversity and climate change (BioDivClim)	Horizon 2020	
2020	Food System and Climate (FOSC): Assessing the impact of climate change on food and nutrition security and designing more sustainable and resilient food systems in Europe and beyond (FOSC)	Horizon 2020	DAFM
2020	Marine Coastal Ecosystems Biodiversity and Services in a Changing World (MaCoBioS)	Horizon 2020	NUI - Maynooth
2020	AGROforestry and MIXed farming systems - Participatory research to drive the transition to a resilient and efficient land use in Europe (AGROMIX)	Horizon 2020	Teagasc
2020	Enhancing Belmont Research Action to support EU policy making on climate change and health (ENBEL)	Horizon 2020	Royal College of Surgeons in Ireland
2021	BIODIVERSITY AND INFRASTRUCTURE SYNERGIES AND OPPORTUNITIES FOR EUROPEAN TRANSPORT NETWORKS (BISON)	Horizon 2020	National Roads Authority
2021	ECIU University Research Institute for Smart European Regions (SMART-ER)	Horizon 2020	DCU
2021	Inventive forecasting tools for adapting water quality management to a new climate (inventWater)	Horizon 2020	UCC
2021	Resilient forest value chains – enhancing resilience through natural and socio-economic responses (RESONATE)	Horizon 2020	Teagasc
2021	Artificial intelliGence applied to pRecision farmIng By the use of GNSS and Integrated Technologies (AgriBIT)	Horizon 2020	RFSAT Ltd
2021	Smart Control of the Climate Resilience in European Coastal Cities (SCORE)	Horizon 2020	UCC (Dun Laghaire Rathdown County Council, Erinn Innovation Ltd)
2021	Activation of NATURE-based solutions for a JUST low carbon transition (JUSTNature)	Horizon 2020	INLECOM Commercial

Year	Project	Funder	Irish research partner
			Pathways Co. Ltd
2021	ReAlising DynamIc vAlue chaiNs for underuTilised crops (RADIANT)	Horizon 2020	University of Limerick
2021	RESILIENCE IN EUROPE THROUGH ACTIVATING CITY HUBS REACHING OUT TO USERS WITH TRIPLE-A CLIMATE ADAPTATION TOOLS (REACHOUT)	Horizon 2020	UCC
2021	Shaping ecosystem-based fisheries management (SEAwise)	Horizon 2020	MI
2021	Integrated Technological and Information Platform for wildfire Management (SILVANUS)	Horizon 2020	EMC Information Systems International Ltd
2021	Individual Change of HAbits Needed for Green European transition (I-CHANGE)	Horizon 2020	UCD
2021	Resilience Strategies for Regions (REGILIENCE)	Horizon 2020	F6S Network Ireland Ltd
2022	Climate Neutral Farms (ClieNFarms)	Horizon 2020	Teagasc
2022	INTEGRATED DigitaL Framework FOR Comprehensive MARITIME DATA AND INFORMATION SERVICES (ILIAD)	Horizon 2020	UCC
2022	Reshaping European Advances towards green Leadership Through Deliberative Approaches and Learning (REAL_DEAL)	Horizon 2020	Trilateral Research Ltd
2022	Early warning systeM for soil dEgRadation: a statistical physics Approach to cLimate change aDaptation (Emerald)	Horizon 2020	Trinity College Dublin

Table 8: List of Interreg adaptation projects ending between 2019 – 2022

Year ending	**Project**	**Funder**	**Irish research partner**
2019	Atlantic risk management plan in water and soil (Risk-AquaSoil)	Interreg	NUI Galway
2020	Collaborative Learning Initiative Managing and Adapting to The Environment (C.L.I.M.A.T.E.)	Interreg	Derry City and Strabane District Council (UCC)
2022	Resilience for EU Bathing Waters and Coastal Communities (Acclimatize)	Interreg	UCD