AICBRN

CLIMATE + BIODIVERSITY

An Analysis of Climate Change and Biodiversity Research from Institutions across Ireland

---

Report prepared on behalf of the All-Island Climate and Biodiversity Research Network by Dr. Paul O'Connor

Commissioned by the Sunflower Charitable Foundation

December 2022

Table of Contents

About the AICBRN

The All-Island Climate and Biodiversity Research Network (AICBRN) brings together researchers from a wide range of disciplines across the island of Ireland who are undertaking research on climate and biodiversity topics. The ambition of the AICBRN is to develop a large-scale research and innovation initiative to support policy and management decisions, underpin business and enterprise strategies and strengthen societal capacity to address the climate and biodiversity emergencies. The diversity of disciplinarity and expertise of members across the physical, natural and social sciences, engineering, and humanities enables this network to cooperatively undertake the essential fundamental and challenge-based research required for Ireland to successfully address the climate and biodiversity emergencies.

Acknowledgements

I want to thank all members of the AICBRN who gave valuable feedback regarding the design and format of the survey and the follow up interview structures within the network's monthly meetings. I wish to acknowledge and thank the following individuals for the time they spent reviewing the final version of the survey design: Dr. Diarmuid Torney, School of Law and Government, Dublin City University, Dr. Paul Bolger, Environmental Research Institute, University College Cork and Prof. Peter Thorne, ICARUS Climate Research Centre, Maynooth University. Furthermore, I would like to thank Prof. Thorne for reviewing this report and making recommendations on its content and layout. I would also like to thank all the individual contributors to the survey and follow up interviews who freely dedicated their time to be part of this study. Finally, I wish to thank the funders of this research, the Sunflower Charitable Foundation, without whose support it would not have been possible to carry out this study.

List of tables

List of figures

Executive summary

The recent declaration of climate and biodiversity emergencies by the government of the Ireland, following a similar declaration by the United Kingdom, has focussed minds on the part academia has to play in relation to tackling these combined crises, particular as academic researchers have a central role in identifying and addressing the related causes, solutions and potential impacts on the island. Little is known about the overall research output metrics or common characteristics of units carrying out climate and biodiversity research on the island. In an attempt to address these knowledge gaps, this study has carried out an in depth analysis of climate change and biodiversity research outputs along with an assessment of what are the most important aspects influencing climate and biodiversity unit performance on the island. By employing a combination of database analysis techniques, surveys and interviews a better understanding of the current state of the climate and biodiversity research environment has been formed. Findings show that the island performs poorly compared to other European countries of similar size and economic status such as Scotland and Denmark, that inadequate funding has been one of the main causes of lower research outputs to date and that there is a degree of insularity in collaboration efforts on the island. Based on results from the three differing strands of analysis, 26 recommendations have been drawn up for consideration by government, funders and relevant institutions on the island. Were they to be implemented it is foreseen that these actions would significantly increase research output and in turn position Ireland as a world-class leader in climate and biodiversity research, allowing academia to confidently address the current knowledge gaps that hinder our ability to prepare for and address the worst impacts of the climate and biodiversity emergencies yet to come.

Key findings

Results of the study were obtained through three independent approaches that formed the basis of the methodology; i). the analysis of historical worldwide publications, using the Web of Science online database, ii). the assessment of quantitative data relating to climate and biodiversity units across the island, extracted using surveys of said units, and iii). the assessment of qualitative data relating to unit performance and suggested means for improving climate and biodiversity research outputs, derived from semi-structured interviews with unit managers. Applying the three approaches in succession, a broad understanding of the research environment was obtained including detailed information on the strengths, weaknesses and possible future directions for research on the island. By comparing and contrasting results it was possible to develop a list of actions that could be taken to support existing climate and biodiversity units, increase research outputs and foster greater collaborations both on the island and further afield. The following subsections provide an overview of the key findings for each of the three approaches, followed by details on the top ten most important recommendations that were derived from the study.

i) Research output

Historical climate and biodiversity research output numbers, from the web of science online database, were downloaded and assessed. The most important finding from this aspect of the research relates to the island of Ireland's publication record compared to some of our European neighbours. Whilst performing well internationally, authors from the island were found to publish considerably less climate and biodiversity research when compared to Scotland and Denmark. This

is clearly shown in Figure 1, with Ireland identified as publishing approximately half the research output of these countries despite it having a greater population. This key finding sets the scene for the majority of the subsequent analysis of categorised research output from the island.

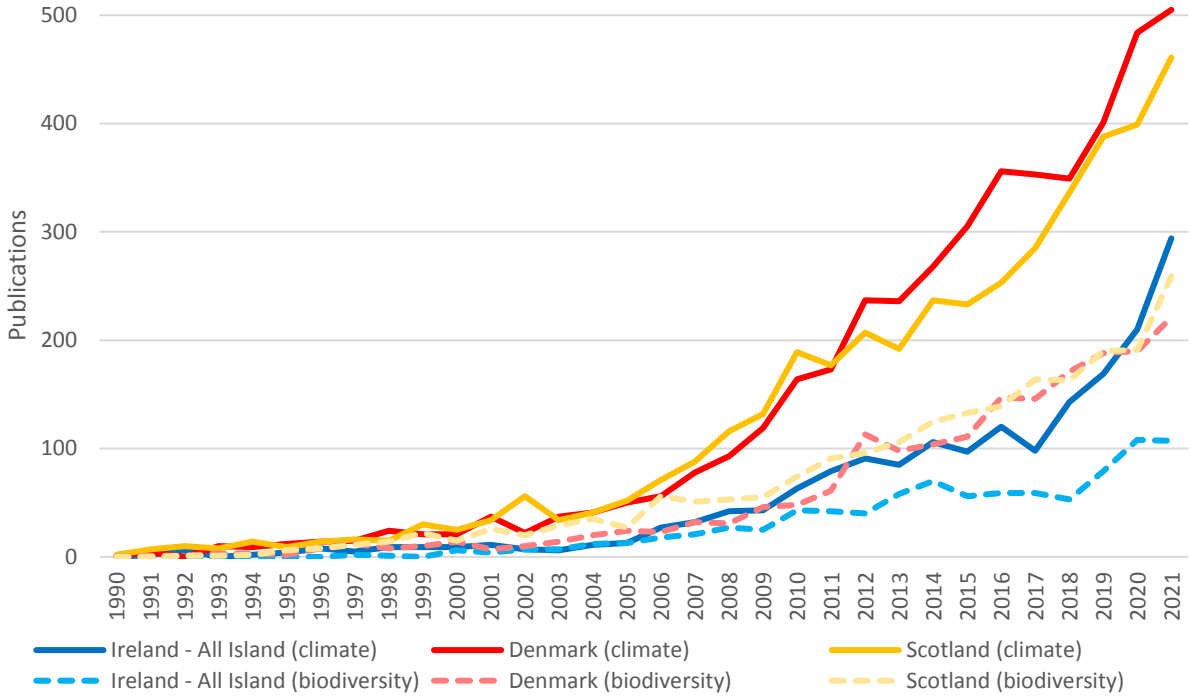


Figure 1. Total annual climate change (solid lines) and biodiversity (dashed lines) publications from the island of Ireland (blue), Denmark (red) and Scotland (yellow).

Some of the other key findings of the research output analysis were as follows:

- The Island of Ireland has 0.09% of the world's population (7.9 million) and publishes 0.9% of the climate and biodiversity research, which indicates a good performance globally.
- Climate change related publications surpass those relating to biodiversity (by a factor of 2:1) on the island of Ireland.
- Both Scotland and Denmark publish over twice as much climate and biodiversity research compared to the island of Ireland despite having lower populations.
- Authors from the island failed to produce any research in 50 climate change and 102 biodiversity related Web of Science categories.
- Of the top 30 Web of Science climate related categories globally the island of Ireland consistently produces a lower percentage of articles compared to Scotland and Denmark.
- With the exception of *oceanography* and *soil science*, Ireland consistently produces a lower percentage of biodiversity related articles compared to Scotland and Denmark across the top 30 biodiversity related categories.
- The island of Ireland performs poorly in *remote sensing* research when compared to outputs from Scotland and Denmark.
- Ireland performs well in *agriculture dairy animal science* (2% of worldwide publications related to climate change), and *marine freshwater biology* (1.7% of worldwide publications related to biodiversity), however output is still surpassed by Scotland and Denmark.
- Worldwide, Ireland performs particularly poorly in *meteorology atmospheric sciences* equating to 0.62% of worldwide publications related to climate change and *plant sciences* which only equates to 0.58% of worldwide publications related to biodiversity.

ii) Survey

The issuing of surveys to climate and biodiversity units across the island of Ireland resulted in the extraction of the most important quantitative information of the study. The surveys yielded considerable understanding of the links between the varying characteristics of units and research outputs. A snapshot of some of the most important overarching numerical values relating to the units is given in Figure 2, with average values presented across a number of prominent categories. Results are presented based on unit sizes with large units having research staff numbers greater than 66, medium being between 33 and 66 and small being fewer than 33. Along with the overall bias towards climate change as opposed to biodiversity research, other interesting findings include the relative importance of larger units in generating research outputs, the balanced approach small units have across climate and biodiversity research and the surprisingly low number collaborations carried out with the United Kingdom.

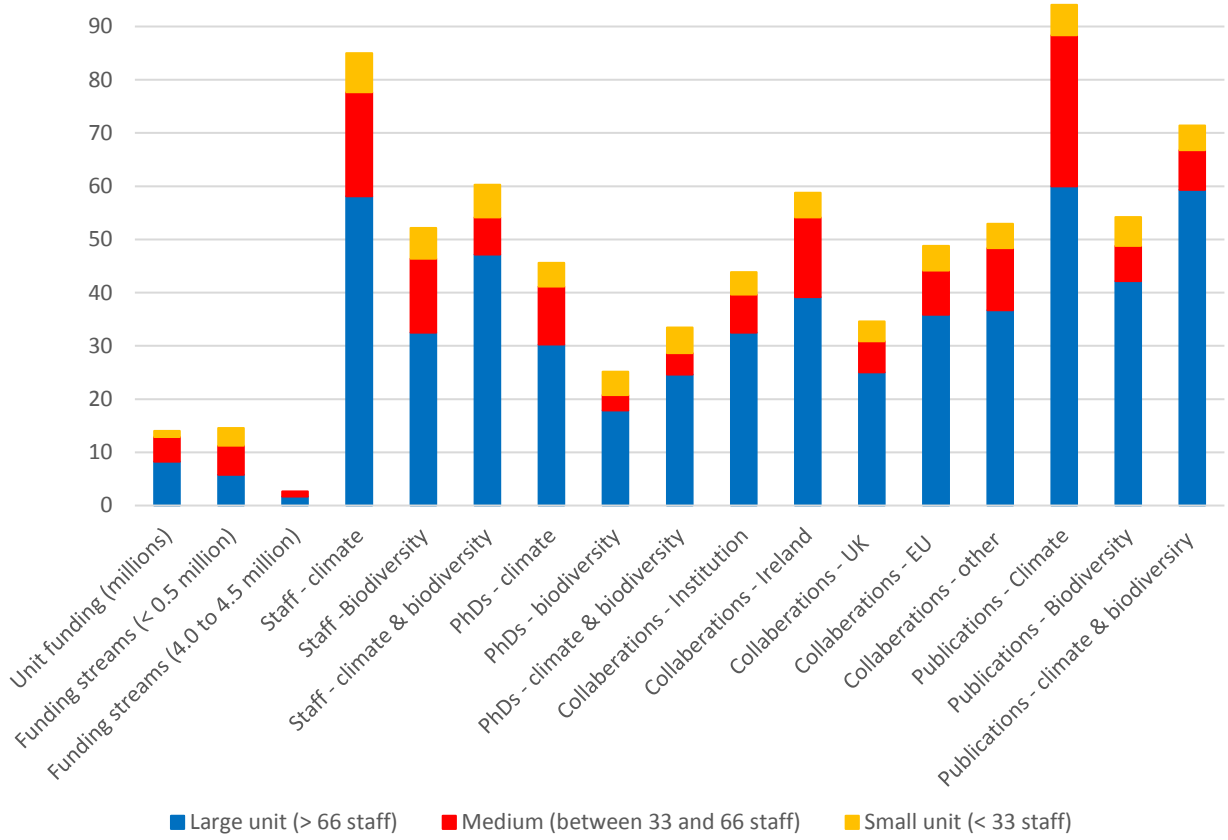


Figure 2. Breakdown of values relating to some of the most important topics investigated in the survey with average values presented for units based on their size (staff numbers).

Some of the other key findings of the surveys were as follows:

- Purely climate change research makes up the vast majority of research (45%) compared to purely biodiversity research (27%), with the combination of the two making up the balance (28%).
- Small units carry out proportionally more biodiversity and combined climate and biodiversity research compared to medium and large sized units.
- Amongst the most researched topics are *adaptation*, *sustainability* and *water* whilst the least are *vector ecology*, *extinction* and *meteorology*.

- Only three units are identified as having at least one active funding stream with an amount greater than 5 million euros whilst small units have the most active funding awards of less than €500,000.
- Science Foundation Ireland is the most important funder for large units followed by Horizon Europe/Horizon 2020. For medium sized units the Environmental Protection Agency stands out whilst for small units it's the Irish Research Council.
- Increases in funding provided to large units has a much greater impact on research output than those of medium sized units, which in turn is, marginally, greater than those for smaller units.
- Biodiversity research consistently shows a lower representation in terms of staff numbers.
- Provision of administrative staff has the greatest impact on research outputs in established units compared to other staff types, with proportionally larger numbers found in large units.
- Climate change related topics make up the vast majority of PhD research (44%) compared to biodiversity (24%) or combined climate and biodiversity (32%), with strong positive relationships evident between PhDs numbers in units and related publication outputs.
- Over half of the respondent's institutions provided a climate change and/or biodiversity related Master's programme.
- Overall the greatest number of collaborations were with other units on the island of Ireland (24%), followed by international collaborations, with the EU and within the institution (22%, 20% and 19% respectively). Only 15% of collaborations were with the United Kingdom.
- Small units had the greatest proportion of collaborations with the United Kingdom (16%), and the EU (21%), whilst internationally it was medium sized units (24%).
- Proportionally, collaborations with the United Kingdom, the EU and other international partners were lowest for units with the largest funding (> 6.5 million euro).
- As staff numbers increase collaborations across Ireland increase at a greater rate than for other international regions and particularly more so than those with the United Kingdom (1.7 times faster).
- 42% of research output specifically related to climate change topics whilst only 25% related to biodiversity.
- Whilst larger units with funding > 6.5 million euros consistently produced greater research outputs, for biodiversity research smaller less funded (< 1.5 million euros) units produced more publications than medium sized units.

iii) Interview

The third approach employed interviews to extract insights into the strengths and weaknesses of climate and biodiversity units across the island of Ireland, to identify what helps and hinders their performance and to find ways to improve the overall climate and biodiversity research landscape on the island. Units of all sizes, across the two disciplines, and from the Republic and Northern Ireland all took part providing a wide set of diverse opinions. Discussions revolved around nine topics with some of the most common responses to each being given in Table 1. Key findings include the identified importance of funding and administrative support on unit performance and that there is a strong desire to take part in greater collaborative efforts with units across the island going forward.

Table 1 Most common responses from the follow up interviews to surveys.

	Common Response No. 1	Common Response No. 2	Common Response No. 3
Top 3 Strengths of Unit	Large amount of collaborations	Diverse range of disciplines	Wide funding options (for SFI centres)
Top 3 Weaknesses of Unit	Unpredictable and insecure funding	Disciplines are too diverse	Equipment/lab space
Future opportunities	Increasing/strengthening expertise of unit	More collaborations	Happy with the current setup
Future risks	Sourcing funding including industry funding	Units future in university/politics	Growing administration burden/workload
Teaching & Sourcing PhDs / postdocs	Teaching is manageable	Cost of living affecting hiring/PhDs	Online teaching was beneficial
Collaborations	Strong interest in collaboration between groups/centres	Collaborations ease workload	Funding for collaborations generally supported
Required Institutional / Governmental Support	More administrative support – with funding	Problem of short term funding	More funding opportunities - collaboration / cross border
Advancing Climate and Biodiversity Research	New climate/biodiversity funding streams	Support for collaboration activities required	Biodiversity needs more attention
Top 3 Research Topics	Land use / Peatland	Marine / Ocean	Provision of baseline data

Some of the key findings of the interviews were as follows:

- Positive commentary on funding mainly related to larger units whilst for smaller units access to funding and its unpredictable nature were often seen as the unit's main weaknesses, with funding insecurity seen as a future risk.
- Lack of resources (equipment and lab space), internal conflicts and politics were also seen as significant weaknesses.
- The growing administration burden on researchers and associated workload was seen as a threat to the running of units with the amount of time and effort required when applying for funding of particular concern.
- Most interviewees want to expand the expertise of their units to include broader profiles of researchers and increase collaborative activities but some did not foresee any radical future changes as they were already "maxed out".
- Interviewees were happy with their teaching workload with many saying it was an important and beneficial part of their work but some lamented the strong move back towards face to face learning which impacted their research time.
- Many units identified the cost of living crisis (high rent prices) as having impacted their ability to attract high quality international PhDs.
- Strong support for targeted funding for those taking part in collaborative research activities, particularly for cross border funding initiatives, was evident with some interested in collaborative activities with regional authorities.
- Whilst there was overarching support for collaboration activities, few comments were made on potential future collaborations with international partners.
- The negatives of short term funding and the difficulties that these grants cause were highlighted, particularly in terms of time writing applications and the negatives of short term awards (of one year or less).
- New funding streams were identified as being required to support climate and biodiversity research which are less prescriptive.
- A general consensus that biodiversity research was undervalued was evident with new funding streams identified as being required that specifically target biodiversity related research.
- Suggestions that the government needs to encourage and fund international conferences, stakeholder forms and other means of linking like-minded people together were made.
- Interest in setting up an all-island climate and biodiversity research centre was mixed with concerns raised by established units regarding future access to funding opportunities. A virtual centre, promoting collaborations between existing climate and biodiversity units, was seen as a possible compromise.
- Land use, peatlands, marine and coastal ecosystems were identified as the most important research topics however are found to be relatively well researched.
- Continuous long term monitoring of baseline data was highlighted as being of huge importance for researchers and should be supported and expanded upon where possible.

Key recommendations

Following a thorough review of the findings from the study's three approaches, a total of 26 actions were identified that could be taken to help improve climate change and biodiversity research outputs from units across the island. In the process these actions would help strengthen

climate change and biodiversity research units and improve the overall climate change and biodiversity research environment. Of these recommendations, 10 were identified as being of high importance as they would facilitate the greatest impacts over the shortest time periods in the areas of funding, administration and collaboration. The identified actions are as follows:

1). Provision of additional funding for both climate and biodiversity research, targeting smaller research units for which precarity of funding is a particular concern.

2). Continued funding of large units using the currently established Science Foundation Ireland model but with the requirement for a much greater amount of biodiversity research output.

3). Implementation of new funding mechanisms that will drive an increase specifically in biodiversity related research across the island.

4). Targeted funding for each of the main underrepresented research topics identified in this study (in the areas of *remote sensing*, *plant sciences* and *meteorology atmospheric sciences*).

5). Immediate increases in stipend funding provided to PhD researchers together with targeted assistance to help address impacts from housing and cost of living crises.

6). Explore the feasibility of creating a virtual centre focused on climate change and, in particular, biodiversity related research.

7). Provision of additional administrative staff to medium and, in particular, smaller units and/or funding to facilitate this.

8). Simplification of grant applications and reporting requirements where possible for all grant types.

9). Support greater all-island and international research efforts by use of conditional research grants, particularly for larger funding allocations associated with medium to large sized units.

10). Provide support mechanisms in institutions to aid and encourage researchers to apply for larger European grants that require collaborative activities.

Chapter 1 | Introduction

1.1 Background

On the 9th May 2019, following the United Kingdom, Ireland officially declared a climate and biodiversity emergency. This declaration came about following the release of the Report of the Joint Committee on Climate Action (Houses of the Oireachtas, 2019) whereby all parties of the Oireachtas and the Climate Change Advisory Council acknowledged that the Irish state's response to climate change and biodiversity crises has been insufficient. Furthermore, the houses of the Oireachtas has accepted findings from successive United Nations Intergovernmental Panel on Climate Change and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services reports, which have shown that climate and biodiversity deterioration has increased across the world in the last fifty years and that the current path of countries, including Ireland, were unsustainable. Since then the Environmental Protection Agency's Status of Ireland's Climate report (EPA, 2021a) has recorded the extent of the change in Ireland's climate with highlights including an overall increase of 6% in annual rainfall amounts over the 1989-2018 period compared to the previous three decades, a 2-3 mm per year rise in sea levels since 1990 and an overall annual increase of 0.9°C increase in temperatures over the last 100 years. Similar indicators of change are evident in Ireland's biodiversity with the Department of Culture, heritage and the Gaeltacht (Government of Ireland, 2019a) report showing that only 9% of Ireland's habitats are in favourable conditions with 50% inadequate and 41% bad. Furthermore trends suggest that 31% are declining in quality. That same report highlights that over the 2007-2013 period the status of 20% of protected species was inadequate and 12% bad with 10% showing declining numbers. Such signs of change in Irish climatological indicators, species and habit show that Ireland is not immune from the impacts of these worldwide crises. It also emphasises the vital importance underlying research being carried out by educational and research institutions across the island of Ireland has in helping to identify, measure, mitigate and ultimately adapt to the most negative aspects of both climate change and biodiversity crises.

1.2 The commissioning of this report

In response to the declaration of the climate and biodiversity emergencies experts from across the two fields came together to form the All-Island Climate and Biodiversity Research Network (AICBRN). The network was formed with the intention of supporting policy and management decisions for both business and governmental organisations and to strengthen their capacity to address the climate and biodiversity emergencies. The network members, who have backgrounds in the natural, physical, engineering and humanity disciplines, have an array of expertise, the combination of which is essential for helping Ireland address these crises using evidence-based solutions. Following their initial broad assessment of the climate and biodiversity research environment in Ireland, the AICBRN highlighted that current research efforts are dispersed across a number of teams working apart, leading to *redundancy of effort* and *under exploitation of synergies* (AICBRN, 2020*)*. Such inefficiencies can lead to wasted resources, the creation of unintended knowledge and data gaps and potential missed opportunities for collaboration, all of which can hinder policy makers from making informed policy decisions based on accurate up-to-date scientific research. As there is a requirement for large-scale research and innovation efforts to address the combined crises, the AICBRN deemed it important that an evaluation of the capacity of climate and biodiversity research be carried out for the island. Such a study would provide a greater understanding of climate and biodiversity research environment on the island,

helping to detect strengths and weaknesses in current systems and would help identify pathways to maximise efficiencies in current processes.

1.3 Climate change and biodiversity research analysis

As a first step to help maximise the potential output of the climate change and biodiversity research community on the island of Ireland a greater understanding of both past and current research and outputs is required. Whilst analyses of worldwide research outputs on the topics of climate change and biodiversity, in the form of peer reviewed journal articles, has been thoroughly assessed (e.g. Fu and Waltman, 2021; Sangam and Savitha, 2019; Stork and Astrin, 2014) such an analysis has been limited for individual countries and in the case of Ireland had not yet taken place. As a result, little is known about the overall extent and depth of research on the topics on the island. Furthermore, there is no one-stop-shop for identifying which topics relating to climate and biodiversity are being extensively studied and which are not. As a result there are potential knowledge and data gaps in the research that may be hindering progress in addressing the dual crises and hiding potential opportunities in the form of collaborations between institutions working on common topics. By mapping the structures and outputs of research units across Ireland in the fields of climate and biodiversity it would be possible to identify these knowledge and data gaps and help address these deficiencies. In doing so it could potentially create a better understanding of the knowledge base, the current capabilities and potential future opportunities that exist on the island and in the long run will help improve the science informing management decisions and public policy, drive business and enterprise strategies and strengthen social capacity, all of which are required to address the climate and biodiversity emergencies.

1.3.1 Online publication databases

Climate change and biodiversity have both been widely researched in Ireland. However, an exact understanding of the depth of research, relevant topics covered and number and type of collaborations between authors remains unknown. One way to address this is by using historical online databases to extract records of relevant research outputs for analysis. Such assessments have been applied extensively worldwide. For example Fu and Waltman (2021) carried out a broad assessment of global climate change research over the 2001-2018 period identifying key scientific topics, changes in research and how research is distributed spatially between regions and countries. Their analysis of publications, extracted from the Web of Science and Scopus databases, found that research has shifted from understanding the climate system to climate technologies and policies, that scientific research is linked to national demands and strategies and that there is an imbalance between developed and developing nations. A regional analysis of climate change research was carried out by Zyoud and Fuchs-Hanusch (2020) who investigated the status and trends in peer reviewed research for the Arab world using the online Scopus database and identified countries with the greatest research in the region together with countries having a high collaboration rate with Arab related research on climate. Stork and Astrin (2014) carried out a broad assessment using the Web of Science directory on biodiversity research output over the 1966-2014 period. They found that up until 2008 research in the area had accelerated rapidly but since then it has levelled out with climate change related topics taking a greater precedence since then. Furthermore, they found that the spread of research across the globe is uneven with research in Africa disproportionately small. These findings highlight that research outputs can

fluctuate considerably over time and by location, raising questions regarding how climate and biodiversity research outputs have changed on the island of Ireland.

Subcategories of climate change and biodiversity research are often subject to detailed analysis too. Wang *et al.* (2014) have assessed research on vulnerability to climate change and have identified patterns of change in publication quantities and growth trends. They employed the Web of Science database identifying publications falling under the category of climate change vulnerability. Li *et al.* (2020) assessed the volume of publications, 'hotspots' and developing trends in relation to publications on climate change and its links to infectious diseases. Fang *et al.* (2018) investigated research relating to climate change and its specific impacts on tourism over the 1990-2015 period. They employed the Web of Science database and the CiteSpace visualisation software to generate network visualisation maps of articles. Results showed global trends and identified countries with the greatest academic output. Huang *et al.* (2020) carried out an assessment of the intellectual landscape relating to climate change and carbon sinks with a specific emphasis on the location and strength of the intellectual base, how the research topic has evolved and research hotspots in the field. Brudvig (2011) investigated the subtopic of restoration in the context of worldwide biodiversity research. Analysis of Web of Science data showed steadily increasing research output on the topic. However, under-researched areas were also identified including landscape and historical factors influencing successful restoration, how functional and genetic components are influenced by restoration and how less studied taxa might be impacted. Rahmann (2011) assessed biodiversity and organic farming and the research undertaken to date with a particular emphasis on German literature which produces the greatest volume of literature (relatively) in that field. Green *et al.* (2019) assessed biodiversity research based on the amount of articles in Web of Science relating to twenty Aichi biodiversity targets linked to the United Nation's Strategic Plan for Biodiversity of the Convention on Biological Diversity. Additionally, major stakeholders were surveyed on progress relating to the reaching of goals in the relevant areas to map progress. Olisah and Adams (2021) carried out an assessment of historic research on South African estuaries. In that study, biodiversity formed a subcategory of research, specifically relating to management of estuaries, socio-economic research (relating to estuaries) and salt marsh research. Such studies demonstrate that historical research outputs from countries can be relatively easily assessed and deficits identified. Potential applications of such techniques therefore exist in the context of climate and biodiversity research outputs from the island of Ireland and warrant further investigation.

1.3.2 Surveys

Surveys can be a very effective tool for extracting quantitative data and are the principal component of many research designs with such objectives (Watson, 2015). In relation to the topics of climate change and biodiversity the vast majority of survey work has been carried out in the former and, in general, has related to members of the public's perceptions of climate change. Stakeholders dealing with climate change and biodiversity related impacts are often investigated too with surveys applied in a broad spectrum of differing studies (eg. Adaptive capacity at heritage sites (Phillips, 2015), barriers to adaptation in the farming sector (Masud *et al.*, 2017) and uncertainties in future polar bear populations under a changing climate (O'Neill *et al.*, 2008)). Whilst a number of studies have used surveys to investigate the perceptions of the research community on the topic of anthropogenic climate change (e.g. Carlton *et al.*, 2015; Blanchard *et al.*, 2022) studies evaluating overall climate and biodiversity research and related collaborations are less prominent. Klein *et al.* (2017) investigated climate adaptation practices and solutions in

the context of the research environment and in the process identified themes and cross-cutting issues important for research, policy and practice. By surveying experts in the fields of biodiversity and climate across Israel, Sternberg *et al.* (2015) deduced that collaboration work is critical for future climate adaptation research. Leal Filho *et al.* (2018) assessed the barriers to climate change related research at institutions of higher education by means of online surveys. The authors found that the online facility was an inexpensive, flexible means of carrying out a wide assessment of research topics and that results were simple to analyse. Such findings highlight the effectiveness of online surveys in gathering qualitative data relating to climate change research and suggest considerable potential exists for similar applications in the context of Irish research analyses.

1.3.3 Interviews

Whilst surveys have been demonstrated to be an effective means of obtaining quantitative information, gathering qualitative data often requires verbal communication with interested parties (Vishnevsky and Beanlands, 2004). Interviews are therefore one of the most widely deployed methods for extracting such information. Interviews can contribute to a body of knowledge relating to a research topic that is conceptual and theoretical and is based on life experiences for interviewees (DiCicco-Bloom and Crabtree, 2006), something that quantitative methods cannot identify. Climate and biodiversity research related interviews have been widely deployed, primarily to assess the perception of researchers on the main areas requiring research. Kappelle *et al.* (1999), for example, used structured interviews to assess the key issues relating to climate and biodiversity research that require addressing and identified numerous knowledge gaps. The authors' subsequently drew up a list of recommended actions based on those findings for implementation. Sovacool *et al.* (2012) gathered the views of researchers on four climate change adaptation policies for some of the least developed nations in Asia. Using semi-structured interviews, qualitative information relating to stakeholders in the region was gathered with the authors finding that the open ended nature of this type of interview best captured the complexities of the topics discussed. Neßhöver *et al.* (2013) used interviews to help derive recommendations on how to improve the interfaces between researchers and policy makers in order to address biodiversity loss. They found that mutual learning and enhanced institutional interface expertise worked best for linking research project outcomes with decision makers. Jones *et al.* (1999) employed interviews to assist in the development of a methodology that assesses the interface between climate change research and policy making in Californian institutions. They found that semi-structured interviews were central to the effective implementation of the methodology as they resulted in much greater understanding of the unique circumstances climate scientists and policy makers work under. The aforementioned studies all successfully demonstrate that qualitative information can be easily extracted from stakeholders using interview techniques. Such techniques would be extremely useful in any analysis of units carrying out climate and biodiversity research on the island of Ireland.

1.4 Current climate and biodiversity research supports

The establishment of the climate change and biodiversity citizen's assemblies, the development of the comprehensive cross departmental road map to address Ireland's spiralling emissions (Government of Ireland, 2019b) and the impending release of the 2023-2027 national biodiversity action plan, suggests there is a strong willingness in government to tackle the climate and

biodiversity crises. This willingness extends to funding bodies with the Irish Research Council, Science foundation Ireland and the Environmental Protection Agency all having recently announced significant new climate related research funding awards that will undoubtedly help improve research in that area. Bodies such as the Climate Research Coordination Group have greatly assisted in coordinating research strategies relating to climate change, particularly between funding agencies, (Government of Ireland, 2022) and individual funders such as the Environmental Protection Agency have made great progress on developing concrete research frameworks from which institutional funding needs can be addressed into the future (EPA, 2021b). Potential collaborative activities on the island have also received a significant funding boost recently with the announcement of the cross border funded Co-Centres programme. However, questions remain over what are the most efficient and effective approaches to funding climate and biodiversity research on the island and, particularly, whether biodiversity research will receive the attention it has been lacking to date. Furthermore, whilst at the institutional level climate and biodiversity research outputs often make headline news little is known regarding what actions are required to help support climate and biodiversity researchers. This study will attempt to address some of these questions and in the process identify possible deficiencies in the Irish research environment. With such information it will be possible to determine what actions are required by government, funding bodies and parent institutions to address these deficiencies and improve the research environment and research output on the island.

1.5 Identified research gaps

Following a review of the literature, the following research gaps, associated with climate and biodiversity research, were identified:

Research gap 1: Currently, it is unclear how much climate and biodiversity research is taking place on the island of Ireland. This includes both recent and historic publication numbers. Obtaining such information would make it possible to compare outputs to those from other European countries and more broadly worldwide.

Research gap 2: A considerable knowledge gap exists regarding the types of climate and biodiversity research activities being carried out by researchers on the island of Ireland. By classifying the different types of publications associated with Irish researchers it would be possible to identify climate and biodiversity research topics that require focused attention.

Research gap 3: Whilst a wide range of research occurs in units based in academic, governmental and other private organisations on the island, it is unclear where exactly climate and biodiversity research occurs, what the volume of research outputs is and what the general statistics relating to climate and biodiversity units are. By assessing the characteristics of such units it would be possible to create a much better understanding of their performance and may help identify different ways of improving climate and biodiversity research output on the island.

Research gap 4: The strengths and weaknesses of climate and biodiversity research units on the island of Ireland are unknown. Furthermore, potential future opportunities and possible threats to these units are unclear. By addressing this knowledge gap targeted assistance to address the identified issues could be provided, helping to build resilience in the community.

Research gap 5: Due to a lack of data, understanding of the current climate and biodiversity research environment on the island of Ireland as a whole is limited. As a result it is unclear what

actions can be taken by government and institutions across the island to improve overall research outputs. By obtaining the opinions of some of the most important stakeholders in the community, this knowledge gap could be addressed.

1.6 Report aims and objectives

The principal aim of this report, commissioned by the Sunflower Charitable Foundation, was to map academic research on climate change and biodiversity across the island of Ireland and in the process create a better understanding of the environment climate and biodiversity research units operate in. In order to achieve this aim each of the five research gaps identified in Section 1.5 needed to be addressed. This was achieved by the drawing up, and subsequently acting upon, five corresponding objectives. The objectives were as follows:

Objective 1: Identify key peer reviewed climate change and biodiversity research outputs from institutes across Ireland and analyse these outputs.

Objective 2: Categorise and compare all-island research outputs to international numbers as well as some select European countries with similar population sizes to the island of Ireland.

Objective 3: Find quantitative information on funding, expertise, staff, education, teaching, collaborations and publication numbers for climate and biodiversity units across the island of Ireland.

Objective 4: Identify the key strengths and weaknesses of climate and biodiversity research units across the island of Ireland.

Objective 5: Make recommendations that would improve the climate change and biodiversity research environment on the island of Ireland.

1.7 Report structure

This report provides a detailed analysis of climate and biodiversity research on the island of Ireland. It explains why the study was required, provides details of other similar studies, lists the study aims and objectives and describes the methodology employed to extract relevant data. The main results of the study are outlined in detail and a discussion of those results is presented. Finally, a number of recommendations are derived from the findings in order to improve climate and biodiversity research outputs going forward. A more detailed description of the content of each of the remaining chapters follows.

Chapter 2 presents details on the three independent approaches that were applied in the methodology, used to extract relevant data from which the final recommended actions were derived. The first approach relates to climate change and biodiversity research publications and uses the Web of Science database to derive estimates of historical research outputs from the island, comparing these to worldwide outputs and that from other European countries of a similar population size. The second approach relates to the performance of units across the island in terms of funding, expertise, staff, teaching, collaborations and publications with details provided on how surveys were employed to extract this information. The third approach relates to the methodology by which a deeper understanding of the strengths and weaknesses of units and ways

and means by which the research environment on the island can be improved and in this case related to the deployment of interviews.

Chapter 3 outlines the results of the assessment. As per Chapter 2, it is broken into three sections with results relating to each of the three approaches of data extraction presented. Firstly, results of the climate and biodiversity research publication assessment are given, with details provided on how the island performs internationally. A comparison of outputs to that from two neighbouring European countries is also given. Secondly, results derived from the survey of the research units are presented giving an overview of responses for each of the topics (i.e. funding, expertise, staff, teaching, collaborations and publications), comparing outputs between each unit and parent institutions. Lastly, results derived from the interviews, where matters relating to climate and biodiversity unit strengths and weaknesses together with the overall research environment on the island were discussed, are presented with the most common responses identified and most interesting quotes listed.

Chapter 4 provides an in-depth discussion of the main findings of this study and outlines a number of actions that can be taken to improve climate change and biodiversity research outputs on the island of Ireland. It initially presents an overview of the main objectives of the study and outlines whether or not each of them have been met. A detailed synopsis of the overall findings from each of the three approaches of data collection is then given with results compared and contrasted. For each of the principal categories identified from the analysis a short discussion is had from which a list of corresponding recommended actions are derived (26 in total).

Chapter 5 is the final chapter of the report. It begins with a brief overview of the study outlining what exactly was carried out and why. Some of the main limitations of the study, together with possible actions that can be taken to address these limitations, are then identified and discussed. These are presented in point form with a total of six items listed with some of the most favourable potential future actions identified. Finally, some concluding observations regarding the study are made, ending the report.

Chapter 2 | Methodology

2.1 Methodology overview

The research methodology was designed around the principle research aims and objectives as listed in Section 1.6. Three independent approaches of data collection and analysis were employed. The first approach related to the aim of identifying historical peer reviewed climate change and biodiversity research output from units across the island of Ireland. This was achieved using the Web of Science database along with specific keyword searches and the categorisation of output. The second approach related to the aim of identifying strengths and weaknesses in the current research environment relating to the topics of climate change and biodiversity as found in units across the island of Ireland. In this instance units represented institutes, centres, groups, departments, governmental and semi state organisations, and private agencies. Surveys were employed to find this data. The third approach attempted to address the aim of determining what actions should be taken to improve the overall climate change and biodiversity research environment and involved interviews of relevant stakeholders. Interviewees were selected from the pool of survey respondents gathered as part of the survey process. From the interview commentary we were able to generate a series of recommendations, using the previously acquired data to justify these recommendations. The following sections provide more detail on the methodology employed for each of these three approaches.

2.2 Research output analysis

In order to carry out an analysis of historical climate and biodiversity research on the island of Ireland a means to assess research output was required. Our analysis of the literature showed that the Web of Science online database [1] has previously been effectively employed to carry out similar analysis and therefore it was decided that it would be used in this study. A decision was made to assess total climate change and total biodiversity research outputs from authors on the island of Ireland (combined output from the Republic of Ireland and Northern Ireland) individually and to compare outputs to that from Scotland, from Denmark and from the rest of the world. The reason Scotland and Denmark were chosen was due to their relatively similar population sizes (all island population of 6.9 million, versus Scotland's population of 5.5 million and Denmark's population of 5.8 million), which allowed for a 'fair' comparison of research outputs between regions where differences relate principally to aspects other than population. Climate change and biodiversity publication data were extracted separately from the Web of Science database to allow for an analysis of results by discipline.

The Web of Science online platform allows access to multiple databases providing details on reference and citation data related to publications in academic journals, conference proceedings and other peer reviewed publication forms. Using the search facility provided on the platform it is possible to extract valuable information on historic publications across all scientific fields using defined search terms. Results can be subsequently refined using a large number of search filters including by publication year, country/region, Web of Science category, and affiliation, all of which were employed in this analysis. Results for articles in other languages were also assessed (abstracts and titles also provided in English) with those making up approximately 2% of climate change and 3% of biodiversity publications.

[1] https://www-webofscience-com

2.2.1 Climate change research

Climate change related research articles on the Web of Science site were identified by searching the titles and abstracts of all publications using the following keywords: “climate chang*”, “climatic chang*”, “climate variabilit*”, “climatic variabilit*”, “global warming”, “climate warming” and “climatic warming”, duplicating the approach taken by Fu and Waltman (2022). The returned results represented data for the entire world since 1947 with a total of 246,125 individual articles. This data was exported for analysis. Subsequently, the countries/regions search filter was applied to exclude all publications bar those from Ireland and Northern Ireland thus providing data for the island of Ireland. These data, of which there were a total of 2,039 associated articles, were downloaded for analysis. Finally, the filter was reset to only include publications from Scotland and then Denmark with relevant datasets downloaded on each occasion (4,503 results for Scotland and 4,907 results for Denmark) allowing for an analysis of differences between all three regions.

2.2.2 Biodiversity research

As per the climate change article data extraction process, biodiversity research output was also extracted from the Web of Science platform. This time however the climate change keyword search terms were replaced with those for biodiversity, which included the following: “biodivers*”, “bio-divers*”, “bio divers*”, “biological divers*”, “ecological divers*”, “eco-divers*” and “eco divers*”. The search results returned publication data for the entire world since 1962 and was made up of a total of 103,024 independent articles. As per the climate change analysis, this data was also exported for review. All publications bar those from Ireland and Northern Ireland were then excluded using the countries/regions filter facility and data downloaded. This resulted in a total of 994 articles and represented data for the island of Ireland. The filter was then reset to include only biodiversity related publications from Scotland and then Denmark with data downloaded. The final number of articles for both regions was 2,346 for Scotland and 2,061 for Denmark.

2.2.3 Data analysis process

The downloaded data was analysed in both Microsoft Excel and R. Article numbers, author affiliations and the associated Web of Science categories were then extracted from both the climate change and biodiversity datasets. Much of the subsequent analysis relates to the period 1990-2021. 1990 was chosen as the start year as it was a year from which more consistent annual articles associated with the countries/territories appeared whilst 2021 was the last full year in the series. As well as a comparison of the total number of articles affiliated with Ireland, Scotland and Denmark, over this period, the rate of change in article numbers was also assessed for each of the regions. Also investigated was the historical change in the percentage of worldwide articles on climate and biodiversity that have authors affiliated with institutions on the island of Ireland, to help determine how Ireland performs on the worldwide stage.

A further topic investigated as part of this component of the study was the Web of Science categories that the climate change and biodiversity articles were linked to. Initially the number of articles in each category was compared and contrasted to those from the rest of the world to help identify which sub-categories Ireland performs well in. This was determined by finding the top 30

most important categories worldwide (by article numbers) and determining how many of those were from authors on the island of Ireland. The categories in which Ireland excels, i.e. that Ireland had a greater percentage of overall articles numbers in, were identified.

The performance of the island of Ireland, in terms of climate and biodiversity research output, was also compared to that from Scotland and Denmark. The percentage differences between articles solely relating to the island of Ireland, Scotland and Denmark were found and compared for each of the thirty previously identified most important worldwide categories. Exactly the same procedure of assessment was then carried out for the worst performing climate change and biodiversity Web of Science article categories. Authors from the island of Ireland failed to produce any research in 50 climate change and 102 biodiversity Web of Science categories. These have been listed separately (see Appendix I).

Data on the affiliations of authors associated with the climate and biodiversity related articles was employed to garner some insight into the top publishing institutions on the island of Ireland. Both climate and biodiversity datasets included over 200 institutional affiliations so our analysis only investigated those based on the island of Ireland, which were generally amongst the top publishing institutions, and amounted to 22 climate change and 17 biodiversity related institutions. Each institution's total climate change and biodiversity publication numbers (articles with at least one author from the institution) were compared to help identify the relative performance of different institutions on the island.

2.3 Survey overview

In order to obtain quantitative data on all aspects of the units carrying out climate change and biodiversity research on the island of Ireland, we employed surveys. Initially we identified all relevant units conducting climate and/or biodiversity research on the island. Surveys were issued to these units with an overall timeline for receipt of response of approximately three months. The results of the survey were then analysed with the most important information relating to the unit type, facilities, expertise, staff numbers, funding details, educational commitments, collaborations and publication output all examined in detail. The resultant data was collated and used to identify the most important findings from the surveys. As well as providing valuable information on the climate and biodiversity research landscape on the island of Ireland the findings were used to help direct the conversations in the follow up interviews that largely took place post-survey response. The following sections provide more in-depth detail on the methodology employed in respect of the application of the survey and the analysis of the resultant responses.

2.3.1 Identifying research units

As no central database of all units carrying out climate change and/or biodiversity research on the island exists it was necessary to carry out a trawl of the internet to find the most likely candidates for inclusion in the survey. In total 85 units were identified through this process but this was subsequently increased to 92 following receipt of feedback from survey respondents. Some prospective candidates were also identified from the research output analysis process previously described in Section 2.2. This identification process was not flawless and has likely resulted in some potential candidates not being offered the opportunity to take part in the analysis, which is regrettable but unfortunately an unavoidable side effect of the selection process employed.

Originally the survey categorised submissions as being solely from institutes and centres as these made up the vast majority of unit types from which submissions would be received (> 80% overall). These terms were to be used in the data analysis process to help differentiate between different unit types and is the reason this terminology was used in the survey document in the first instance. However, as some units incorrectly classified themselves as centres (not officially centres) and as a number of units could not be classified as either institutes or centres (e.g. groups, governmental and semi state organisations, departments, and other private agencies) it was decided to use the term unit for all submissions and carry out the analysis of data based on research staff numbers in each unit, which allowed for a clear differentiation between larger and smaller units to be made.

2.3.2 Survey design

The survey (see Appendix II) was designed around eight topics, each provided with its own section, with a total of 29 questions asked. The sections focused on attaining details on each of the unit's background, expertise, funding, staff numbers, education, collaborations and publications and ended with a section providing respondents the opportunity to be included in the follow up interview process as well as to receive a copy of the final report. Each of the sections helped to ascertain how the given unit fits into the climate and biodiversity research environment on the island and aided in determining the strengths and weaknesses in the overall research ecosystem. In order to maximise the benefits of this process the data requested from the respondents was detailed and ambitious on our behalf. In the initial section of the survey it was made clear to the respondents that they should complete the survey on behalf of the unit they belong to, that their personal details would remain anonymous at all times and that they should leave blank any question that they could not answer, with the latter being important as it would result in more accurate responses. In order to avoid any confusion the use of the terms climate change and biodiversity were defined at the beginning of the survey making it clear that, in the context of the survey questions, they related to active studies being carried out into climate and ecological change and related impacts (historical, current and future change in environmental, social and economic conditions).

2.3.3 Survey correspondence and timelines

The survey was first issued on the 13th July 2022 to email contacts identified through the unit identification process. Contacts were typically either a member of the AICBRN network or a senior member of staff. In some instances a generic address within the organisation was used as contacts were unavailable. AICBRN members were preferentially contacted so as to maximise the possibility of a response being received from the given unit. The initial deadline was given as the 31st July 2022. This was extended by a further week due to the low response rate at the time with respondents being notified of this extension in a prompt email which was sent on the 29th July 2022. Through the initial survey submissions a number of additional units were identified for inclusion in the survey and were duly contacted in early to mid-August. One final generic prompt was sent to non-responding units on the 15th August with a deadline of 21st August provided. Any emails sent after this date were targeted towards specific units that we believed valuable to acquire a response from. The last survey submission was received on the 6th October 2022, approximately 3 months after the first request was issued. A complete copy of the generic emails that issued to units can be seen in Appendix II.

2.3.4 Unit details

The first section of the survey related to the unit's background information and requested some basic details including the name of the overall organisation to which the unit belonged as well as the name of the unit. The respondents were also asked how many centres/institutions (units) were in their organisation overall and to list their names. A number of follow up surveys were sent to units identified through this process. The exact questions asked in this section of the survey were as follows:

1). Please confirm the name of your organisation/university.

2). Please confirm the name of your centre/institute.

3). How many centres/institutes are there in your organisation/university?

4). Please list by name the centres/institutes at your organisation/university that focus specifically on climate change and/or biodiversity research?

2.3.5 Expertise

The second section of the survey related to the self-declared expertise of the unit, i.e. the research topics on which the unit carried out substantial amounts of work in and which they deemed themselves to be experts in. The purpose of this section was to garner a wider picture of what aspects of climate and biodiversity research are being carried out within the respondent's institution and to identify the expertise of each of the units. This helps identify key research areas that are over and under researched on the island. The respondents were also asked what, if any, laboratories/research facilities are available within their units and what if any laboratories/research facilities are required by the unit to progress their research. Having a list of available amenities for each unit and those that are required could possibly promote collaborations between units. It could also help identify research infrastructure that is lacking over a number of units, which could possibly be prioritised for inclusion in any future research infrastructure development plans by government and/or related funding bodies. A complete list of the questions asked in this section are as follows:

1). Which of the disciplines listed below does your organisation/university carry out climate change and/or biodiversity research in? [List of disciplines provided].

2). Which keywords below best describe the climate change/biodiversity research expertise in your centre/institute? [List of keywords provided].

3). Does your centre/institute have specialist laboratories/facilities specifically for climate change/biodiversity research? (E.g. a sediment core analysis lab).

4). If you answered yes to the question above then please provide some detail (i.e. list the laboratory/facility types).

5). Does your centre/institute require further specialist laboratories/facilities specifically for climate change/biodiversity research? (Please list required laboratories/facilities).

2.3.6 Funding

Determining the amount the funding that research units were in receipt of and how it compares to funding received by parent institutions was seen as an important element of the study as it could be used to estimate the percentage of overall institutional funding for climate and biodiversity research in units across the island. Identifying funding stream amounts and determining who were the biggest funders of this research were also necessary to help develop a picture of where climate and biodiversity funding is coming from and what amounts are involved. It was also needed to identify how the size of the unit (based on staff numbers) linked to funding amounts so that comparisons could be made on outputs. Total funding amounts of units were also compared to total climate and biodiversity publication numbers and total collaboration numbers within the island of Ireland but also with the rest of the United Kingdom, the EU and further afield. By carrying out this assessment it was possible to identify what funding sources and funding amounts were most efficient and effective at generating climate and biodiversity research. The questions posed to extract the underlying information on funding sources and amounts were as follow:

1). Approximately how much research funding (externally sourced research grants) was your organisation/university in receipt of in 2021? (Overall annual figures in euros). [List of values provided].

2). How much research funding (externally sourced research grants) was your centre/institute in receipt of in 2021? (Overall annual funding in euros). [List of values provided].

3). Please provide a breakdown of the number of research funding streams (from external sources) for climate and/or biodiversity research in your centre/institute that fall within the following monetary ranges (overall annual funding in euros). [List of values provided].

4). Please rank the top five providers of funding (by total grant amount) for climate change and/or biodiversity research in your centre/institute. [List of funders provided].

2.3.7 Staff Numbers

Identifying the number of staff in each of the surveyed units and determining their professions was required both as a benchmark for comparing outputs from differing units (number of staff) and for calculating what professions are most important in making a unit effective at generating climate change and biodiversity related research outputs. Funding, collaborations, publication numbers and overall survey responses were all categorised based on staff numbers with grouping of small (< 33 staff) medium (> 33 and < 66 staff) and large (> 66 staff) employed in the subsequent analysis. As such, respondents were asked to provide an approximate figure of total staff numbers in their units. Overall institutional research staff numbers were also requested to ascertain the size of the unit in terms of the overall institution. Finally a breakdown of staff profession numbers were requested to find out which type was most effective in helping generate climate and biodiversity research outputs. The three exact questions asked as part of this section are listed below.

1). Approximately how many staff members are working in your organisation/university? (Academic/research staff only). [List of values provided].

2). How many academic/research staff members are carrying out research in your centre/institute? [List of topics provided].

3). Please complete the table below providing a breakdown of the number of staff working in the areas of climate change and/or biodiversity in your centre/institute at each of the listed grades. [List of professions provided].

2.3.8 Education

As a considerable majority of survey respondents would likely be linked to an academic institution it was necessary to derive some data on PhD candidates and underlying Masters programmes to help find out how they may impact climate and biodiversity related research output. It was therefore decided to include a section on education in the survey. As per all other parts of the survey, there was no requirement for questions in this section to be completed if it was not relevant to the respondent unit (i.e. units with no PhDs or Masters programmes). Firstly, the number of PhD candidates in both the institution and the unit were requested so that an overall estimate of the percentage of climate change and/or biodiversity PhDs from the unit compared to the institution could be made. Secondly, respondents were asked about their institution's climate change and biodiversity Masters programmes including whether such courses were provided, the number of students taking part and a list of the topics covered. Using this information it would be possible to estimate the impact such courses have on research output, sourcing of PhDs and whether or not all aspects of climate change and biodiversity research are adequately covered in the respective curricula. Feedback received from these questions was subsequently employed in the interview process to ascertain more detail on the importance of Masters programmes and PhDs in relation to filling professional roles and carrying out research in respondent units.

1). Approximately how many PhD candidates does your organisation/university currently have? [List of values provided].

2). How many PhD candidates are currently enrolled in your centre/institute? [List of values provided].

3). Does your organisation/university have a Masters programme(s) specific to climate change and/or biodiversity?

4). If your organisation/university has a Masters programme(s) specific to climate change and/or biodiversity then please confirm the total number of students who were enrolled in the 2021/22 academic year? [List of values provided].

5). Which of the topics below are taught as part of the climate change and/or biodiversity Masters course(s)? [List of topics provided].

2.3.9 Collaborations / publications

The main aim of this portion of the survey was to ascertain total publication numbers for each unit in 2021 and how they relate to funding amounts received, funding providers involved, unit size, staff type, educational commitments and research expertise. The amount of collaborations between surveyed units and others on the island, within the United Kingdom, the EU and further afield was also determined. As per the approach taken for other topics in the survey, it was

deemed important to ascertain how the unit performed compared to its host institution. The amount of climate and biodiversity related research output of the unit versus the total research output from the institution was therefore found. Unit and institutional publication figures were requested from respondents (questions 1 and 2 below) along with more detailed numbers on the unit's climate change, biodiversity, climate change and biodiversity and non-climate change /biodiversity publication outputs. This data was used to compare outputs to other institutions across the island and also to provide a breakdown on differences between biodiversity and climate related output from those same units. A single question on collaborations (question 3 below) was asked to identify the amount of research collaborations the unit's researchers were involved in. The subsequent analysis process employed each unit's climate and biodiversity publication and collaboration numbers (particularly international collaborations), along with staff numbers and funding amounts to help determine how successful a unit was in terms of their own research area.

1). Approximately how many publications (articles, books, proceedings and data papers) were published by researchers (lead or co-authors) from your organisation/university in 2021? [List of values provided].

2). What is the total number of publications (articles, books, proceedings and data papers) issued by researchers (lead or co-authors) in your centre/institute in 2021 that... [Selection of options provided].

3). How many publications (articles, books, proceedings and data papers), specific to climate change and/or biodiversity, issued in 2021 that involved researchers from your centre/institute and... [Selection of regions provided].

2.3.10 Feedback and consent

The final section in the survey was primarily used to ascertain if the respondent was happy to have someone in their unit take part in the follow up interviews process. They were asked to give a relevant contact address(es) for the potential interview candidate(s), to confirm whether or not they wished to receive a copy of this report, and were given the opportunity to make some general comments on the survey. The final four questions of the survey are listed below. Whilst it was noted in the original survey document that candidates would be contacted in September to take part in the survey, in reality interview requests issued from mid-August. In general, when provided, feedback was positive. However, some concerns were raised regarding the level of detail required. Results suggest that data was obtainable in the vast majority of cases with complete responses received from most respondents.

1). Would you and/or a colleague agree to be contacted by a researcher in early September to answer further questions on the topics covered in this questionnaire? (Giving your consent does not commit you to anything, you will simply be offered an invitation).

2). Do you wish to receive a copy of our final report when our analysis is completed?

3). If you answered yes to either question directly above then please provide your email address below (If applicable and with their approval, please include a colleague's email address).

4). Do you have any final thoughts on the survey or its contents?

2.4 Interviews overview

Whilst the research output analysis process helped identify how the island of Ireland performed internationally, in terms of climate and biodiversity research output, and the surveys extracted extremely useful quantitative information on the many climate change and biodiversity focused research units across the island, including details on unit facilities, expertise, funding, staffing, teaching, collaborations, publication outputs, such data failed to capture the insights of respondents regarding the climate change and biodiversity research environment on the island. In particular the surveys failed to identify perceptions of specific strengths and weaknesses in the units, the potential future opportunities and threats to those units and how these affect research output. Semi-structured interviews were employed to fill these knowledge gaps, providing more qualitative information on the workings of the related research units and some suggestions on how best to improve research collaborations, publication outputs and the overall direction of climate and biodiversity research on the island.

2.4.1 Designing the interviews

The interviews were planned to be semi-structured in nature, focusing on eight broad topics that display some similarities to those of the corresponding surveys. The topics included the strengths and weaknesses of the interviewee's unit, the future opportunities and risks of the unit, the teaching and postgraduate commitments of unit's staff, future potential for collaborations, required institutional / governmental supports, ways of advancing climate and biodiversity research on the island of Ireland and the most important climate and biodiversity research topics as deemed by the interviewees. The semi-structured format of the interviews meant that questions relating to the topics were not always asked directly or in sequence but in all cases some feedback was received. Each interview was approximately one hour long and took place online using Microsoft Teams video conferencing software. At the beginning of each interview it was made clear to the interviewee why the surveys were taking place, what would be discussed, that their personal details would remain anonymous at all times and that no unit would be made identifiable from the quotations derived from the process. Interviews were recorded and transcribed, once agreed to by the interviewee, with both data to be destroyed on publication of this report. It was also made clear that responses should be in respect of the interviewee's unit and would relate to the unit's climate and/or biodiversity research output. Whilst the vast majority of interviews involved survey respondents, two were carried out with units that failed to submit a survey.

2.4.2 Interview correspondence and applied timelines

Excluding late survey submissions (post September 30th), all survey respondents who agreed to take part in the interviews were contacted by email over a period ranging from the 23rd August to the 30th September with a suitable time agreed between both parties on each occasion. Interview requests were staggered due a combination of delayed survey submissions, demand for time slots and respondent availability. A copy of all standardised correspondence that issued to potential interviewees can be found in Appendix III. Despite the option to include multiple individuals in the interview process, in all cases a single individual took part. Interviewees were representative of a diverse array of units coming from institutes, centres, groups, organisations and semi state

governmental organisations. Furthermore, participants from across the island of Ireland took part and included all sizes of units, allowing for a diverse mix of opinions to be extracted.

2.4.3 Main discussion points

The interview discussion revolved around seven key topics which were as follows:

1). Unit strengths and weaknesses.

The strengths and weaknesses of the interviewee's units were firstly discussed in the semi-structured interview process. The purpose of this was to garner a better understanding of the units themselves and how they perform. In the majority of interviews the interviewee was asked to state the top three strengths and the top three weaknesses of their unit, with a short discussion around each topic. The resources of the institute (including human resources), or lack thereof, were often raised along with research areas that performed well together with what was deemed the units unique advantages over others and what areas needed improvement.

2). Greatest opportunities and threats/challenges to the unit.

Identifying what the interviewees saw as the greatest opportunities for their units was discussed next as this provided some positive visions for the future of research on the island of Ireland. Complimenting this question was an equally important request for detail on what the interviewees thought were the greatest threats/challenges to their units. In the interviews the possibility of expanding opportunities, research areas and collaborations were discussed together with competitive threats, funding issues and the negative impacts of institutional and governmental policies. The most common responses in these discussions were identified, categorised and subsequently used to help determine the most suitable actions that can be taken to help improve the performance of such units.

3). Teaching commitments including Masters programmes and PhDs.

For the majority of units who took part in this study an underlying climate change and/ biodiversity Masters programme was in place that often was used to source PhDs who were identified as important producers of climate and biodiversity research. Furthermore, teaching commitments impacted researchers and research output. It was therefore deemed important to discuss these topics with the interviewees to garner their opinions on teaching and how they attracted PhDs into their units. Whilst most interviewees represented units with teaching commitments not all did so in some cases this question topic was not relevant and skipped. The results of this part of the interview provided a much greater understanding of how teaching impacts research outputs and identified difficulties in attracting PhDs into climate and biodiversity research roles.

4). Encouraging collaboration.

Finding out how collaborations between units on the island of Ireland, with the rest of the United Kingdom, the EU and further afield could be encouraged was an important element of the overall research and as such was included as a question in the interviews. Discussions focused mainly on what interviewees believe to be the biggest hindrance to taking part in collaborations. Particular emphasis was placed on how collaborations could be encouraged between the Republic of Ireland and Northern Ireland. Funding and its relationship to collaborations was also discussed. As per the other topics, the results from this part of the interview process were analysed and the most highly recommended actions identified.

5). Required institutional and governmental support.

Identifying what actions parent institutions and governments could take to help improve a unit's climate and biodiversity research output was an important component of the interviews, particularly given the expertise of the interviewees and their knowledge of the research landscape on the island. Recommended actions for related institutions often revolved around administrative issues whilst for the government it was mainly focused on funding. Again, commentary from interviewees on this topic was extremely insightful and was used to help determine what actions by institutional and governmental are required.

6). Progressing climate and biodiversity research on the island of Ireland.

The ultimate aim of this study was to identify a means by which climate change and biodiversity research could be progressed on the island of Ireland. The interviews offered an opportunity to extract some of the best ideas from individuals that are at the forefront of such research and who are best placed to identify how this can be achieved. Whilst there were some biases in responses from candidates, e.g. targeted funding to their units, there were also novel suggestions made that could help improve research output markedly on the island.

7). Climate change and biodiversity research topics.

The final part of the interview process was to ask interviewees what they believed were the most important climate change and/or biodiversity related research topics that should be the primary focus of future research on the island of Ireland. As these individuals are extremely well positioned, in terms of understanding of research topics directly related to the climate and biodiversity emergencies, it was thought to be a useful exercise to carry out. Whilst biases with regard to the chosen topics were undoubtedly included in the related responses the discussion did find common responses of interest. Further details on the most interesting responses received to this and all other topics discussed in the interviews can be found in Section 3.3.2.

Chapter 3 | Results

3.1 Climate change and biodiversity research assessment overview

Climate change and biodiversity research publication outputs were assessed for the 1990-2021 period using extracted data from the historical datasets that were downloaded from the Web of Science database (see Section 2.2). Worldwide data was firstly analysed followed by data specifically for Ireland and Northern Ireland, for Scotland and then for Denmark, facilitating a comparison of outputs from countries/territories of similar population sizes.

3.1.1 All island climate change and biodiversity research output

An assessment of all-island publication data for the period 1990-2021 in comparison to worldwide publication numbers suggests that the percentage contribution from the island of Ireland of climate change related publications has increased from 0% to approximately 0.9% over the last 31 years (Figure 3.1). Whilst across the period the overall trend is increasing, in recent years (since approximately 2006) the rate of change in the percentage of worldwide publications has remained flat. For biodiversity related publications research output does not occur until 1996 and reaches a maximum of 1.4% of publications worldwide in 2014. As of 2021 however this reduced to approximately 0.9% of worldwide output.

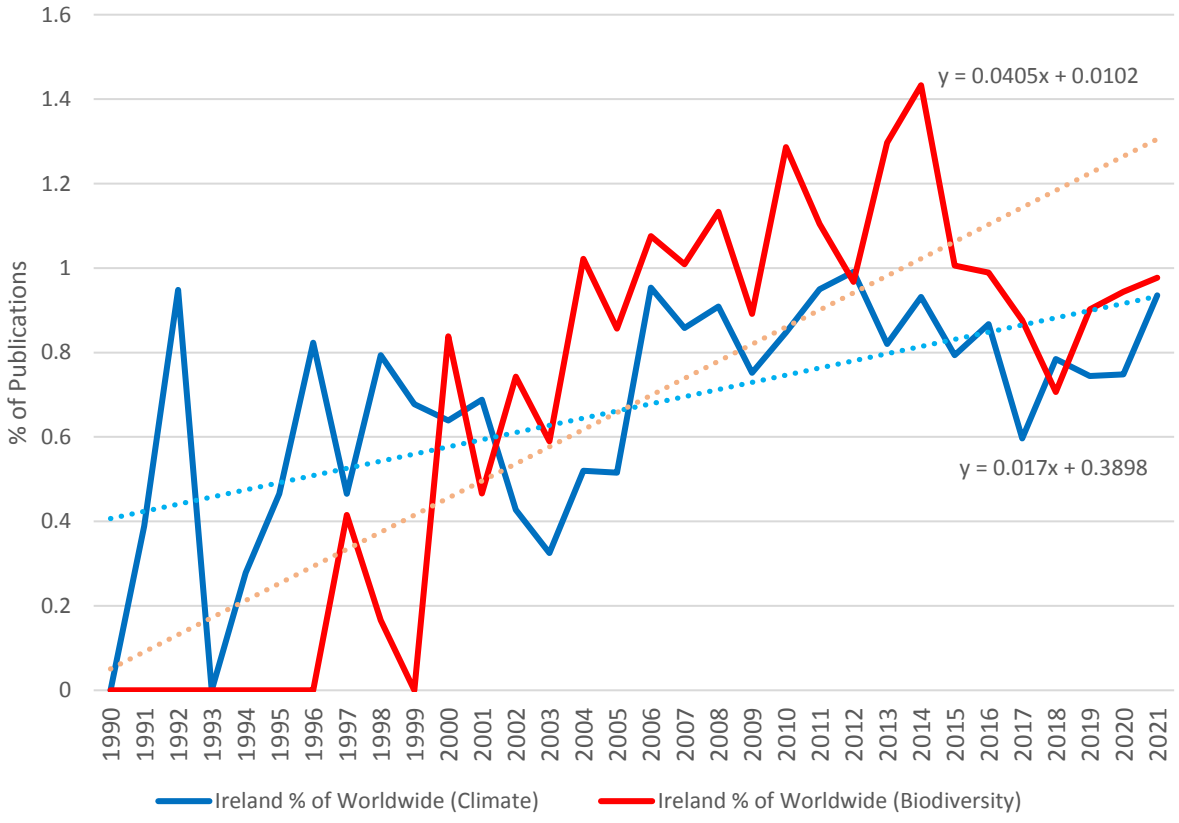


Figure 3.1 Percentage of worldwide climate change and biodiversity publications (Island of Ireland). Also included are linear regression fits to these series.

3.1.1.1 A comparison of climate change outputs to international partners

Whilst the island of Ireland has approximately 0.09% of the world's population (7.9 million) it publishes 0.9% of the climate publications which indicates a good performance overall. To assess how it compares to other western countries, output was compared to that from Scotland (population: 5.5 million) and Denmark (population: 5.8 million). Figure 3.2 displays the annual publication numbers of climate related articles linked to authors from each of the three for the period 1990-2021. Clearly evident is the greater publication outputs of authors from Scotland and Denmark, which both have issued considerably more (2.4 times more on average) publications compared to the island of Ireland despite the somewhat smaller population numbers. There are indications however that the difference between Irish research output and those in comparator countries has narrowed in recent years.

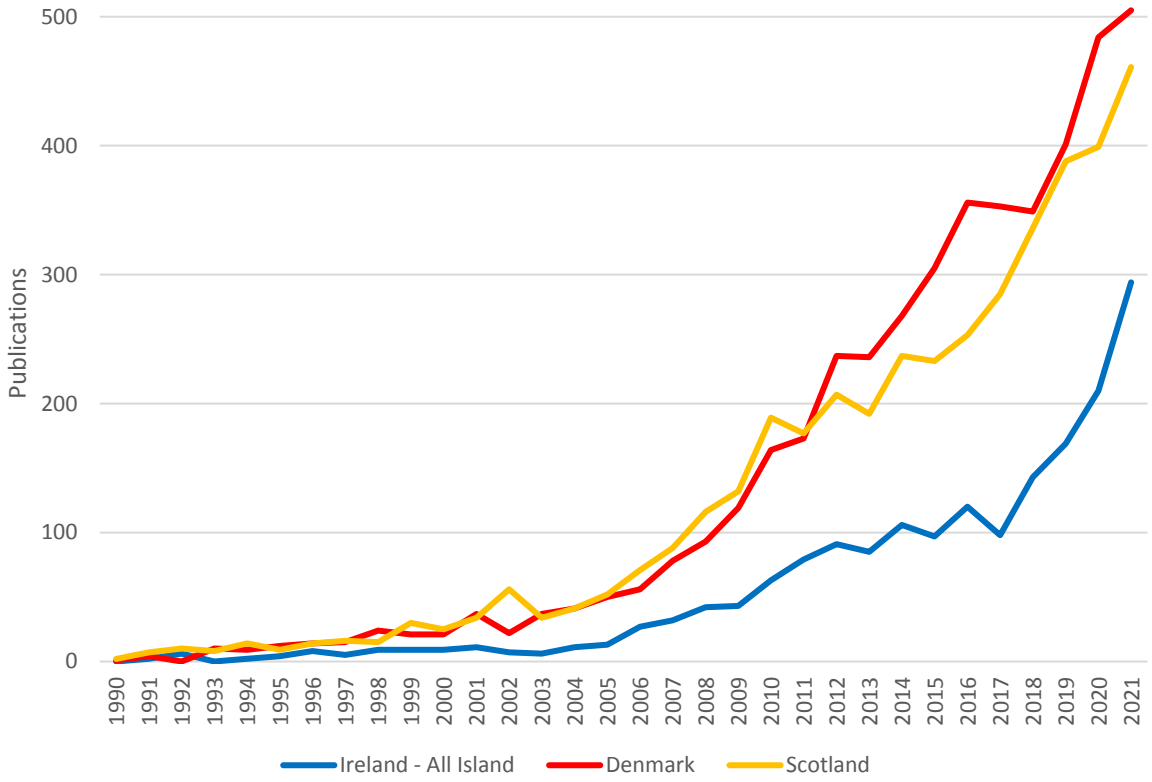


Figure 3.2 Annual climate change publications (Ireland vs Denmark vs Scotland).

3.1.1.2 A comparison of biodiversity outputs to international partners

As previously identified for climate change related publications, biodiversity publications from authors on the island of Ireland make up 0.9% of worldwide output despite having approximately 0.09% of the world's population. However, once again, when compared to outputs of authors in other western countries' with similar to smaller population amounts, i.e. Scotland and Denmark, the performance of the island is underwhelming. Figure 3.3 displays the annual publication numbers of biodiversity related articles from authors based in each of the three territories for the period 1990-2021. Again clearly evident is the greater publication output from Denmark and Scotland with both on average producing 2.2 times as many articles as Ireland over the 1990-2021 period. As was the case for climate change publications, there are signs that the rate of change of

island of Ireland biodiversity publications has increased in recent years leading to some potential closing of the gap.

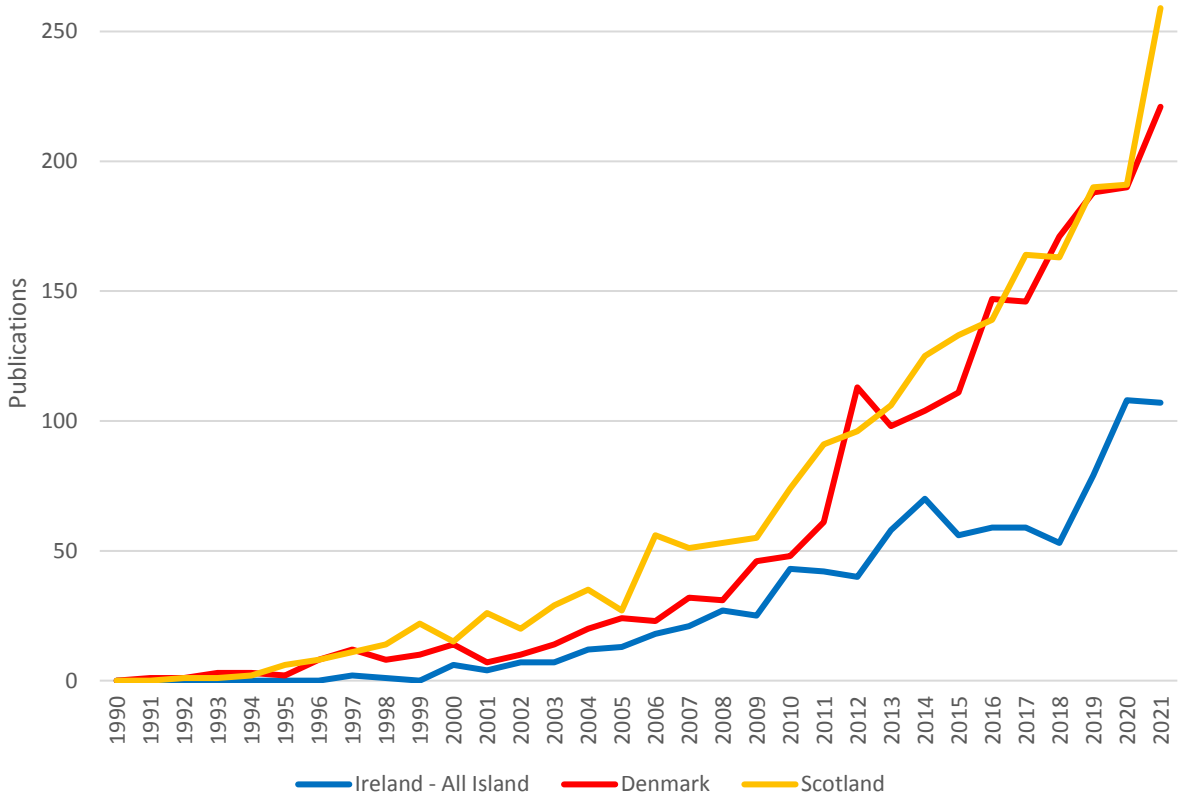


Figure 3.3 Annual biodiversity publications (Ireland vs Denmark vs Scotland).

3.1.2 Climate change research topics

Understanding what aspects of climate science the island of Ireland excels in and what requires further research can be assessed using the categorization facility provided by the Web of Science and identifying the top worldwide categories that relate to climate change publications. Listed in Figure 3.4 are the top 30 of these publication categories with environmental sciences the most prominent, followed by geoscience multidisciplinary etc. The relative importance of the environmental sciences category is understandable as it covers a large number of possible research topics. Others such as zoology are much more discipline focused and therefore related article numbers are much smaller overall. Of note in the plot is the relatively small component island of Ireland research equates to internationally.

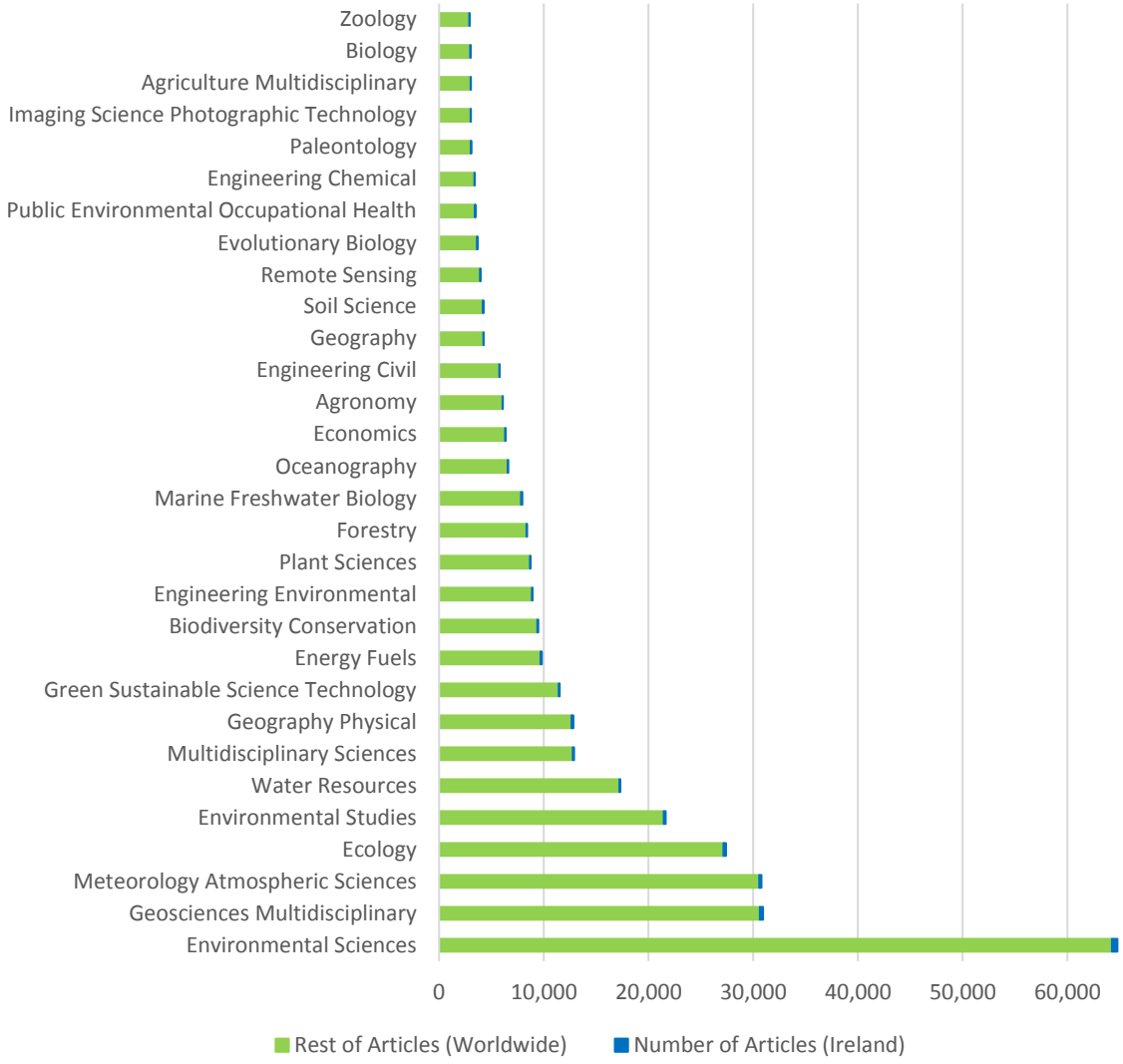


Figure 3.4 Top 30 worldwide climate change related publication categories (Worldwide vs Island of Ireland; totals).

Figure 3.5 displays a plot of the top 30 Web of Science climate change related publication categories derived from worldwide data, however this time the overall percentage outputs from the island of Ireland, Denmark and Scotland are assessed with total output numbers from each of the territories for each category used to calculate their percentage components. Of particular note is that authors from Ireland consistently produce a lower percentage of articles compared to Scotland and Denmark across all categories. Of these top 30 worldwide topics, Ireland performs particularly poorly in *remote sensing,* which only represents 10% of climate change related publications when compared to output from Scotland and Denmark. The best performing category is i*mage science photographic technology* which accounts for 30% of publications. On average, island of Ireland publications represent 17% of the combined publications of all three territories.

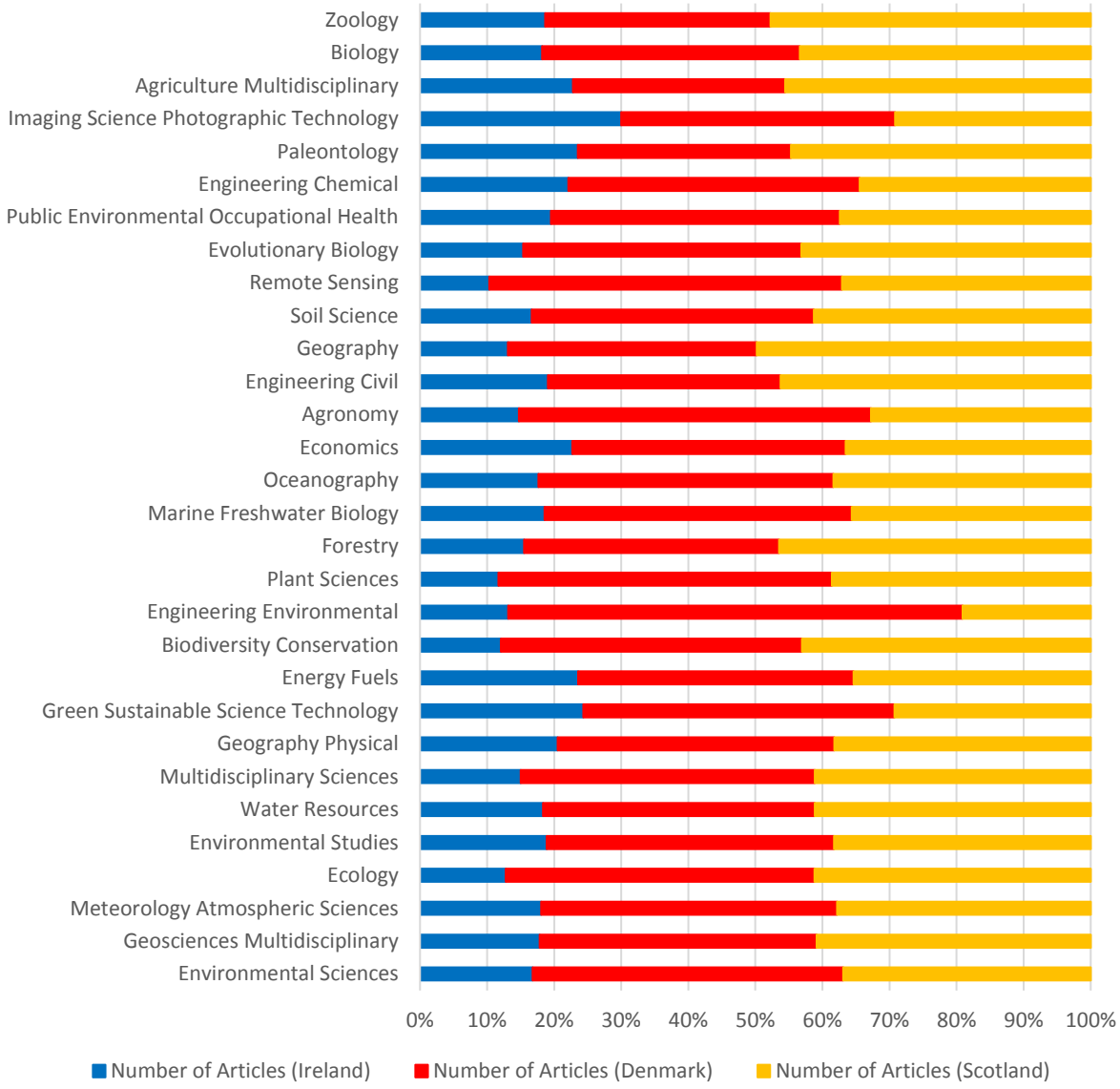


Figure 3.5 Top 30 worldwide climate change related publication categories (Island of Ireland vs Denmark vs Scotland).

3.1.2.1 Climate change research strengths

Whilst overall figures suggest that the island of Ireland performs poorly compared to Scotland and Denmark, there are research categories in which we excel compared to our two neighbours and more broadly internationally. Figure 3.6 shows a plot of the top 30 best performing categories for climate related research articles published by island of Ireland authors compared to those from the rest of the world. Of particular note in this graph is the performance of Ireland in *agriculture dairy animal science* which equates to approximately 2% of worldwide articles in this category.

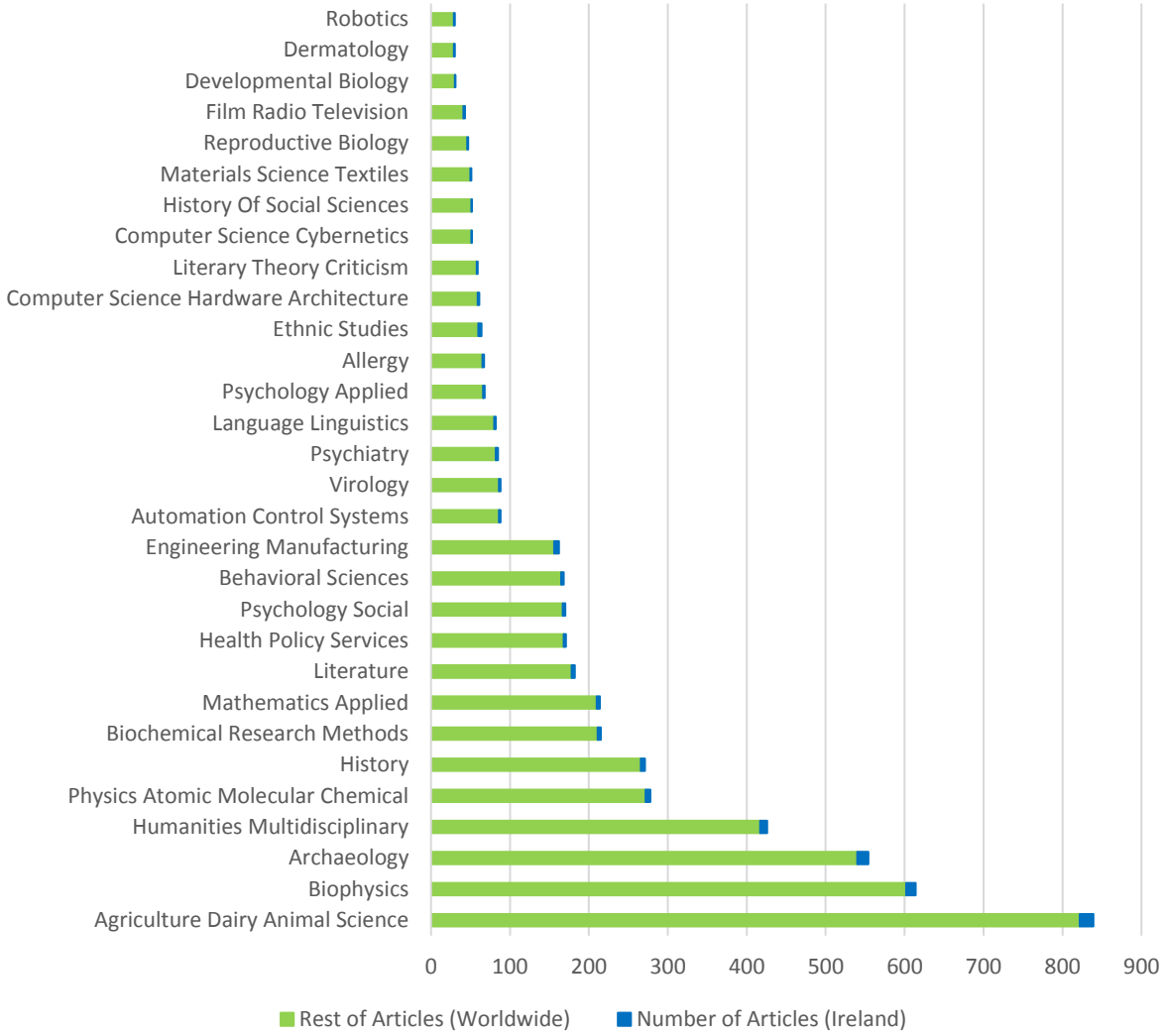


Figure 3.6 Top 30 best performing island of Ireland climate related publication categories (Worldwide vs Island of Ireland; totals).

Figure 3.7 plots the top 30 climate change related categories for Web of Science publications derived from worldwide data that the island of Ireland excels in. Here values are compared to equivalent output from Scotland and Denmark, with the plot derived in the same manner as that presented in Figure 3.5, allowing for a comparison of the three territorial outputs for the categories for which island of Ireland authors excel in. Whilst Ireland outperforms both Scotland and Denmark in the majority of these categories some exceptions exist. For example for *physics atomic molecular chemical,* Denmark produces 78% of the publications whilst for *development biology* Scotland produces 67% of the publications. For some of its best performing categories, e.g. *film radio television*, *ethnic studies* and *language linguistics*, the island of Ireland dominates with 100% of the research output. It is worth noting however that by and large these categories are less prevalent in the Web of Science database. Also of note is that Scotland performs better in the previously identified best performing island of Ireland category worldwide, i.e. *agriculture dairy animal science*.

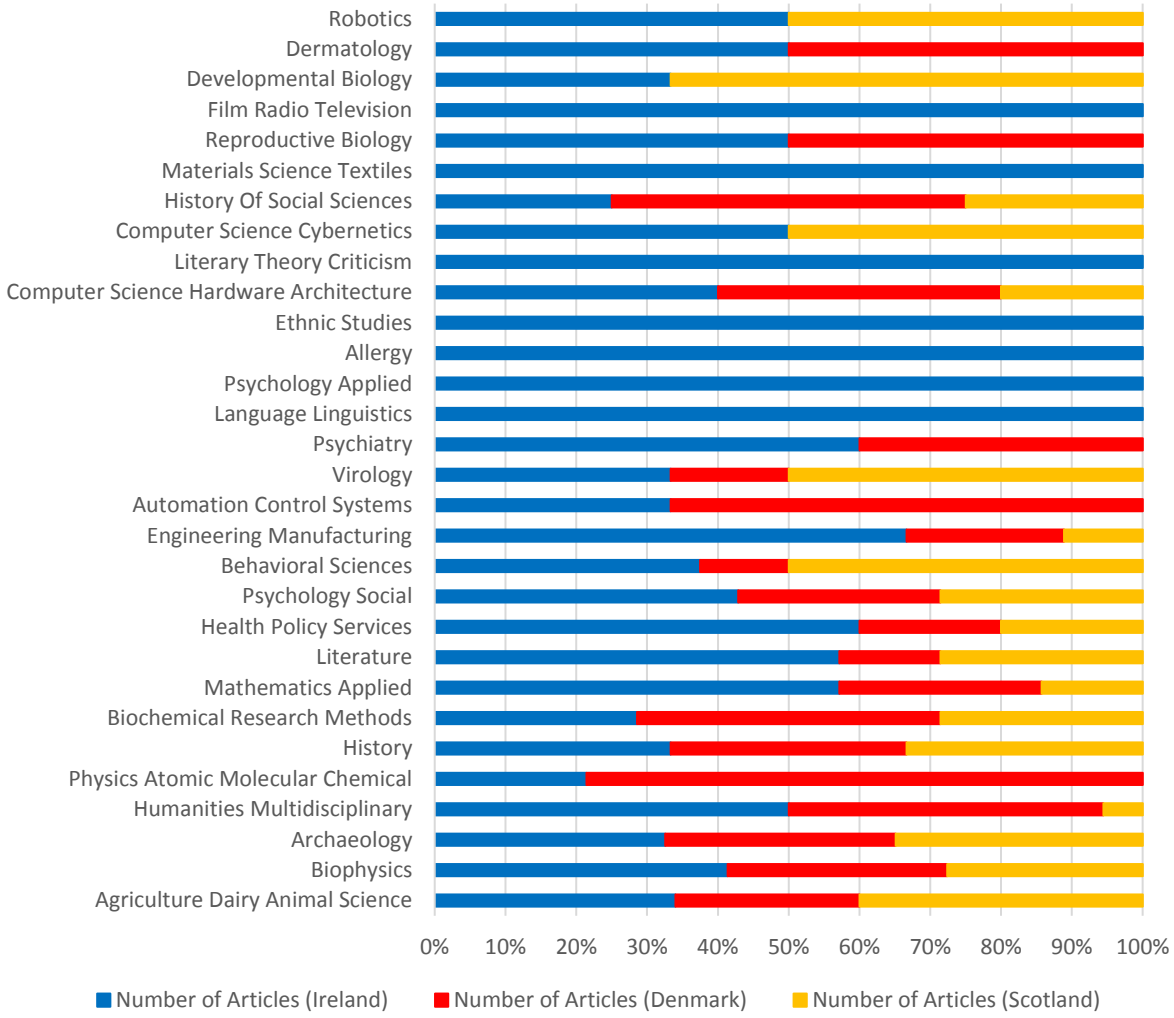


Figure 3.7 Top 30 worldwide climate related publication categories in the Web of Science database that the island of Ireland excels in (Island of Ireland vs Denmark vs Scotland).

3.1.2.2 Climate change research weaknesses

Previously we have shown that the island of Ireland performs poorly in climate related research compared to Scotland and Denmark. In this section we investigate the weakest performing areas of research on the island. Of the listed Web of Science categories, 50 did not contain any articles for the island of Ireland. A list of these 50 categories can be found in Appendix I. Here we investigate the categories for which authors on the island of Ireland produced the lowest percentage of articles. Figure 3.8 shows a plot of the 30 worst performing categories for island of Ireland climate related research output (after excluding the 50 entirely absent categories) compared to worldwide totals. Of particular note in this graph is the poor performance of *meteorology atmospheric sciences* which equates to approximately 0.62% of worldwide articles in this category.

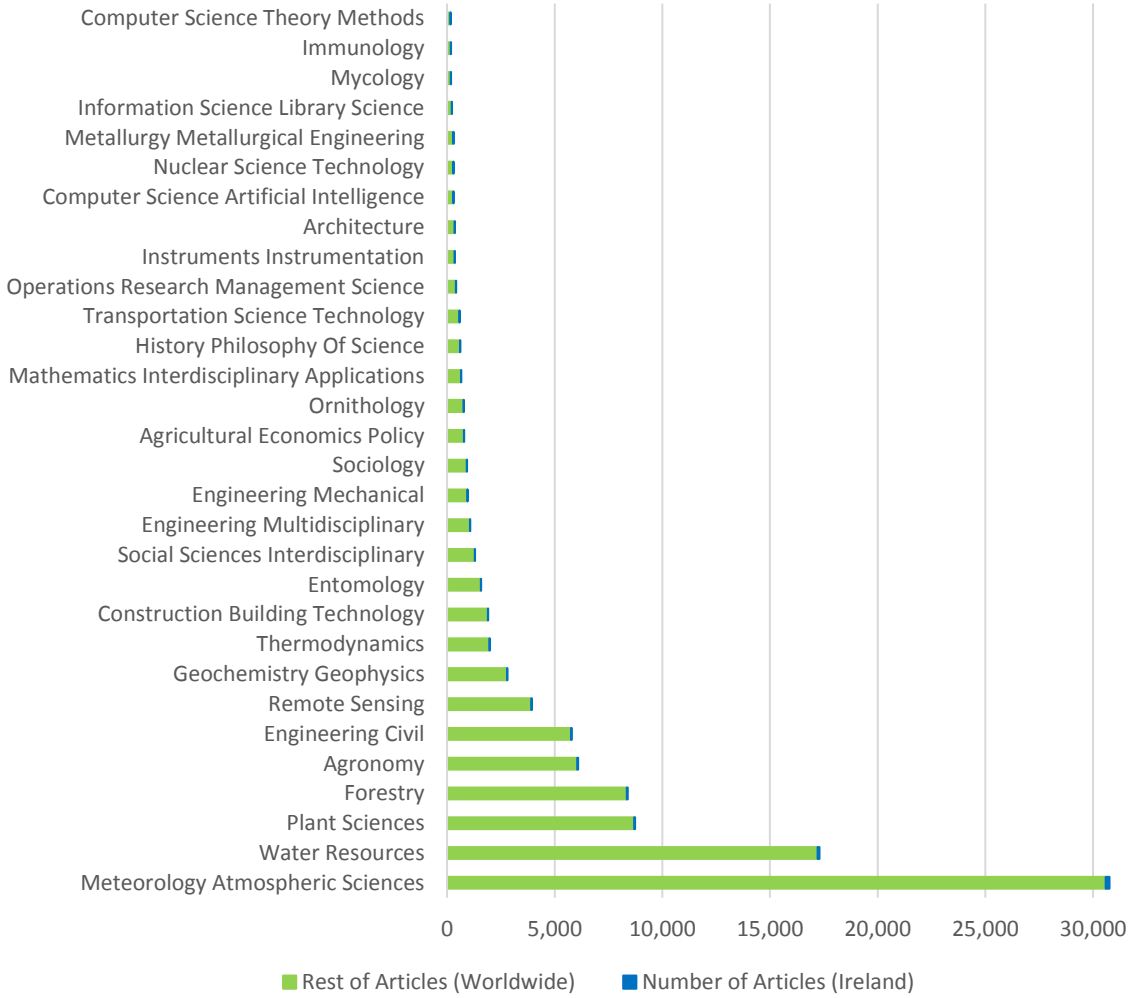


Figure 3.8 Top 30 worst performing island of Ireland climate related publication categories (Worldwide vs Island of Ireland; totals).

Figure 3.9 plots the top 30 climate related categories for Web of Science publications derived from worldwide data that the island of Ireland performs poorly in, comparing outputs to that from Denmark and Scotland for each of the categories in a manner that has previously been demonstrated in Figure 3.7. Results show that Ireland performs poorly against Denmark in the majority of these categories and is consistently outperformed by Scotland. The poorest performance overall is in the category of *sociology* for which the island of Ireland produces only 3% of the climate change related articles produced across the 3 territories. Another category of note is the previously identified *meteorology atmospheric sciences* where both Scotland and Denmark produce over twice the volume of publications in relation to climate change. Finally, it is worth highlighting that some large international biodiversity and agricultural related topics are underrepresented in climate change studies on the island of Ireland with *plant sciences*, *forestry* and *agronomy* of particular note, having also less than half the research output categorisations than the equivalent in Scotland and Denmark.

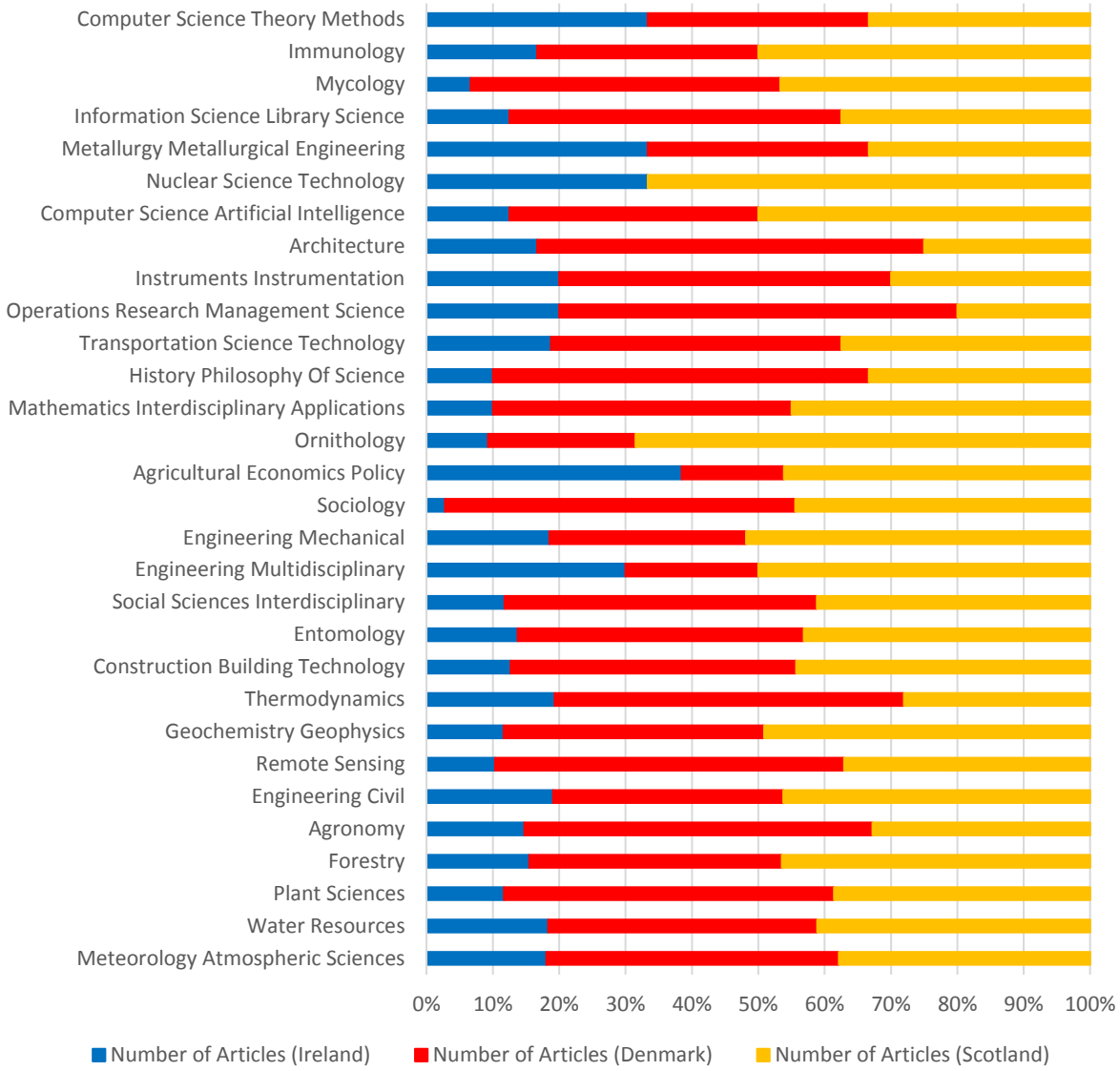


Figure 3.9 Top 30 worldwide climate related publication categories that the island of Ireland performs poorly in (Island of Ireland vs Denmark vs Scotland).

3.1.3 Biodiversity research topics

The analysis carried out for climate related publications was next repeated for biodiversity output with results again compared to both worldwide outputs and those from Scotland and Denmark. Listed in Figure 3.10 are the top 30 biodiversity publication categories based on worldwide figures with *ecology* the most prominent category, followed by *environmental sciences* etc. The relative importance of *ecology* in terms of biodiversity research is unsurprising as it covers a large number of possible biodiversity related research topics. Others such as *urban studies* are much more discipline focused and therefore related article numbers are much smaller overall. Again, the relatively small component of island of Ireland research is evident. Also it is worth noting that considerable similarities exist in respect of the climate change related research topics shown in Figure 3.4 which displays the strong correlation between both research areas.

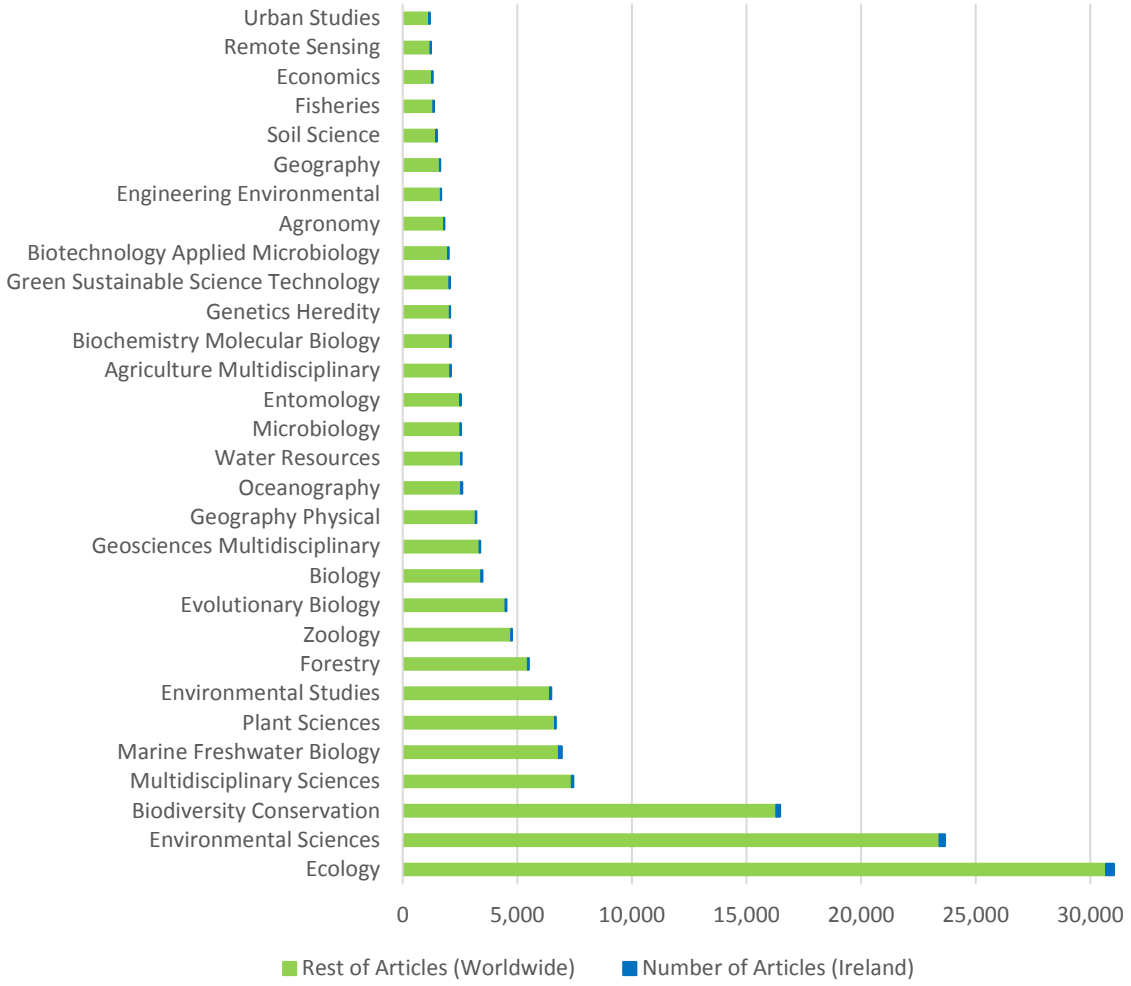


Figure 3.10 Top 30 worldwide biodiversity related publication categories (Worldwide vs Island of Ireland; totals).

Figure 3.11 displays the top 30 biodiversity related categories for Web of Science publications derived from worldwide data, following the same format as the plot displayed in Figure 3.5 for climate change related data. With the exception of *oceanography* and *soil science*, Ireland consistently produces a lower percentage of articles compared to Scotland and Denmark across categories. Of these top 30 worldwide topics Ireland performs particularly poorly in *remote sensing,* which is only 10% of biodiversity related publications matching that found in the analysis of climate change related categories (Figure 3.7). The best performing category is *oceanography* which accounts for 28% of publications for that category. On average, island of Ireland author's publications represent 18% of the combined publications of all three territories for the top 30 categories worldwide which is remarkably similar to the 17% found for climate change related topics. Note: for a balanced number of articles based on population numbers between all three territories Ireland should be publishing in excess of 35% of articles on climate and biodiversity topics.

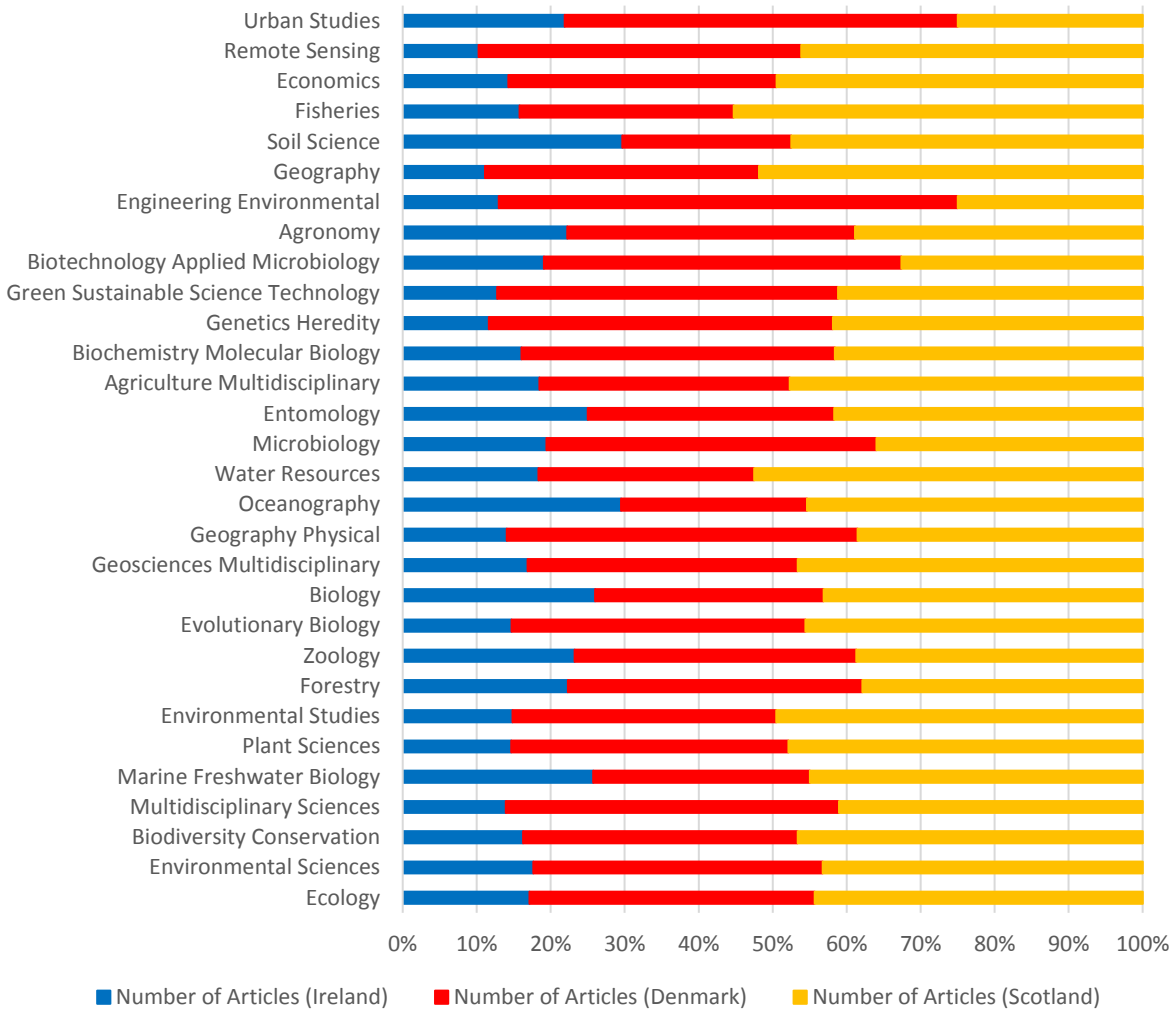


Figure 3.11 Top 30 worldwide biodiversity related publication categories (Island of Ireland vs Denmark vs Scotland).

3.1.3.1 Biodiversity research strengths

Whilst overall figures highlight the poor performance of the island of Ireland compared to Scotland and Denmark there are biodiversity research categories in which island of Ireland authors excel compared to our two neighbours and more broadly internationally. Figure 3.12 shows a plot of the top 30 best performing categories for island of Ireland biodiversity related research output compared to worldwide totals. Of particular note in this graph is the performance of the island of Ireland in *marine freshwater biology* which equates to approximately 1.7% of worldwide articles in this category.

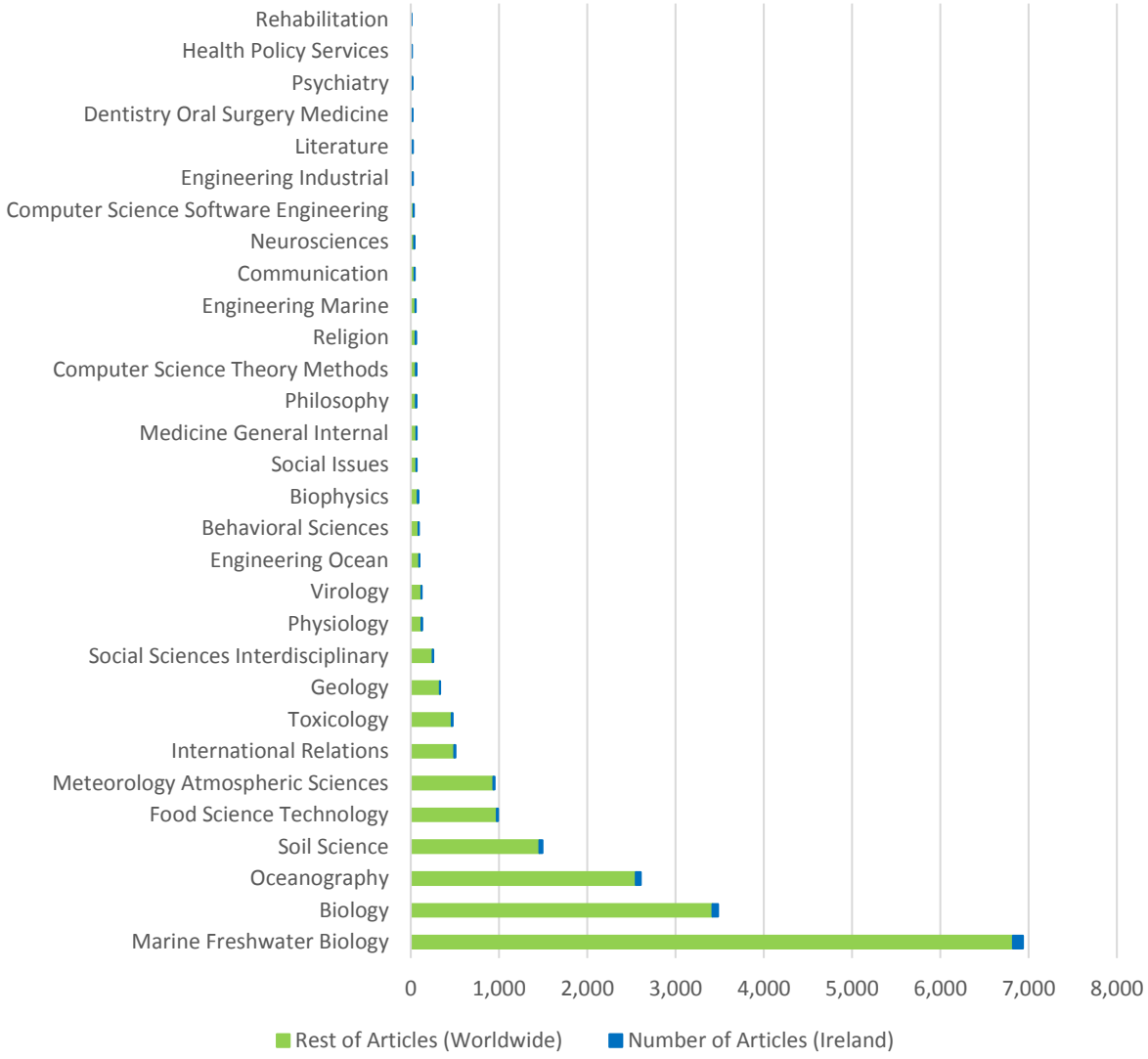


Figure 3.12 Top 30 best performing island of Ireland biodiversity related publication categories (Worldwide vs Island of Ireland; totals).

Figure 3.13 plots the top 30 biodiversity related categories for Web of Science publications derived from worldwide data that the island of Ireland excels in with percentage differences between total research output numbers assessed between each of the three territories. Whilst Ireland outperforms both Scotland and Denmark in the majority of these categories some exceptions exist. For example for *engineering marine* Scotland produces 67% of the publications whilst for *medicine general internal* Denmark produces 51% of the publications. For some of its best performing categories, e.g. *literature*, *computer science engineering* and *rehabilitation*, Ireland dominates with 100% of the research output. It should be noted, however, that these categories are notably less prevalent in the Web of Science database. Also, despite *marine freshwater biology* publications from the island of Ireland being of a much greater proportion relative to population size when compared to worldwide output, both Denmark and Scotland exceed the research output of the island of Ireland for this category.

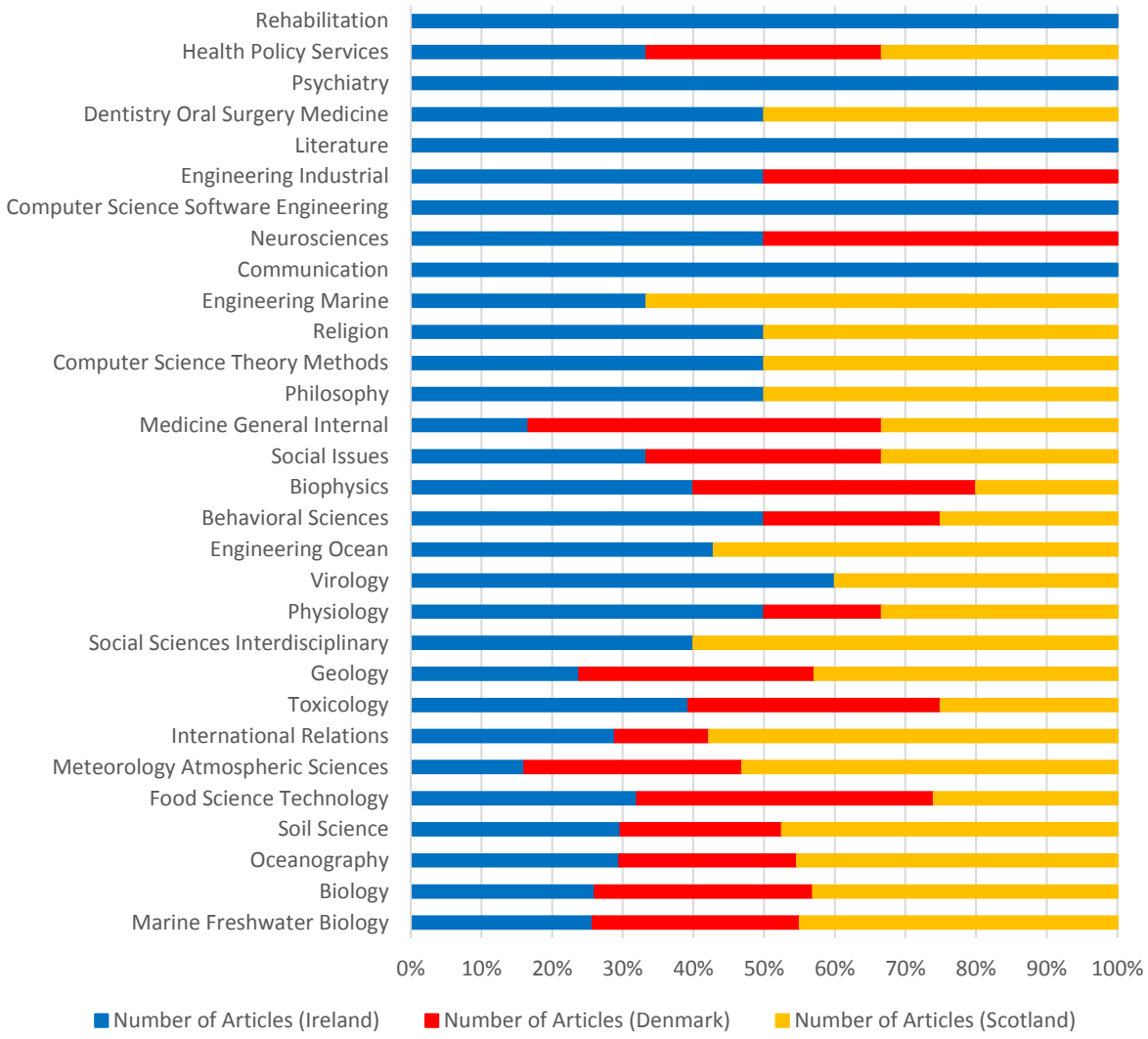


Figure 3.13 Top 30 worldwide biodiversity related publication categories that the island of Ireland excels in (Island of Ireland vs Denmark vs Scotland).

3.1.3.2 Biodiversity research weaknesses

As previous sections have shown, overall the island of Ireland performs poorly in terms of biodiversity research output when compared to Denmark and Scotland. In this section we investigate the weakest performing areas of biodiversity research on the island. Of the listed Web of Science categories, 102 did not contain any articles for the island of Ireland. A list of these 102 categories can be found in Appendix I. It is worth highlighting that this is twice as large as that for climate change related categories. Here we investigate the remaining categories for which the island of Ireland produced the lowest percentage of biodiversity related articles. Figure 3.14 shows a plot of the 30 worst performing categories for island of Ireland biodiversity related research output compared to worldwide totals. Of particular note in this graph is the poor performance of Ireland in *plant sciences* which only equates to approximately 0.58% of worldwide articles in this category.

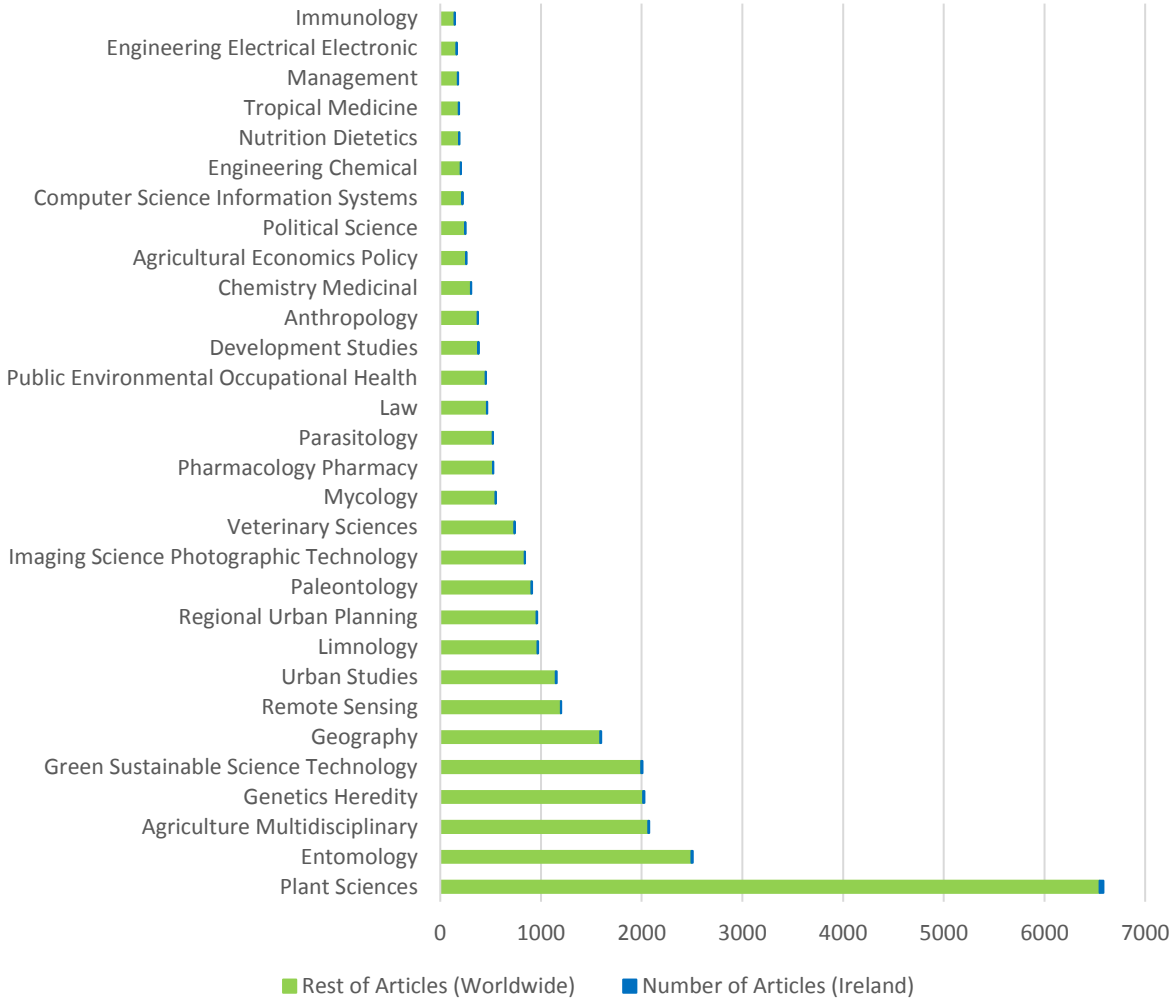


Figure 3.14 Top 30 worst performing island of Ireland biodiversity related publication categories (Worldwide vs Island of Ireland; totals).

Figure 3.15 plots these same 30 biodiversity related categories for Web of Science publications in comparison to Scotland and Denmark. With the exception of *immunology*, Ireland is consistently outperformed by Scotland. In only three categories does Ireland outperform Denmark; *political science*, *parasitology* and *pharmacology pharmacy*. The poorest performance overall is in the category of *law* for which the island of Ireland produces 8% of the biodiversity related articles. Another category of note is the previously identified *plant sciences* where Denmark produces over twice the volume and Scotland produces three times the volume of publications highlighting a considerable deficit of biodiversity related research in that area.

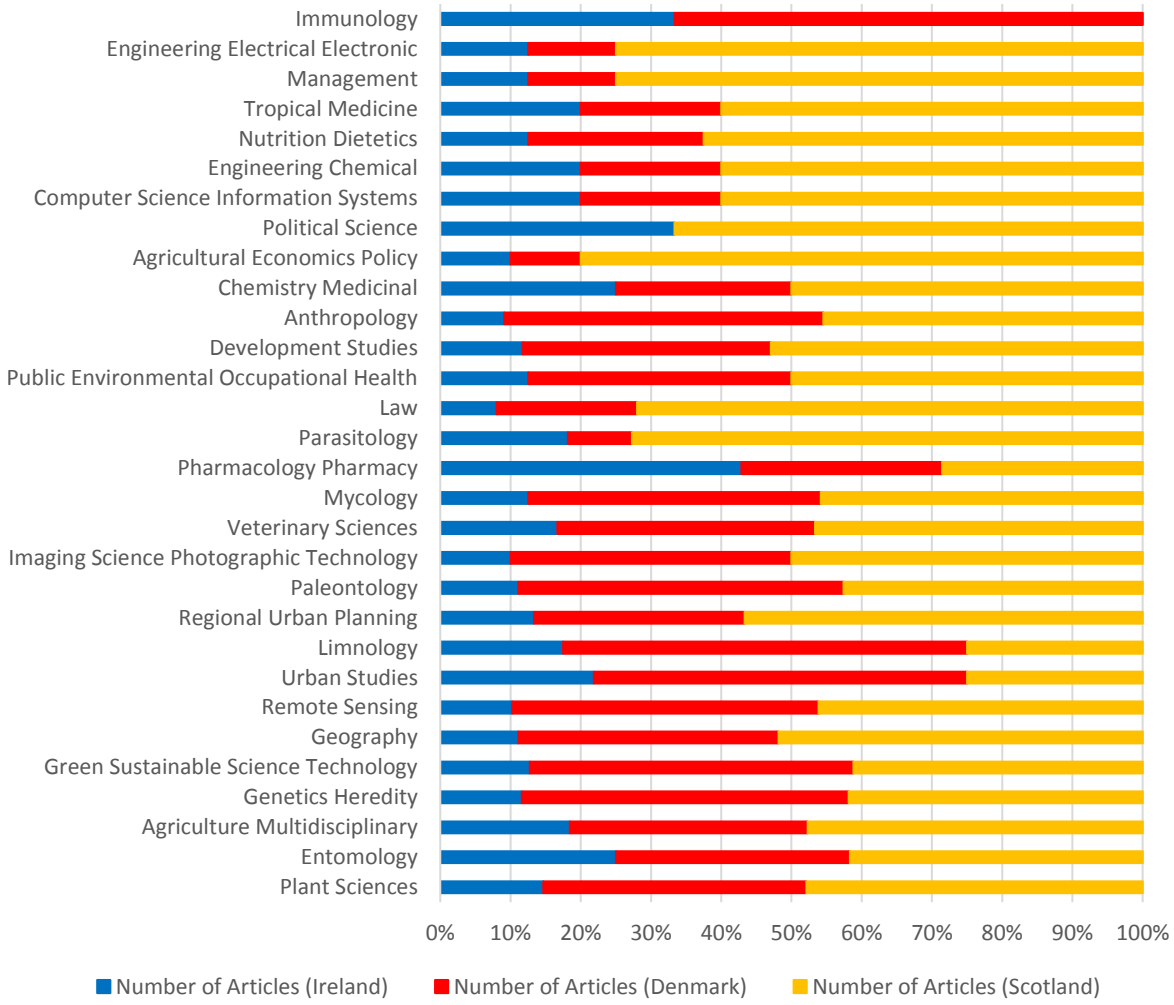


Figure 3.15 Top 30 worldwide biodiversity related publication categories that the island of Ireland performs poorly in (Island of Ireland vs Denmark vs Scotland).

3.1.4 Institutional research outputs

Using the Web of Science publication dataset it was possible to identify the institutions on the island of Ireland that have historically produced the greatest amount of publications related to climate change and/or biodiversity research topics. Figure 3.16 shows the institutions who have the greatest number of researchers listed as authors/co-authors in studies that relate to climate change and biodiversity research articles over the 1990-2021 period. A review of the output shows that authors from Queen's University in Belfast are the greatest producers/collaborators in such research followed closely by University College Dublin and Trinity College Dublin. Aside from the bigger universities some organisations perform particularly well at publishing climate and biodiversity research, in particular Teagasc who have registered over 100 publications. Overall climate change related publications surpass those relating to biodiversity (by a factor of 2:1).

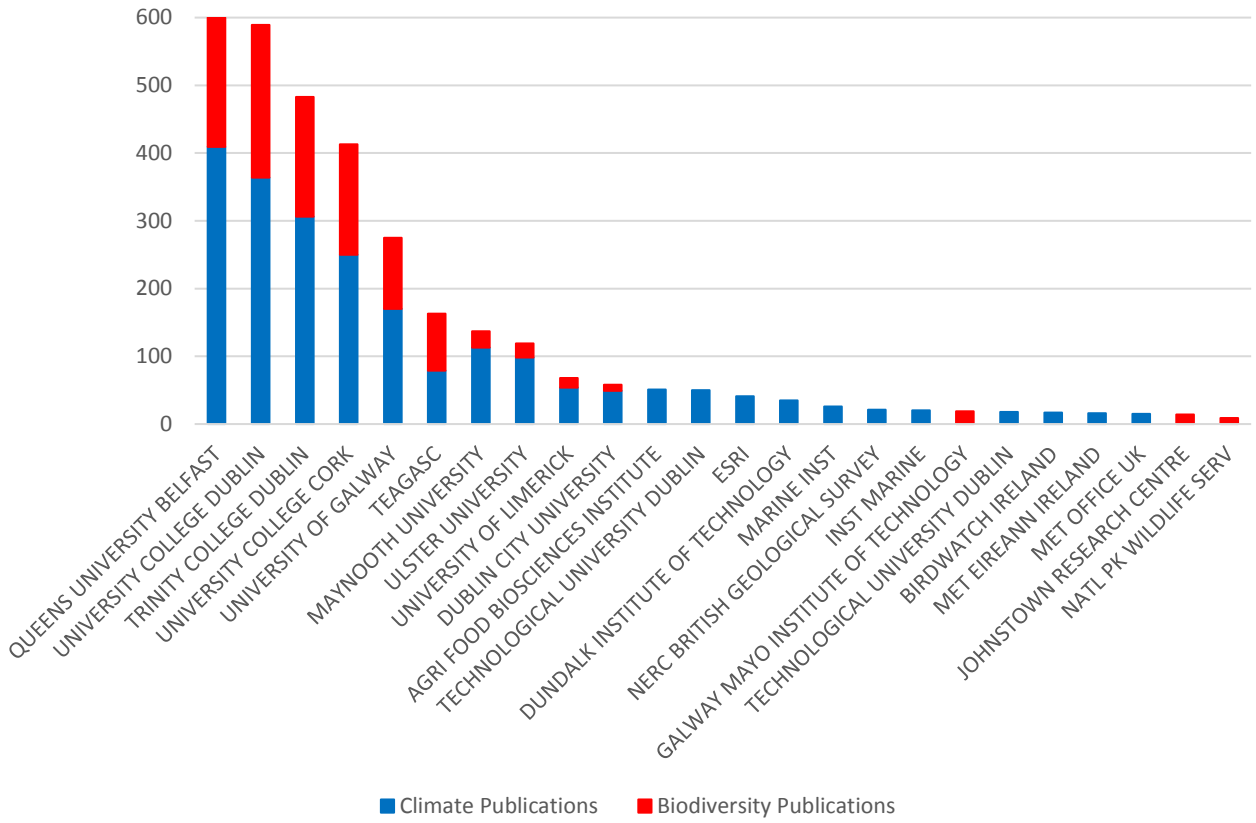


Figure 3.16 Climate change and biodiversity related publication numbers by institution on the island of Ireland.

3.1.5 Research output analysis summary

The comprehensive assessment of the historical databases of climate change and biodiversity related research outputs has provided a broad overview of research publication numbers of authors from the island of Ireland. It also has been effective at identifying what topics the island performs well in and what areas require further work. Whilst the data presented in this section provides valuable insights in publication numbers it is worth highlighting that considerable numbers of climate change and biodiversity related publications may not be picked up in this process so overall numbers are likely under-estimating outputs. This is because articles that relate to climate change and biodiversity research but fail to use the terms climate change and/or biodiversity directly in their abstracts or titles were not captured by the search process. Despite this, as the results compared like for like from the different territories, the findings are robust and highlight substantial deficiencies on a per capita basis in Irish climate change and biodiversity related research output compared to comparable nations / territories, highlighting the need for strong, coordinated actions from government and institutional leaders to help address this problem.

3.2 Survey overview

Details on the chosen questions, survey layout, along with the timeline by which the survey was conducted can be found in the methodology (see Section 2.3). Here we will look at the overall response rate from units across the island and will analyse the main findings from each of the seven parts of the survey. We will place a particular emphasis on how survey responses impact climate and biodiversity publications output and collaborations from the units across the island.

3.2.1 Survey response rate

Figure 3.17 shows that of the 92 surveys issued 34 completed surveys were submitted with no response received in 42 instances. In the remaining 16 cases the option to take part in the survey was declined. Reasons for declining included the survey not being seen as suitable, the unit to whom the survey was sent not being active anymore and the unit being part of a larger unit that had already responded or was in the process of responding.

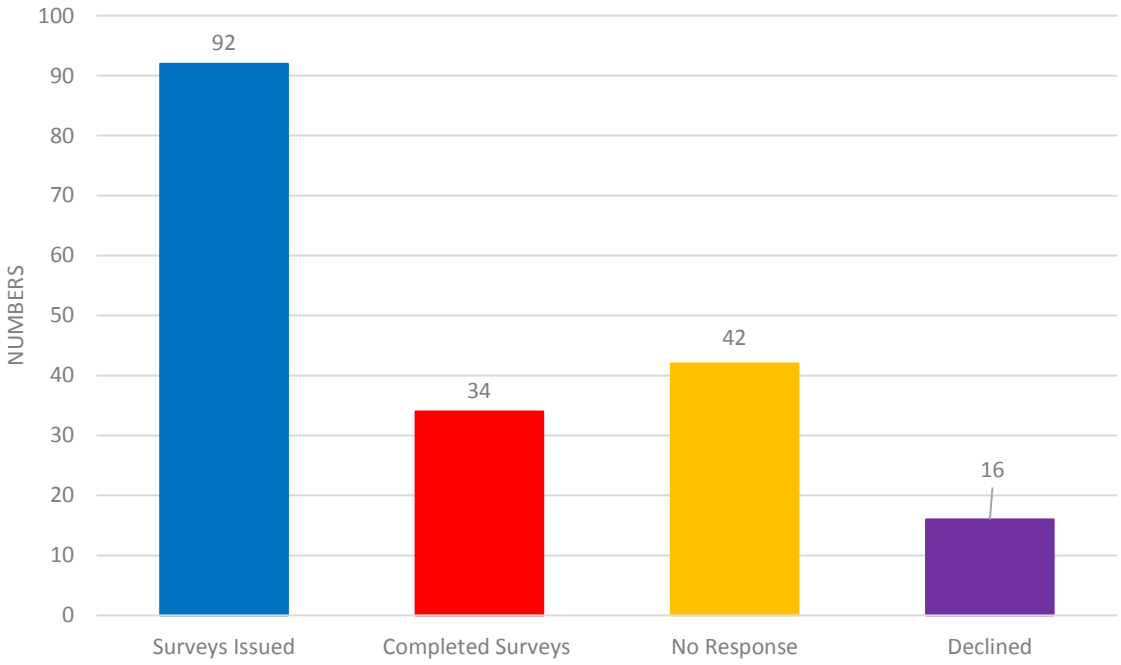


Figure 3.17 Breakdown of response numbers to the all-island climate change and biodiversity research assessment survey.

Overall the response rate to the survey was approximately 37% (Figure 3.18). When the declinations are disregarded this rises to 45%. In both instances this represents a robust response rate when compared to typical response rates internationally to online surveys, which are of the order of 36% (Daikeler *et al.*, 2022). Despite this it should be pointed out that as over 50% of possible candidates did not take part in the survey, total numbers associated with research funding, collaborations, publications, staff, etc. are under-representative of overall values. Also, all relevant expertise and available all island climate and biodiversity research facilities are not included. Further discussion on this is provided in Chapter 4.

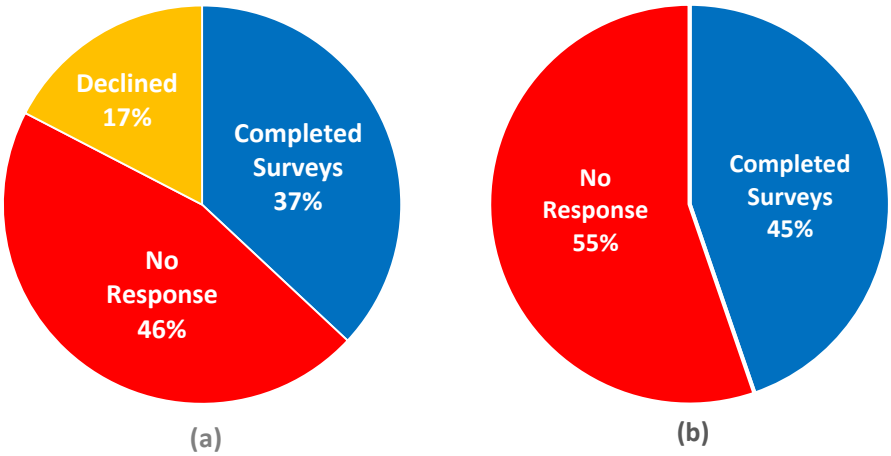


Figure 3.18 Survey response, percentages overview, including declined (a) and excluding declined (b).

Figure 3.19 gives a breakdown of institutional responses received in respect of the survey. Institutionally, the greatest number of surveys were issued to Trinity College Dublin, University College Dublin and Queen's University. Here, *other* represents responses from other organisations across the island carrying out research that are not aligned specifically with one or any university. These include government bodies, such as the Geological Survey of Ireland, and other cross institutional units such as ICRAG. Of particular note is the high response rate from smaller universities such as the Atlantic Technical University, South East Technical University and Technical university of Dublin.

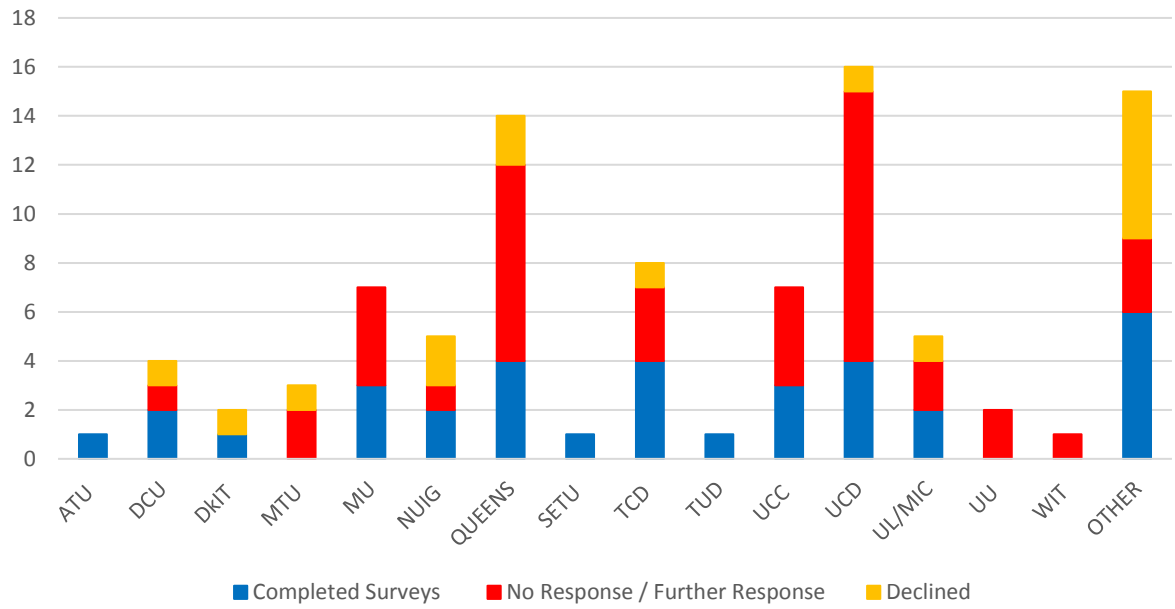


Figure 3.19 Academic institutional survey response rates by number of units. Acronyms can be identified in Appendix IV.

3.2.2 Survey questions overview

In total the survey contained seven sets of questions (Section 2.3), the final of which related to participation in the follow up interviews, which are discussed further in Section 3.3. A large proportion completed the survey in its entirety whilst a very small number only supplied basic data relating to the relevant unit. Some responses included details for only a subset of each of the six sections. However, as the structure of the survey had grouped questions into independent sections it was possible to carry out robust analysis for each section despite some units not having submitted responses.

3.2.2.1 Climate change and biodiversity research facilities

Initially, details regarding the climate change and biodiversity facilities in the relevant institutions were requested with totals used to identify an estimate of the overall percentage of climate and biodiversity units in institutions across the island. Figure 3.20 shows the accumulated values, which suggests that of all institutes, centres and other units in academic institutions and organisations on the island of Ireland, a total of 13% relate to climate and biodiversity in some manner.

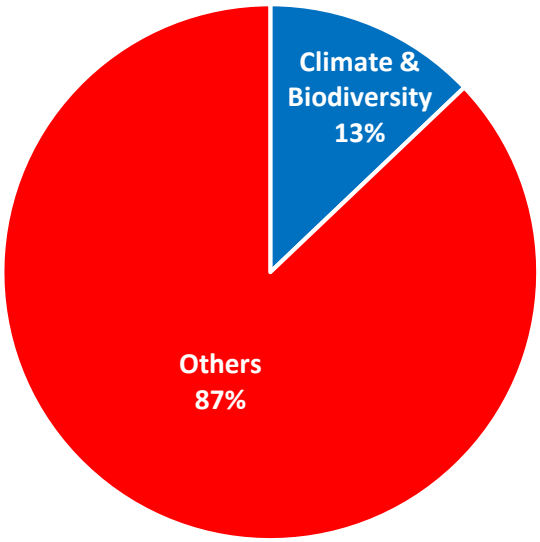


Figure 3.20 Climate and Biodiversity Centres/institutes per institution.

A breakdown of the number of units across the institutions on the island, as identified by survey respondents, is shown in Figure 3.21. Note that the total unit numbers presented in the graph are based on survey responses and are only provided for institutions for which data was submitted. It is also worth noting that whilst some institutions have a relatively low number of climate and biodiversity units this does not mean that climate and biodiversity research is not being undertaken in some form. For example, departments/schools within universities could have individual academics who carry out climate or biodiversity research.

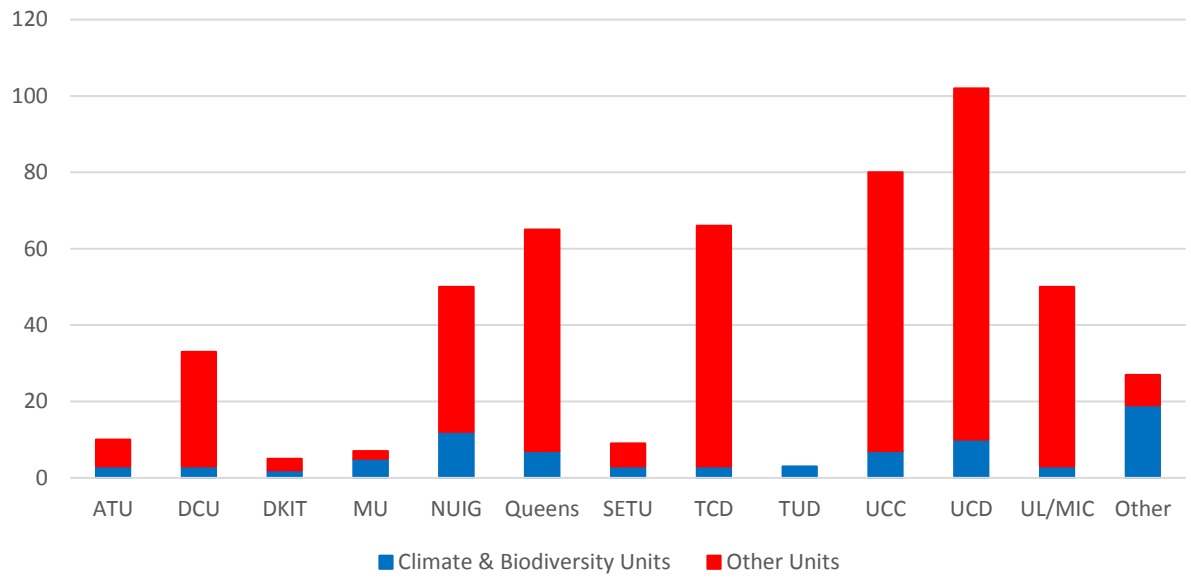


Figure 3.21 Number of climate and biodiversity units per institution.

As part of the survey, respondents were asked to confirm if they had access to facilities within their institution that related to climate and biodiversity research and to outline details of those facilities. A complete breakdown for each is provided for in Table 3.1. Of the 34 respondent units 68 % stated that they had access to research facilities whilst 32 % said they did not (Figure 3.22). Of the available facilities some duplication is identifiable. For example iCRAG and Maynooth University have access to sediment core laboratories. Similarly Queens has similar sediment laboratory facilities. Please note that some of the units listed in Table 3.1 are based principally within specific universities (e.g. MaREI based in University College Cork) so duplicative accounting of some resources is possible here.

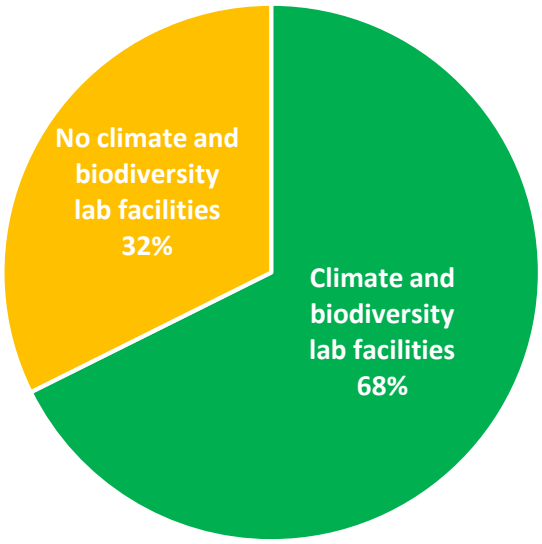


Figure 3.22 Specialist climate and biodiversity research facilities (laboratories and equipment).

Table 3.2 provides a list of facilities, laboratories and equipment that certain units identified as being required to facilitate their research that are not yet available. Of particular note is the requirement for analytical and glasshouse facilities. Some requested facilities are available in other institutions/universities, such as the sediment core analysis laboratories, suggesting potential exists for future collaborations.

Table 3.1 List of available laboratories (labs), equipment and other facilities by institution.

Institution	Current Labs					
BiOrbic (UCD)	Specialist labs in Food tech	Specialist labs in analytical chemistry	Specialist labs in analytical chemistry, chem. engineering	Specialist labs in material science	Specialist labs in ecology, biodiversity	Specialist labs in soil, microbiology
Centre for GIS and Geomatics (Queens)	GIS	Geophysics	Drones	Remote sensing	DGPS	
Climate Matrix Team (MI)	50+ scientific labs	2 national research vessels				
CREDIT gateway (DkIT)	Bioenergy	Anaerobic digestion	Wind energy measurement			
Dept. of Biological Sciences (UL)	Soil carbon analysis	Chambers for field based GHG flux measurement				
Environmental Research Institute (UCC)	Lir National Ocean Test Facility	Biogas and hydrogen production and analysis	Atmospheric simulation chambers	Energy modelling		
ESHI (TUD)	Dublin Energy Labs	Shared facilities				
GSI	Numerous online databases	core facilities				
ICARUS (MU)	Sediment core analysis,					
ICHEC (NUIG)	Satellite data archives	Supercomputer facilities	land observation archives	marine observation archives		
iCRAG (UCD)	Analytical labs for materials	Atmospheric modelling chambers	Sediment core analysis lab			
IFI	monitoring data buoys on lakes	Other monitoring equipment				
MaREI (UCC)	National Ocean Test Facility	Renewable Fuel Labs	Material & structures labs			
MFRC (ATU)	Molecular/proteomics labs	Cell culture and microbiology facilities	Analytical chemistry facilities - spectroscopy	Histology and image analysis suite	land-based marine recirculation facility	General wet & dry lab space
Nature+ (TCD)	Marine Climate Change mesocosms	Field facilities: grassland, peatland, renewable	Environmental analysis lab	environment parasitology facility	Climate chambers	Freshwater mesocosms
Planet' Research Group (Queens)	Physical geography Lab	Pollen / Paleoecology Lab.	Biogeography Lab	Sediments Lab	GIS lab	
Ryan Institute (NUIG)	Mace Head Climate Change Station	Carron Field Research Station				
Teagasc	Teagasc National Farm Survey	Soil Carbon Observatory	National agricultural greenhouse gas lab	The national soil and DNA archive	Anaerobic digestion (AD)	Slurry tanks for GHG measurement
Teagasc	National LANDSAT Archive	Enteric methane facilities	Microbiology labs	Genomic, proteomic and endocrine labs	FAPRI-Ireland model	DNA sequencing capacity
Teagasc	flux tower sites	Soil Information System				
Trinity Centre for the Environment (TCD)	Soil & water quality analysis					

Table 3.2 List of required laboratories (labs), equipment and other facilities by institution.

Institution	Required Facilities					
BiOrbic (UCD)	Sediment core analysis	Carbon flux towers	Analytical facilities	CO2 off gas analysis Bioreactor		
Centre for GIS and Geomatics (Queens)	Digital monitoring					
Climate Matrix Team (MI)	Carbon and zooplankton lab	Human capacity				
CREDIT gateway (DkIT)	Carbon sequestration equipment	Carbon flux equipment				
Dept. of Biological Sciences (UL)	CN analysers	Rhizotrons	GHG chambers			
Dept. of Geography (MIC)	Decent spec physical geography lab					
ESHI (TUD)	Air quality monitoring	Outdoor research facility	Water filtration facilities			
Forest Ecology Lab (MU)	Environmental growth chambers	outdoor controlled environment facilities				
ICARUS (MU)	Lab space					
ICHEC (NUIG)	Larger scale computation					
iCRAG (UCD)	Analytical facilities					
MFRC (ATU)	Expansion of existing facilities					
Nature+ (TCD)	Glasshouse facilities					
NUIG	Computation					
Ryan Institute (NUIG)	Open-access longitudinal field sites.					
Teagasc	Curated biobank of soil isolates	Indoor/outdoor controlled glasshouse facilities	CO2 enrichment facilities	National soil biology lab	Soil functional phenotyping facilities	Respiration chamber(s)
Teagasc	Greenfeed machines	Metabolism house	Gas lab equipment	Facilities for sustainable manure management & nutrient cycling	Facilities to support nutrient cycling management	Facilities to support bio-economy

3.2.2.2 Expertise

Details on the number of staff researching topics related to climate change and biodiversity for each of the units were also extracted from the survey. A breakdown of overall percentages can be seen in Figure 3.23. Climate change related topics make up the vast majority of research (45%) compared to biodiversity related topics (27%) with the combination of the two making up a greater percentage (28%) compared to biodiversity on its own.

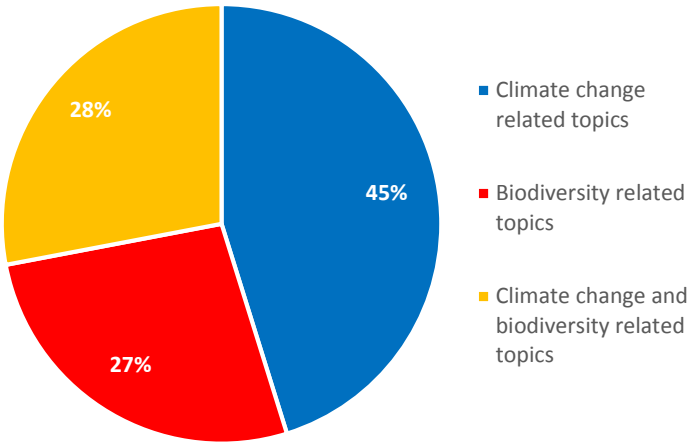


Figure 3.23 Overall percentage of research on climate change and/or biodiversity research.

The percentage of staff researching climate change and biodiversity topics based on unit size (small being < 33 staff; medium being > 33 and < 66 staff; large being > 66 staff) were also derived and can be seen in Figure 3.24. As expected, the larger the unit the more research on climate change and biodiversity related topics is carried out. One exception is for combined climate and biodiversity research where small units carry out more work than medium sized units. Also, small units carry out proportionally more biodiversity research compared to climate change research (38% versus 31%) compared to medium sized units (52% versus 30%) and large units (44% versus 25%). Whilst medium sized units carry out proportionally more climate change research (52%) they carry out the smallest percentage of combined climate change and biodiversity research overall (17% versus 32% for small and 31% for large units).

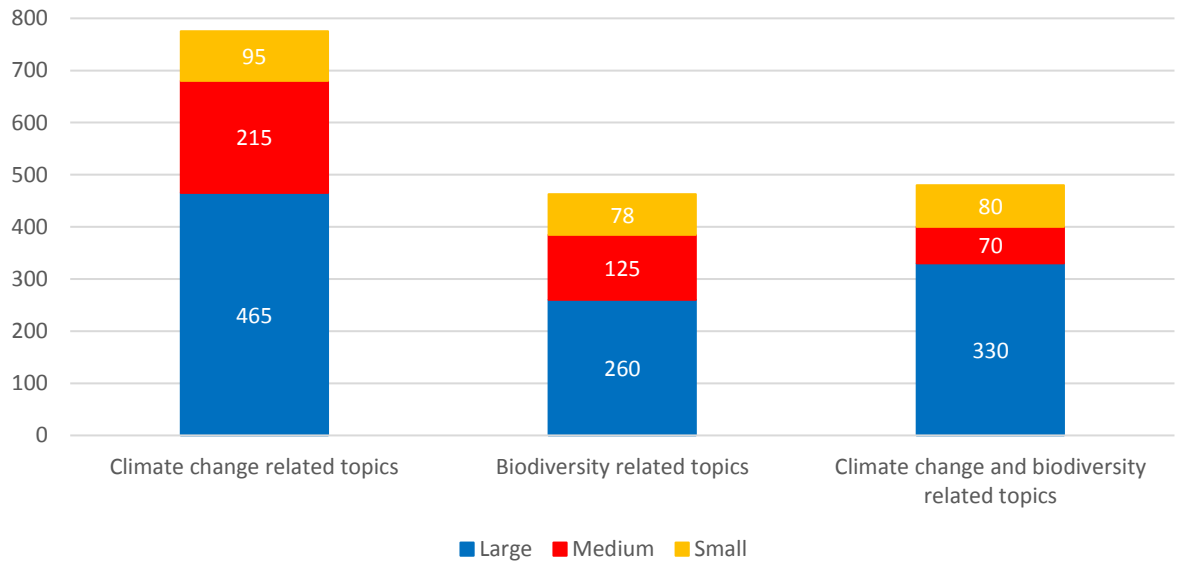
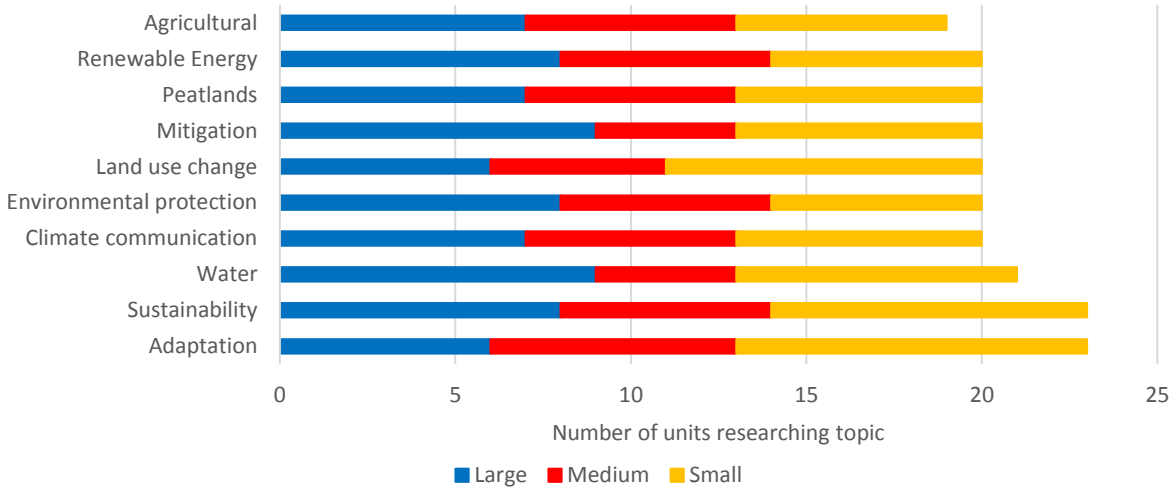
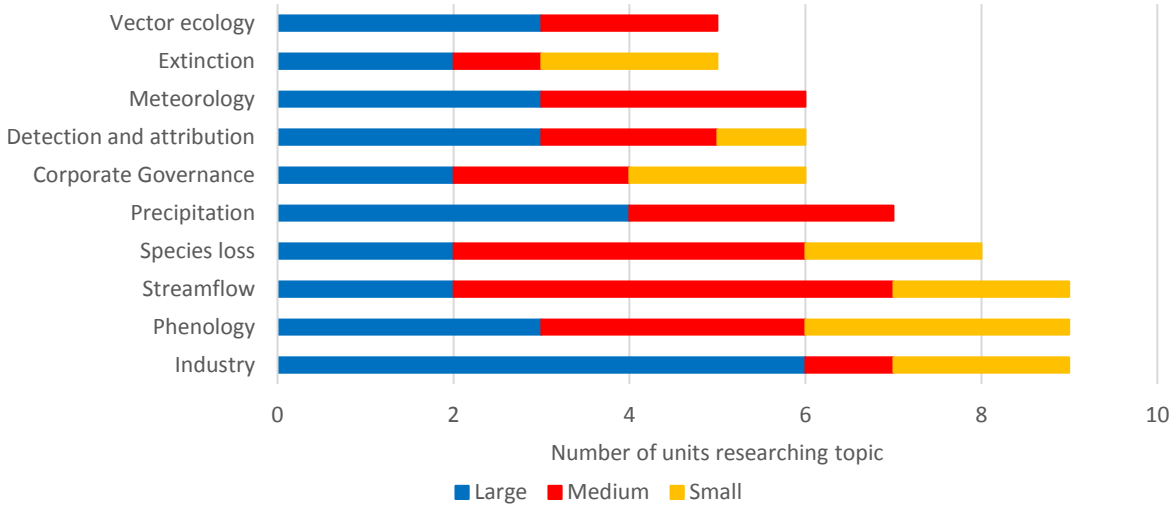


Figure 3.24 Total staff researching climate change and/or biodiversity research topics based on unit size.

Respondents to the survey were asked to note the most relevant research topics from a list of over 50 items (full list and responses available in Appendix II). Figure 3.25 shows the ten most researched topics (a) and the 10 least researched topics (b) from this list and their relationship to unit sizes. Amongst the most researched topics are adaptation, sustainability and water whilst the least are vector ecology, extinction and meteorology. It is evident that biodiversity related topics are typically less researched than those related to climate change. The degree to which topics are researched, based on unit type, is also linked to their prevalence overall. For example large, medium and small sized units all carry out research in the top ten research areas (typically greatest for large units and the least for medium sized units), for the bottom ten research areas some topics are not researched at all by smaller units including *vector ecology*, *meteorology* and *precipitation*. These results highlight the importance of larger units in the Irish climate change and biodiversity research landscape as they capture all of the most relevant research.



(a)



(b)

Figure 3.25 Top ten most researched (a) and least researched (b) climate change and biodiversity related topics based on unit size.

3.2.2.3 Funding

Figure 3.26 gives an overall breakdown of funding provided to units compared to their respective institutions overall funding. Values here are provided based on survey respondent's unit size (research staff numbers). In total climate change and biodiversity related unit funding from survey respondents makes up approximately 10% of institutional funding amounts, with large units having the largest portion of this funding (5%) even though they only make up 9 of the 34 survey responses. Medium sized units make up a similar sized portion of the funding (4%). Smaller units receive considerably less funding overall (1%) despite being the grouping that submitted the most survey responses (13 in total).

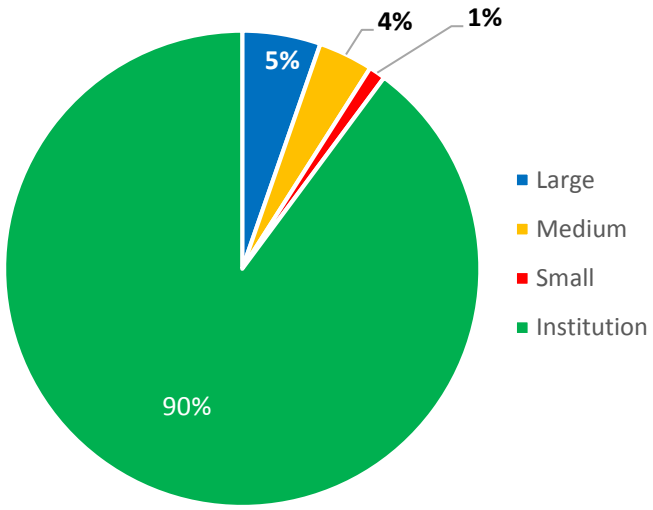


Figure 3.26 Percentage breakdown of total research funding for large, medium and small climate and biodiversity research units and their parent institutions.

A more detailed breakdown of institutional versus unit funding is given in Figure 3.27. Here, available total institutional funding amounts are shown along with related climate change and/or biodiversity unit values. Included in this chart are funding amounts for units that were previously categorised under *other* as they straddled multiple universities such as ICRAG. For these units (excluding Teagasc) overall unit funding is given. In terms of institutional funding Dublin City University, Trinity College Dublin and University College Dublin all have over 100 million euros worth of funding, closely followed by University College Cork. Also of note is the considerably lower funding amounts received by relatively smaller institutions such as Dundalk Institute of Technology and the South East Technical University. Of the bigger universities, University College Dublin has secured the greatest amount of climate and biodiversity research funding whilst Dublin City University has secured the least (only 1% of funding displayed here based on survey responses). Of the units not affiliated with a single university the best at acquiring funding has been iCRAG.

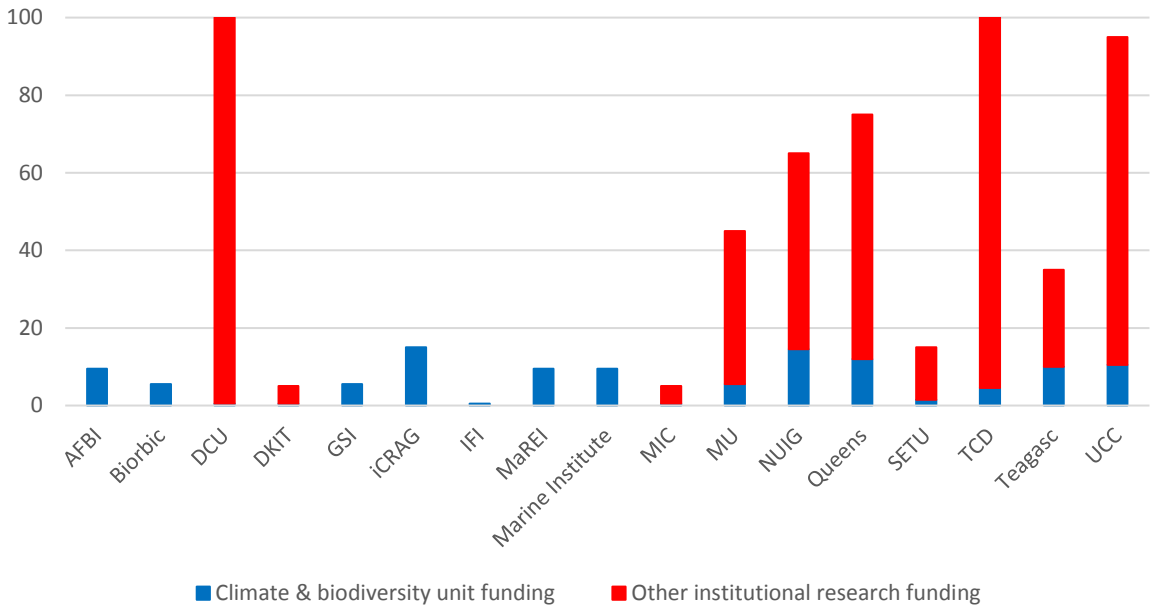


Figure 3.27 Climate and biodiversity research unit versus institutional funding in millions of Euros.

A breakdown of the number of active funding streams at varying amounts, for large, medium and small sized units is displayed in Figure 3.28. Funding amounts of up to 0.5 million euros dominate and most likely relate to stipends to PhDs and short term contracts to Postdocs. Amounts above 0.5 million euros represent less than 40% of overall funding streams across all units from which a survey response was received. Although relatively uneven, a general decrease in the number of secured funding awards is seen as the values increase. Only three units are identified as having active funding streams with the maximum amount of > 5 million euros and these go to medium to large sized units. Conversely smaller funding amounts go to medium to small sized units with small units having the most active < 0.5 million euro funding awards.

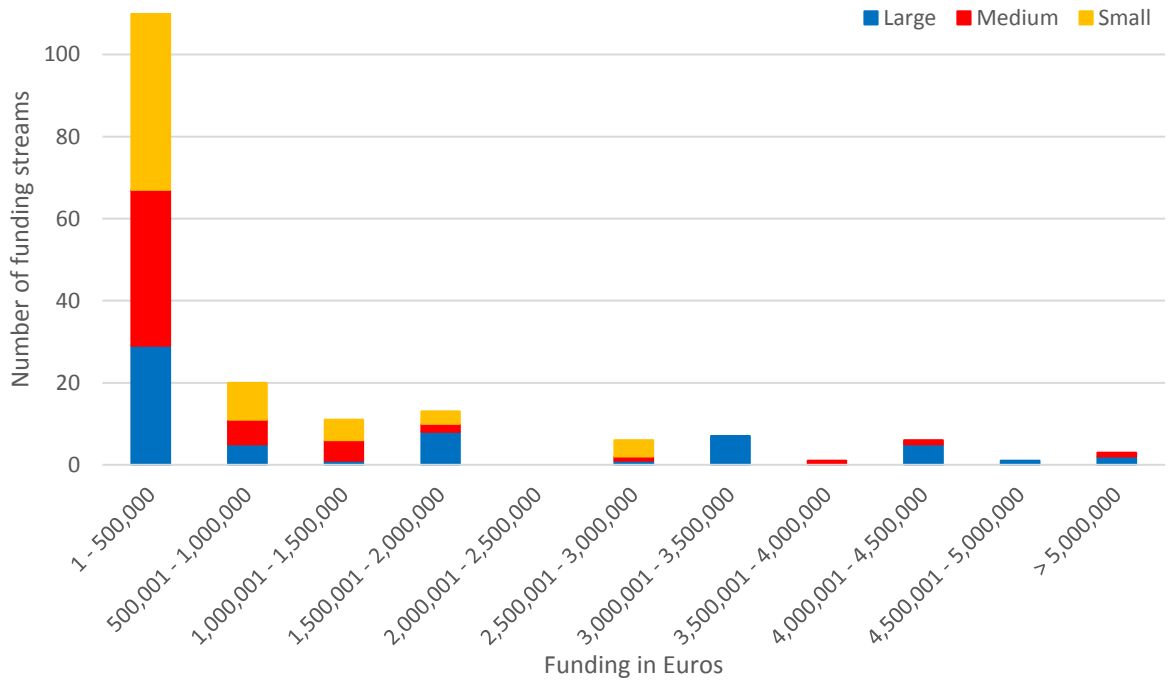


Figure 3.28 Categorisation of active funding stream amounts in 2021 by unit size.

Twenty of the most important funding agencies across the island of Ireland were assessed to identify how prevalent the funders were in relation to climate change and biodiversity research (Figure 3.29). Across the 34 units from which survey responses were received the top three providers based on total rankings from 1 to 5 were Horizon Europe/Horizon 2020, Science Foundation Ireland and the Environmental Protection Agency. Focusing solely on the primary funding agency per unit, Science Foundation Ireland is identifiable as the most important followed by Horizon Europe/Horizon 2020, again highlighting the importance of these funders in climate and biodiversity research. Finally, it is worth noting that the *other* grouping is the joint fourth most important source of funding. This grouping includes amongst others, philanthropic and private funding sources.

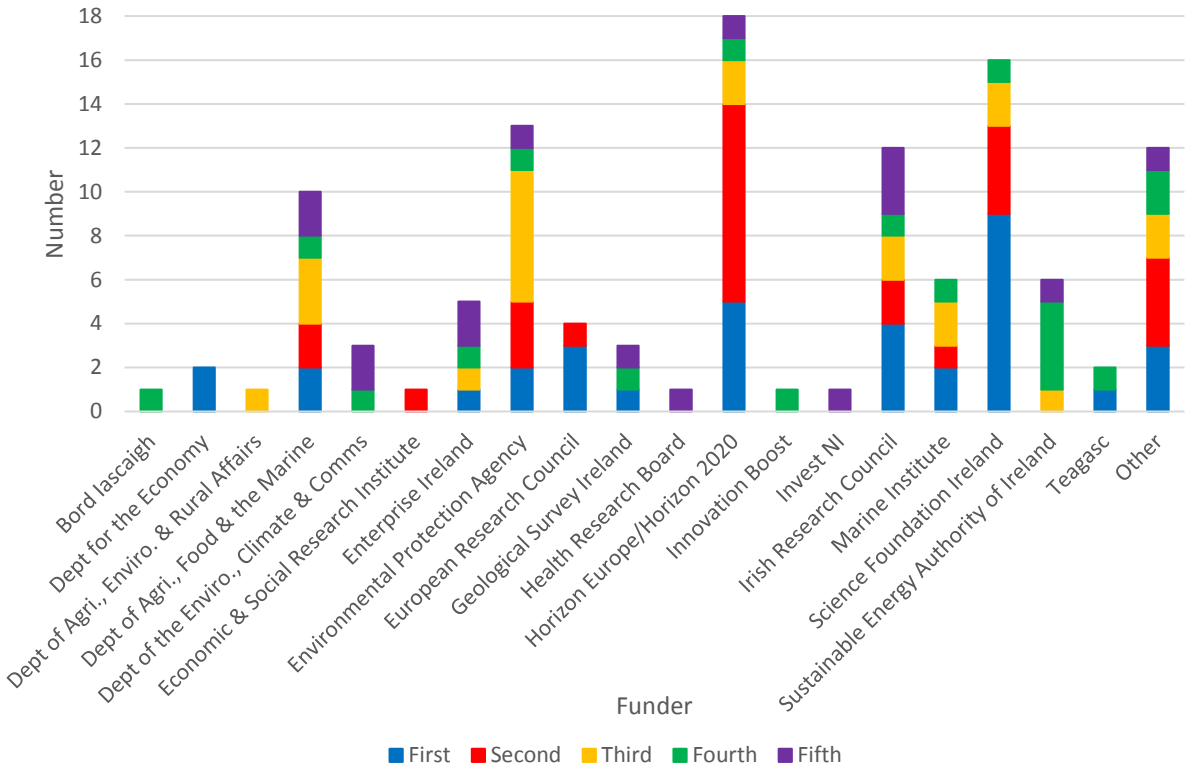


Figure 3.29 Top five sources of funding across all units.

An analysis of funding sources based on unit size was also carried out, with the amount of funding allocated to the previously defined unit sizes (based on staff numbers) being investigated (Figure 3.30). In this assessment only the top three funders by organisation are included to help identify the most important funders within the three different unit sizes. Once again Horizon Europe/Horizon 2020, Science Foundation Ireland and the Environmental Protection Agency all stand out as being important across units. However, clear differences are identifiable depending on unit size. For example, Science Foundation Ireland is the most important for large units of over 66 staff closely followed by Horizon Europe/Horizon 2020. For medium sized units the Environmental Protection Agency stands out as being vital whilst for smaller units the Irish Research Council and other funding sources are crucial. Overall the most balanced funding, based on unit sizes, comes from the Department of Agriculture, Food and the Marine.

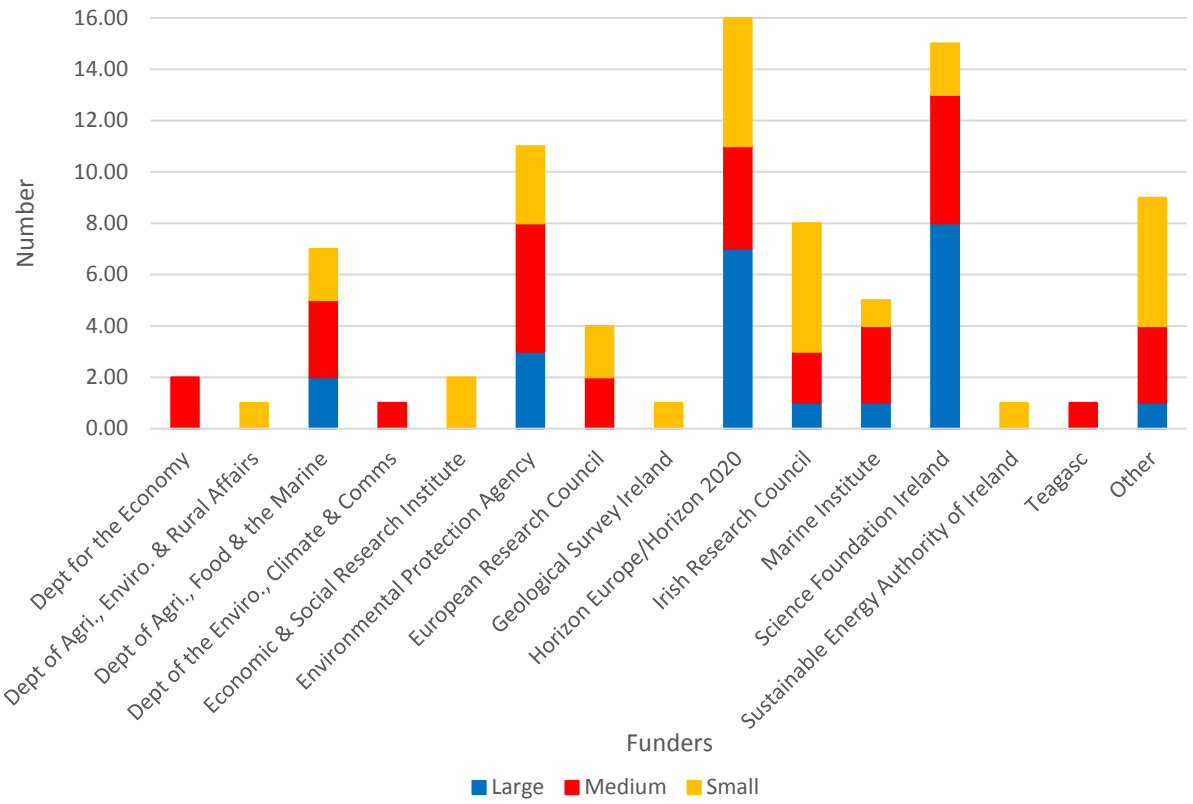


Figure 3.30 Funding allocations per unit size (top 3 listed funders; total per unit).

Figure 3.31 plots total research funding per research unit versus climate and biodiversity research output. Across each unit size increases in unit funding results in an increase in climate and biodiversity research output, however in general, increases in funding provided to large units has a much greater impact than those of medium size, which in turn is, marginally, greater than those for smaller units. The rate of change is greatest for large units suggesting that funding spent on such units produces the most amount of additional research output per additional euro spent.

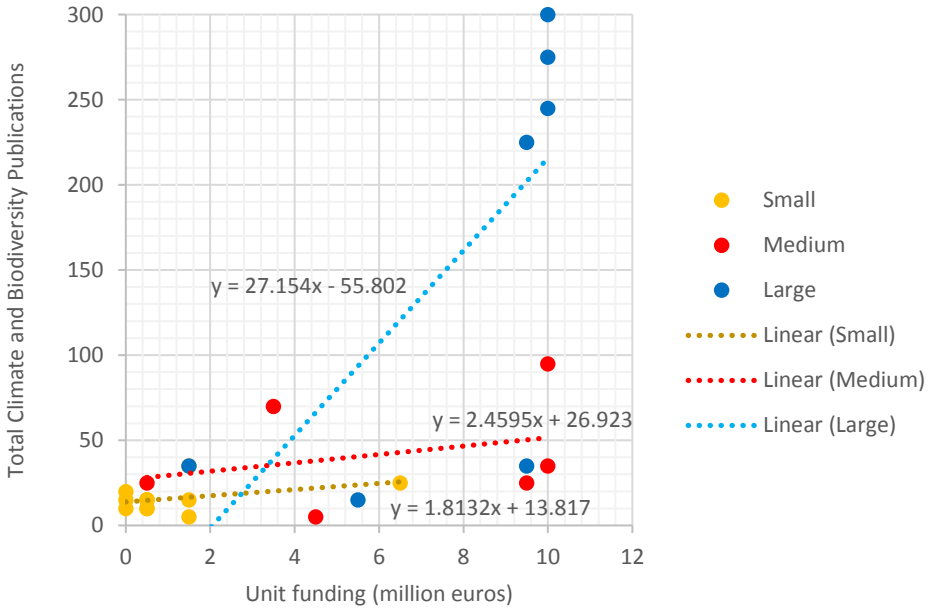


Figure 3.31 Plot of unit funding amounts vs total climate and biodiversity research output in terms of self-declared publication outputs.

3.2.2.3 Staffing

An overview of research staff numbers for units of sizes small, medium and large in comparison to the total related institutional values is provided for in Figure 3.32. Units taking part in the survey are found to make up approximately 10% of total research staff numbers. Smaller units (< 33 staff) only represent approximately 1% of the overall total whilst larger units (>66 staff) represent approximately 5%. Medium units (between 33 and 66 staff) represent approximately 4%.

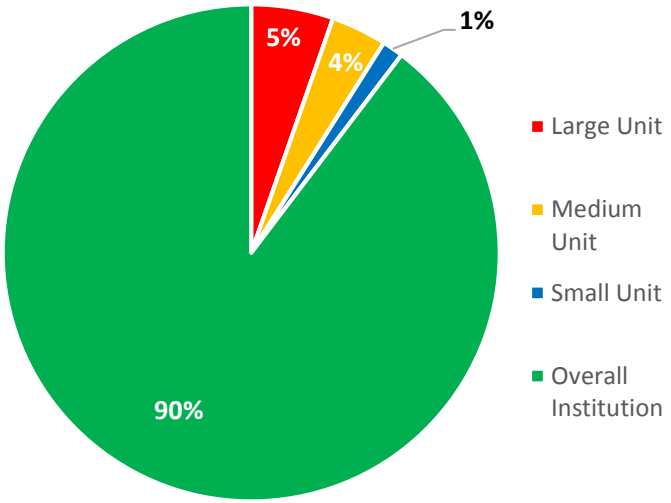


Figure 3.32 Percentage breakdown of total research staff numbers for large, medium and small climate and biodiversity research units and their parent institutions.

Climate and biodiversity research staff numbers, for units across the island together with related institutional research staff numbers (totals) are shown in Figure 3.33, with marginal differences identifiable between institutions overall. One exception is for University College Dublin where approximately 250 individuals are noted as working in climate and biodiversity research units, the largest across surveyed institutions based on survey responses. Other large institutions such as Queen's University and University College Cork have half as many staff. The proportion of unit staff members working on climate and biodiversity topics was found to be highest in MaREI. Please note that the figures provided above may over represent total researcher staff numbers where some researchers may be part of more than one unit. Also, for the purpose of this assessment, Science Foundation Ireland (SFI) centres are treated independently of their host universities.

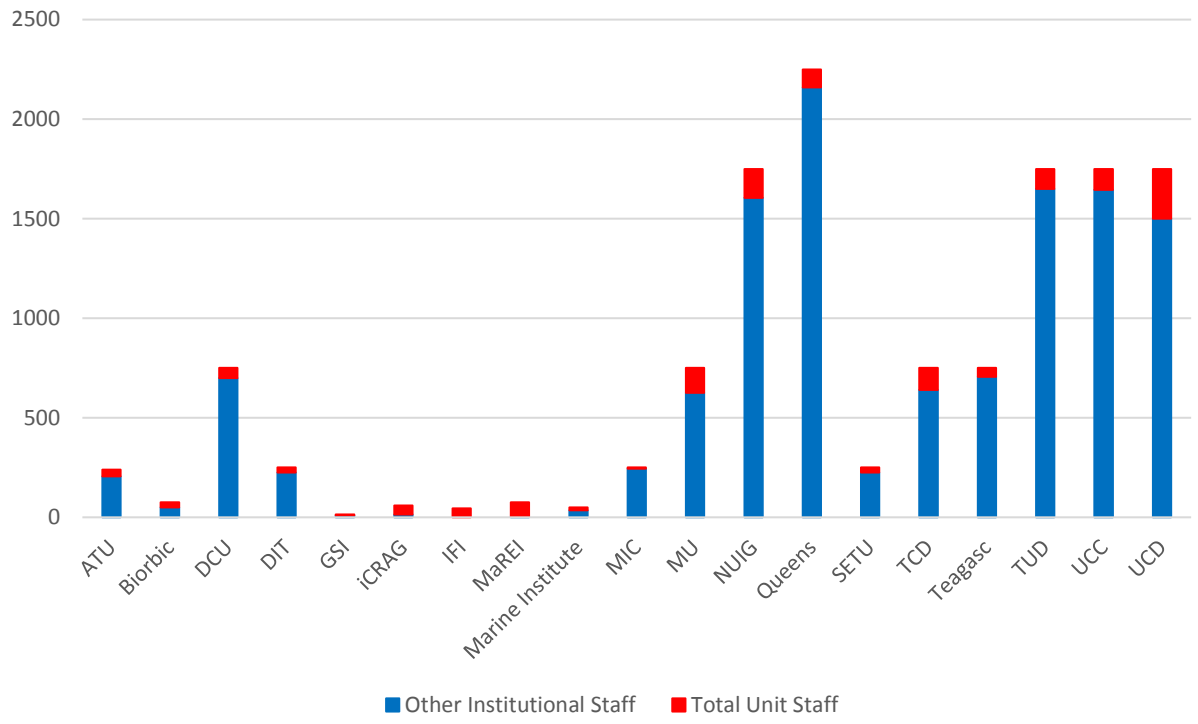


Figure 3.33 Total institutional versus unit research staff numbers.

Figure 3.34 provides a detailed breakdown of staff numbers working on topics related to climate change versus biodiversity based on overall unit staff numbers as well as unit size. Of particular note is that biodiversity research consistently shows a lower representation in terms of staff numbers. Just over one third of staff active across these topics are researching biodiversity topics compared to just under two thirds of staff researching climate change related topics. When looking at unit totals for smaller units the difference is 44% to 56% (75 to 95), for medium sized units the difference is 37% to 63% (125 to 215) and for larger units the difference is 36% to 64% (260 to 465) showing that medium to large units have proportionally lower staff numbers working on biodiversity research overall.

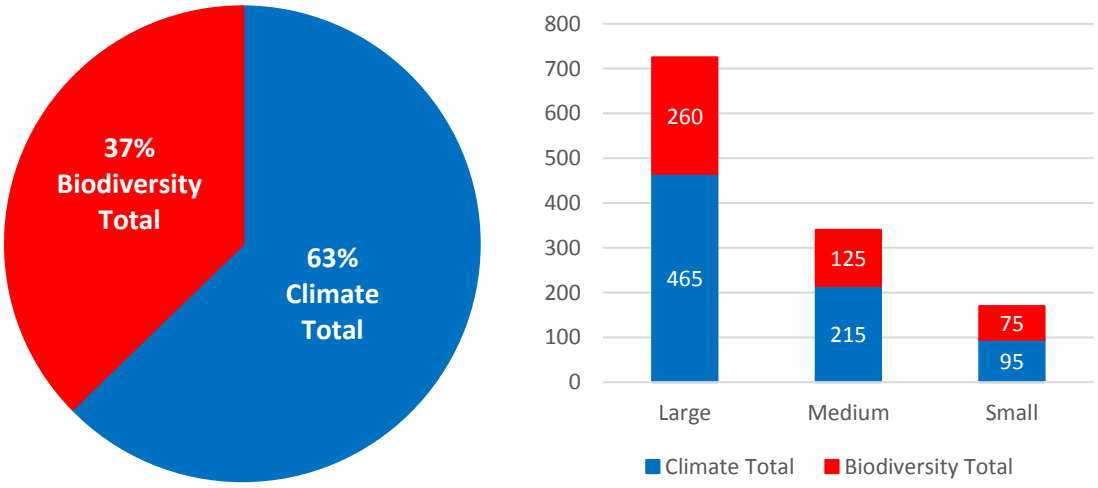


Figure 3.34 Total climate versus total biodiversity staff numbers across all units (left) and based on unit sizes (right).

A breakdown of the percentage of staff types across all units is provided for in Figure 3.35. Results show that the majority of climate and biodiversity related staff are post-doctoral researchers (20%), closely followed by lecturers (17%). Technicians and other unlisted staff make up the smallest grouping (5% or less). A more detailed breakdown of staff numbers based on unit size is shown in Figure 3.36. Larger units consistently have the greater numbers of staff per staff type than smaller units with the exception of lecturers for small units, which are greater in number than those for medium sized units, and other staff type which are greater in medium sized units than those for larger units. Of particular note is the large proportion of research assistants, technicians and administrative support staff in larger units, which are generally proportionally lower in number in smaller unit sizes. Also of note is the high number of postdoctoral researchers in larger units. A detailed discussion of these findings can be found in Section 4.3.2.

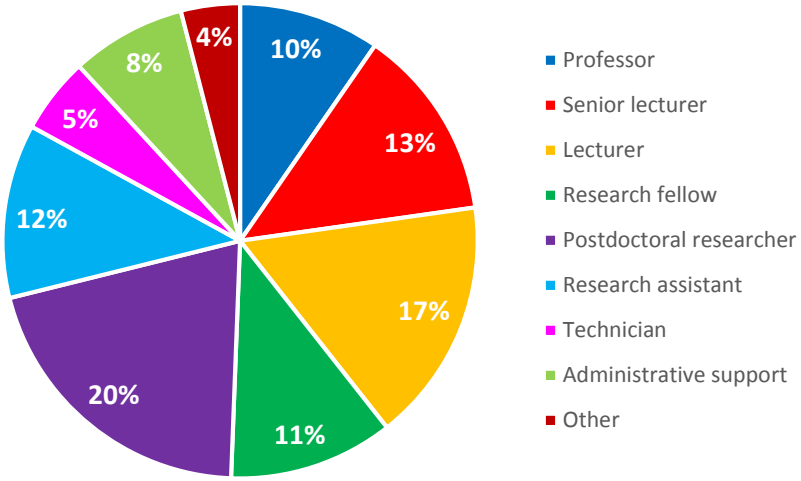


Figure 3.35 Overall percentage of different staff types per unit.

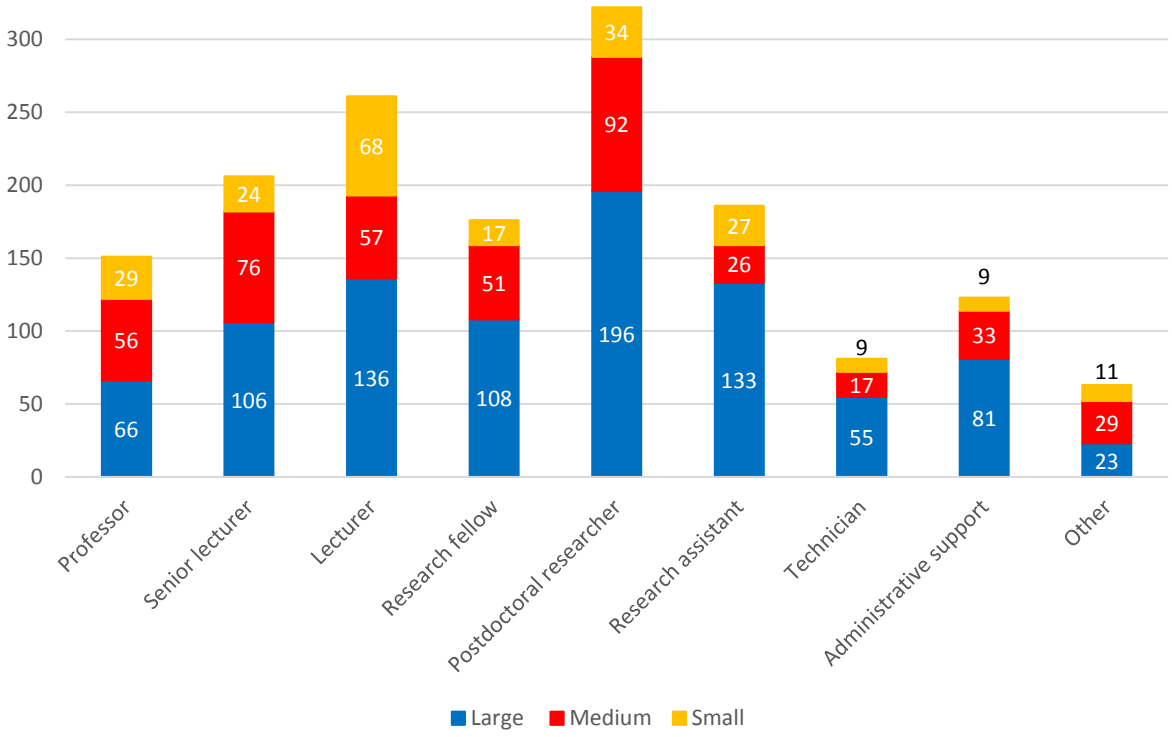


Figure 3.36 Total number of different staff types based on unit size.

A detailed plot of how changes in staff numbers of specific types impact total climate and biodiversity research output is presented in Figure 3.37. The analysis shows that, for all professions, an increase in staff numbers results in an increase in climate change and biodiversity research output, however the rate of change is considerably different depending on the chosen profession. For example, whilst increases in technicians, research assistants and other staff groupings produce relatively small increases in research output (per staff member increase), similar increases in administration staff have a markedly greater impact (by a factor of approximately four times) highlighting the importance of administrative staff in facilitating climate change and biodiversity researchers to do their research.

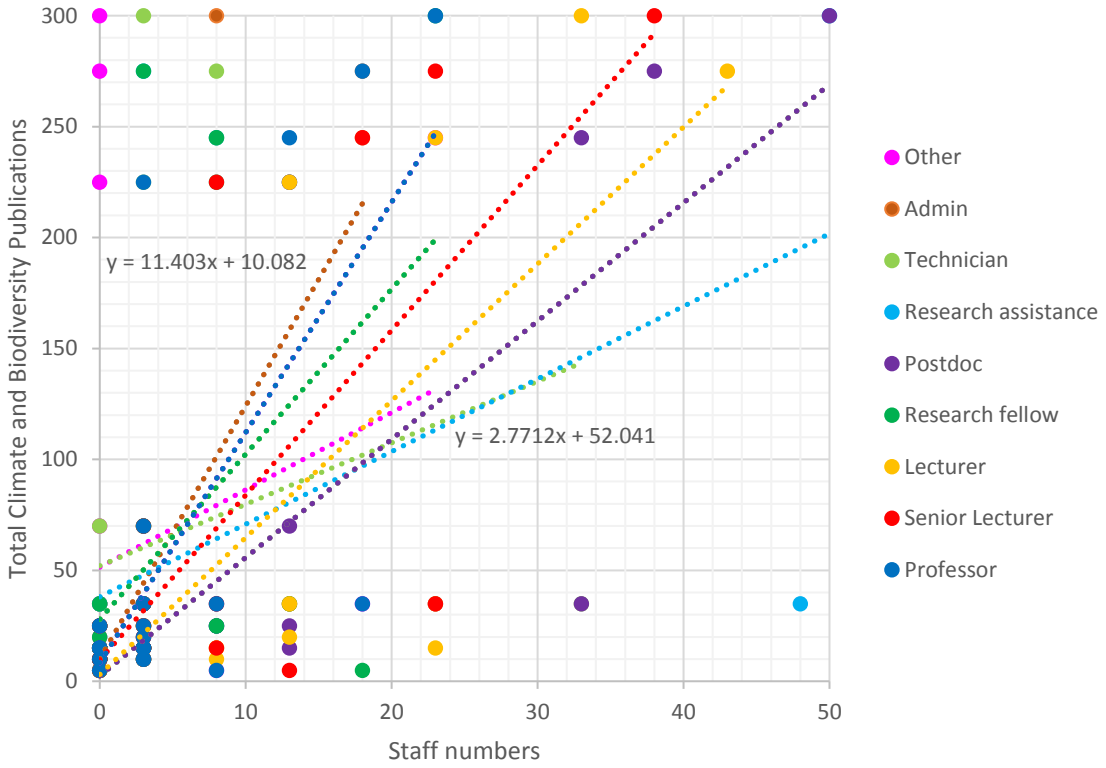


Figure 3.37 Total publication outputs per staff type across all units. Note: equation of lines for *Admin* and *Technician* are provided. Publications are self-declared unit outputs.

3.2.2.5 Education

The number of PhD candidates and the topics they researched were also identified for each unit in the survey. Figure 3.38 gives a broad breakdown on the percentage of climate and biodiversity research carried out by PhDs. As found previously, climate change related topics make up the vast majority of research (44%). Combined climate and biodiversity research represents nearly a third of research output (32%), which is considerably more than solely biodiversity related topics that represent less than a quarter of research by this grouping (24%).

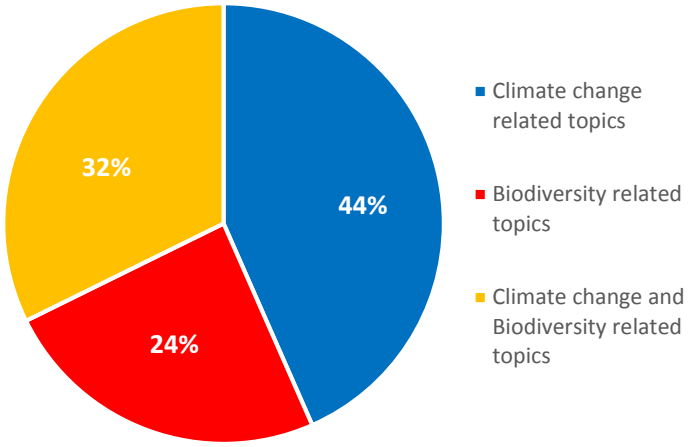


Figure 3.38 Percentage of PhD candidates studying climate and biodiversity topics

A breakdown of total PhD numbers and their type of research by unit size is shown in Figure 3.39. Whilst large units consistently have the greatest number of PhD students working on climate and/or biodiversity related topics, small units have notably more PhDs working on combined climate and biodiversity and solely biodiversity topics compared to medium sized units. For medium sized units biodiversity related topics only make up 15% of research compared to 25% for large and 32% for small units. Of particular note is that nearly equal numbers of PhDs research climate, biodiversity and climate and biodiversity related topics in small units. Also, combined climate change and biodiversity related topics are consistently researched in greater numbers than solely biodiversity related topics across all unit sizes.

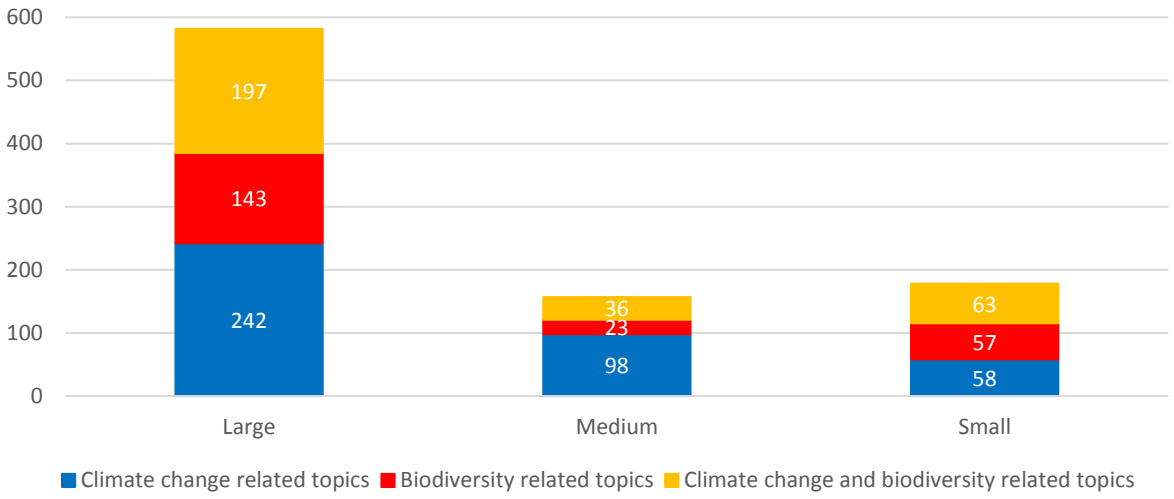


Figure 3.39 Total number of PhD candidates studying climate and biodiversity topics based on unit size.

As PhDs often contribute significantly to the research output of institutions the impact PhD numbers have on climate and biodiversity research was also assessed. Results displayed in Figure 3.40 show the strong, positive relationship between PhDs numbers and related publication numbers. Combined climate and biodiversity PhDs are found to relate most strongly to climate and biodiversity research outputs whilst biodiversity PhDs have the least impact (by a factor 1.3) highlighting the importance of cross discipline PhDs in producing peer reviewed publications.

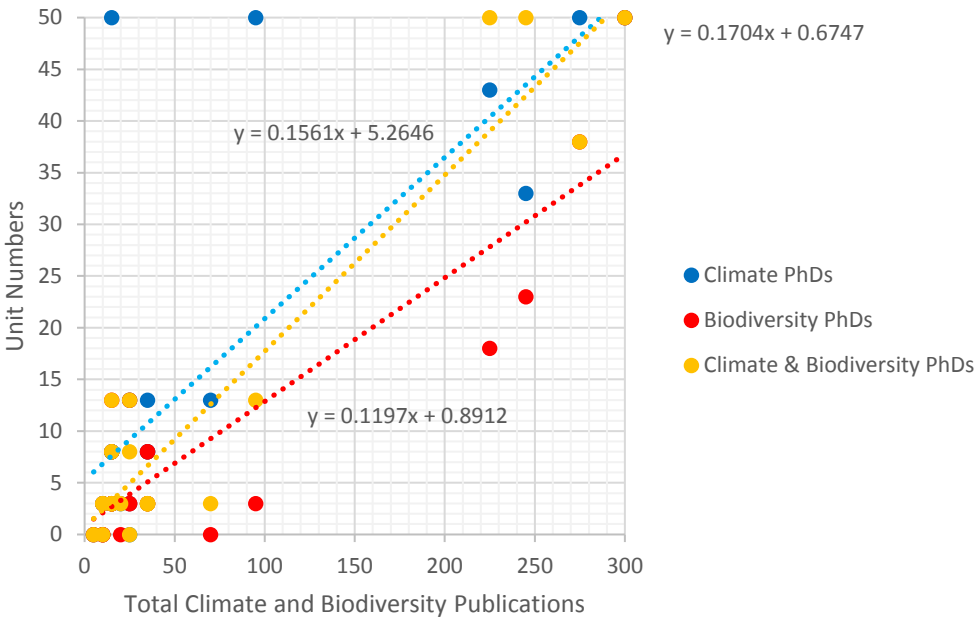


Figure 3.40 The number of PhD students studying climate, biodiversity and combined climate and biodiversity research topics versus total unit climate and biodiversity research output.

Part of the survey focused on Masters programmes provided by the respondents' institutions and how climate and/or biodiversity related topics are covered in these Masters. Figure 3.41 gives a breakdown on whether or not climate change and/or biodiversity related Masters are available in the given institutions. Over half of the institutions provide a climate change and/or biodiversity related Master's programme. The majority of these are solely climate change Masters (20%) closely followed by both biodiversity and climate change related Masters (19%). Only 6% of institutions solely provided a Masters relating to biodiversity.

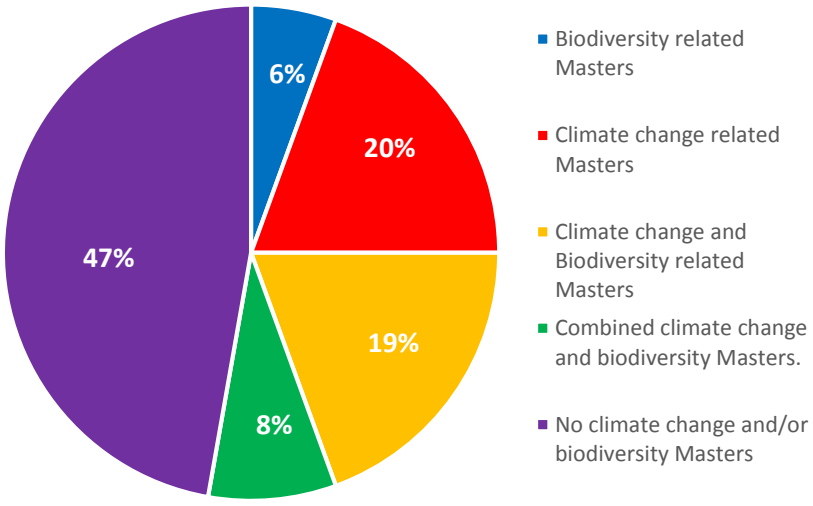


Figure 3.41 Percentage of Masters programmes provided by institutions that relate to climate and/or biodiversity.

The types of modules provided in the climate change and biodiversity related Masters programmes were also investigated to help identify those topics that may be underrepresented in such curricula (Figure 3.42). The most common module was *advanced GIS and spatial analysis* closely followed by *climate resilience*, *environment and health*, and *sustainable development*. Of

particular note is the identification of zero modules in *geo-engineering* and the limited provision of modules in *computational geophysics* and on the *economics of ecosystems and biodiversity*.

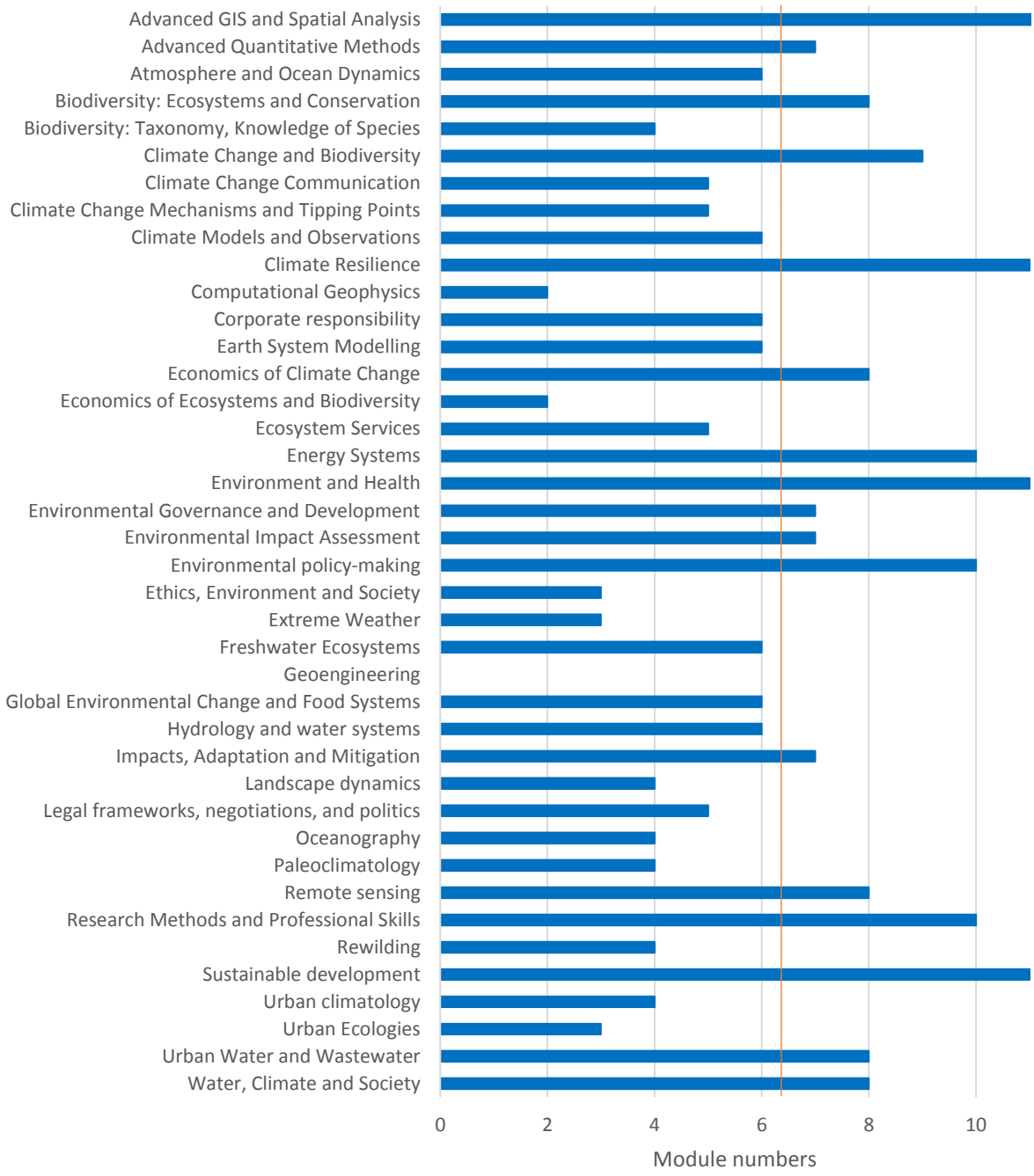


Figure 3.42 M.Sc. courses providing modules on the listed research topics (averages). The red line represents the average number of all 40 topics.

Finally, to help determine the impact climate change and biodiversity related Masters programmes have on research the impact of student numbers relating to such courses has on research output was assessed. The results of this assessment are shown in Figure 3.43 and suggest that Master's student numbers have limited impact on climate and biodiversity research output for the surveyed units.

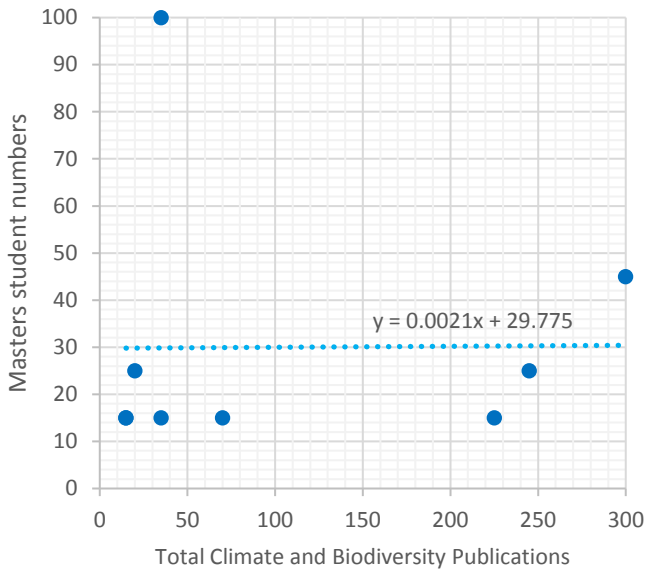


Figure 3.43 Measure of impact the number of climate and/or biodiversity student numbers has on total unit climate and biodiversity research output.

3.2.2.6 Collaborations

A percentage breakdown of unit collaborations by region in 2021 are shown in Figure 3.44. Overall the greatest amount of collaborations were with other units on the island of Ireland (24%). Collaborations within the institution, within the EU and internationally were comparatively similar (19%, 20% and 22% respectively). Of note is the relatively low amount of collaborations with the United Kingdom (only at 15%), which is particularly interesting considering the strong academic relationships between Northern Ireland and the rest of the United Kingdom.

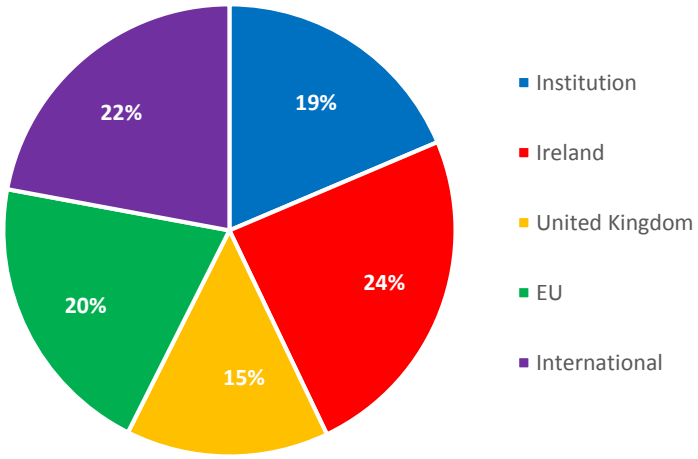


Figure 3.44 Percentage of collaborations across all units that relate to climate and/or biodiversity within the listed regions.

Figure 3.45 provides a breakdown of collaboration numbers between different regions for each of the three unit groupings; large, medium and small. Collaboration numbers are consistently greater for large units as would be expected, with ranking of importance being similar to that found in Figure 3.44. Small units outperform medium sized units in terms of total collaboration numbers within the EU, the United Kingdom and within their home institution. In all three groupings,

collaborations with the United Kingdom were lowest. The greatest proportion of collaborations with the United Kingdom are for the small group (16%), with the EU are the small group (21%) and internationally are the medium group (24%). This shows that, on average, larger units collaborate proportionately less with the United Kingdom and other international partners.

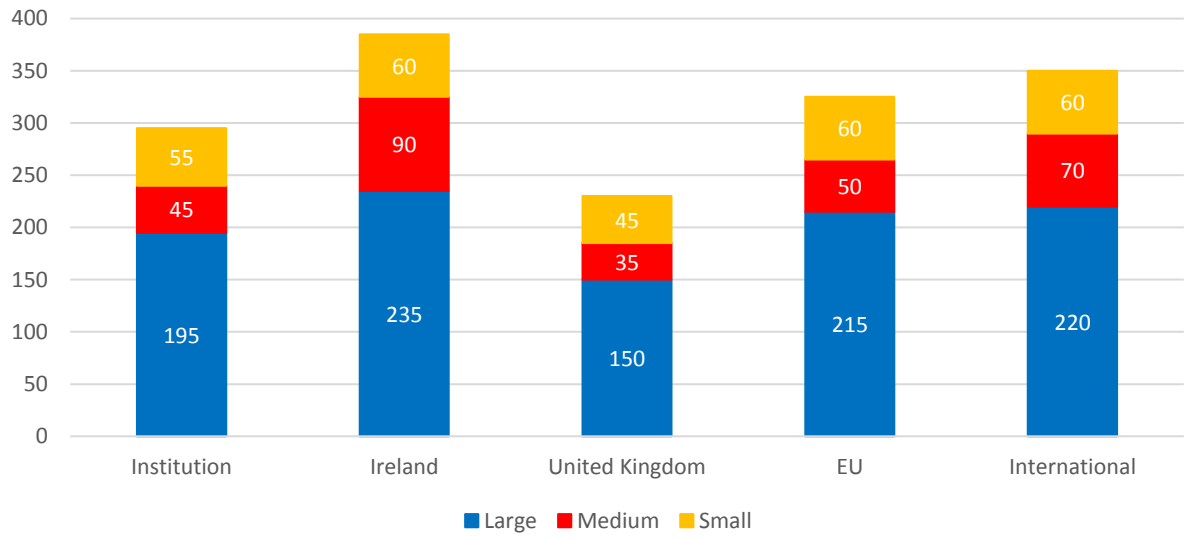


Figure 3.45 Total number of collaborations that relate to climate and/or biodiversity within the listed regions for large, medium and small units.

Figure 3.46 groups funding into three categories (with near equal numbers of units in each) and displays the total amount of international collaborations (including with the United Kingdom) for each grouping. As expected, units with larger funding amounts (> 6.5 million in 2021) consistently have the greatest collaboration numbers across categories. The greatest percentage of international collaborations per funding group is for < 1.5 million euro whilst for EU and United Kingdom collaborations it is the > 1.5 million to <6.5 million grouping. The least collaborations with the United Kingdom, the EU and other international partners is for units with the largest funding amounts (> 6.5 million euro).

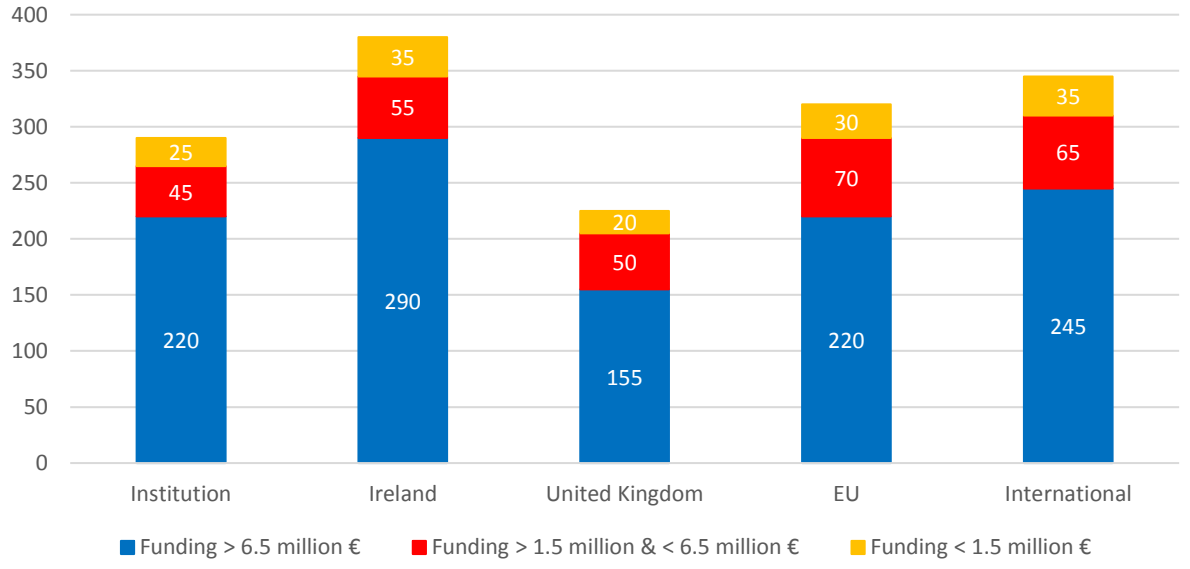


Figure 3.46 Total number of collaborations that relate to climate and/or biodiversity within the listed regions based on differing funding amounts.

The impact differing staff numbers has on research output was investigated to help identify how international research output can be increased. The findings of this analysis show that increasing staff numbers results in greater research outputs as would be expected. However, the rate of increase is regionally dependent (Figure 3.47). Collaborations across Ireland increase at a greater rate than for other international regions and particularly more so than those with the United Kingdom (1.7 times faster). These results suggest that as unit staff numbers increase the more insular research collaborations become on the island of Ireland. This may be a result of the larger units tending to be SFI research centres or associated therewith.

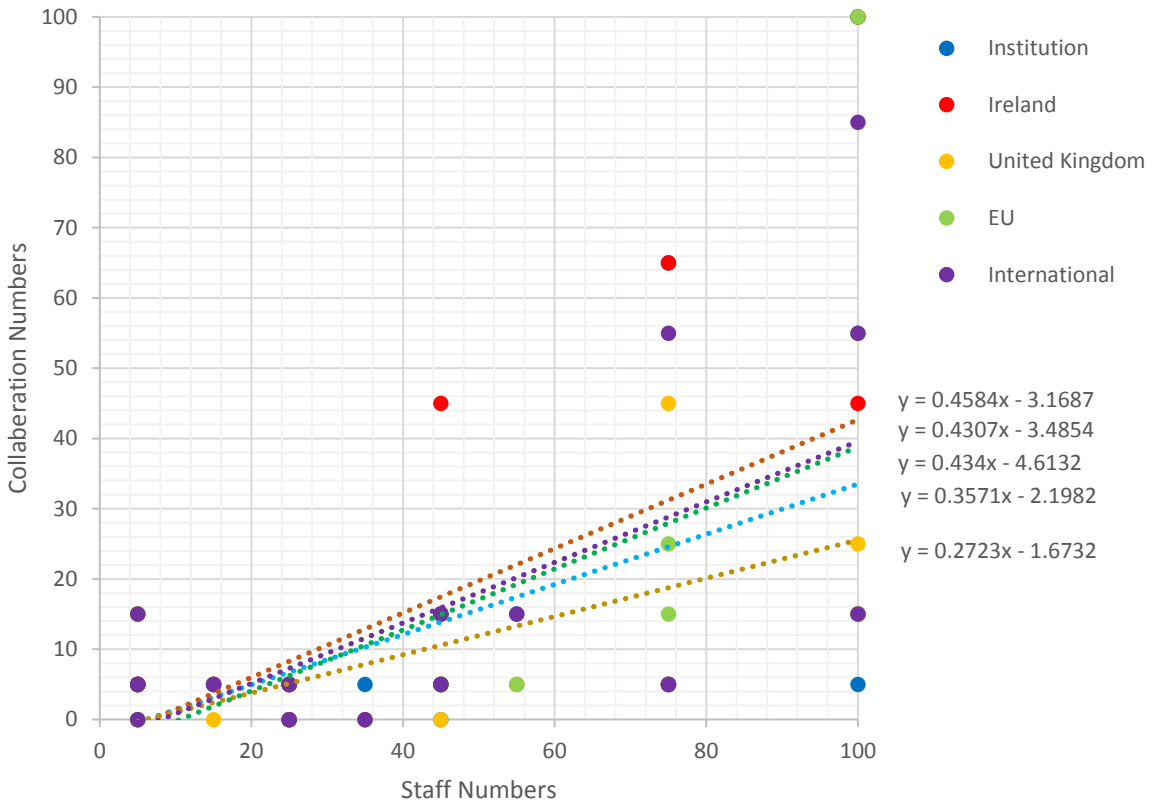


Figure 3.47 Staff numbers in each unit versus the number of climate and/or biodiversity research collaborations that occur for each of the listed regions.

3.2.2.7 Publications

The self-declared climate and biodiversity publications of units were also assessed. Note that unlike Section 3.1 this relates to the totality of publications (in 2021) and includes literature not picked up via the Web of Science search terms in 3.1. The amount of climate and biodiversity research publications being produced by units along with a comparison to related institutional output was identified (Figure 3.48). Overall, 42% of research output specifically related to climate change whilst only 25% related to biodiversity research. A greater percentage of output (33%) related to combined climate and biodiversity research showing the strong link between both topics. Of the units surveyed, climate and/or biodiversity research output only represented 7% of the relevant institutions total research. Large units produced the greatest percentage of publications (5%) whilst both medium and small units produced a considerably smaller portion (only 1%) of research. Note: non-climate and biodiversity related research outputs of large, medium and small units are not included in this plot.

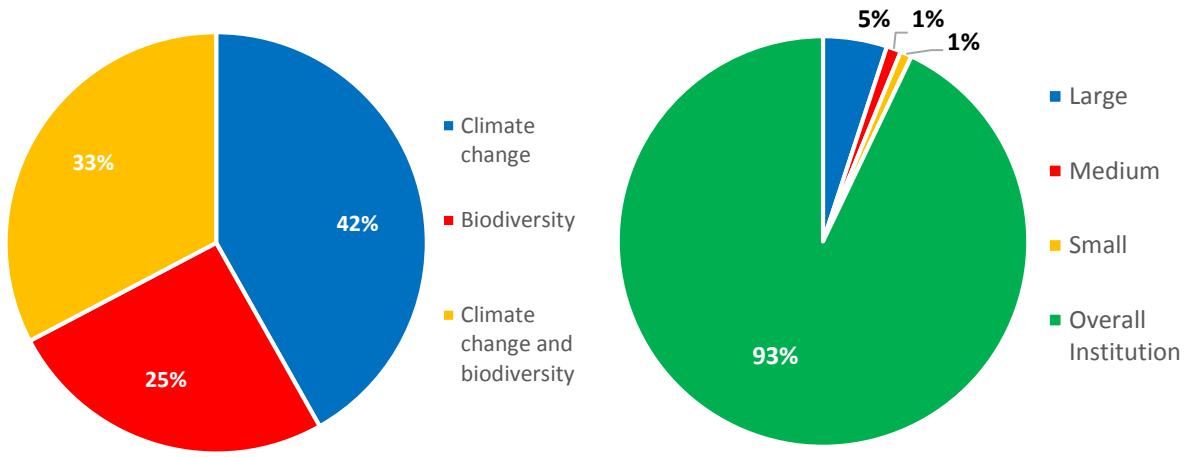


Figure 3.48 Percentage of publications across all units that relate to climate and/or biodiversity (left) and by unit size in comparison to the related institution (right).

A breakdown of the total number of climate and/or biodiversity related publications by unit size is shown in Figure 3.49. Of particular note is the considerably greater number of publications produced by larger units of > 66 staff members. Also, medium sized units of between 33 and 66 staff publish less biodiversity and combined climate change and biodiversity research output than smaller units of < 33 staff. Proportionally, however, medium sized units produce a large amount of climate change research output with it making up 67% of total climate, biodiversity and combined climate and biodiversity research outputs for that size of unit. This compares to 37% for large units and 36% for small units.

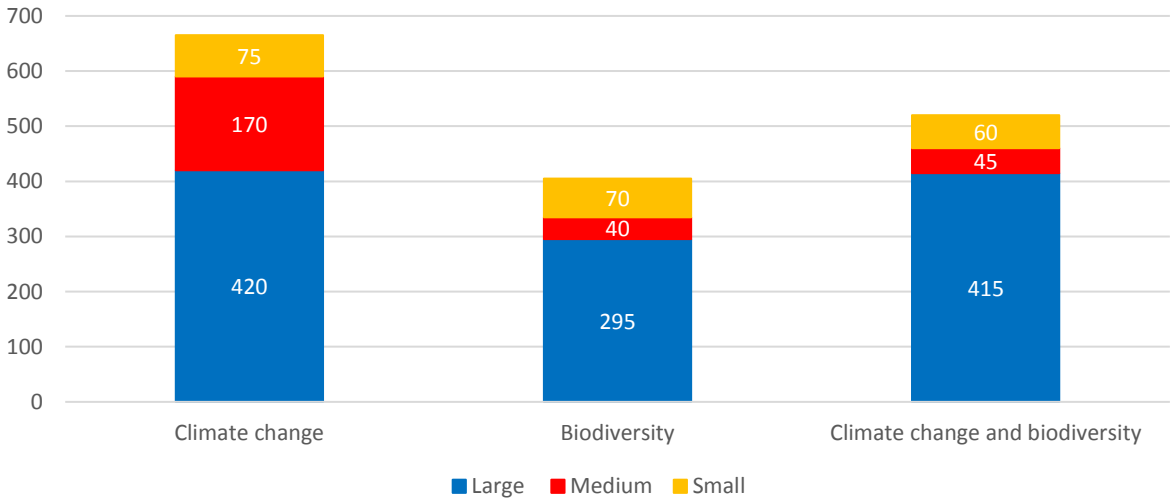


Figure 3.49 Total number of publications in 2021 that relate to climate and/or biodiversity based on unit size.

Climate and biodiversity related output from units across institutions, derived from survey submissions, was also investigated (Figure 3.50). Overall outputs from units in institutions made up approximately 7% of publications. The greatest number of climate and biodiversity research output related to the National University of Ireland, Galway which published approximately 300 articles (7% of output). Other universities generated considerably less output including Trinity College Dublin (TCD), which only had 1% of its publications relating to climate and biodiversity. It should be noted however that the survey submissions do not always represent all institutional climate and biodiversity research output which may explain TCD's low performance here. Of the

units not aligned to a single university, including Science Foundation Ireland centres, MaREI performed best with over half of their publications (> 200) relating to climate and/or biodiversity.

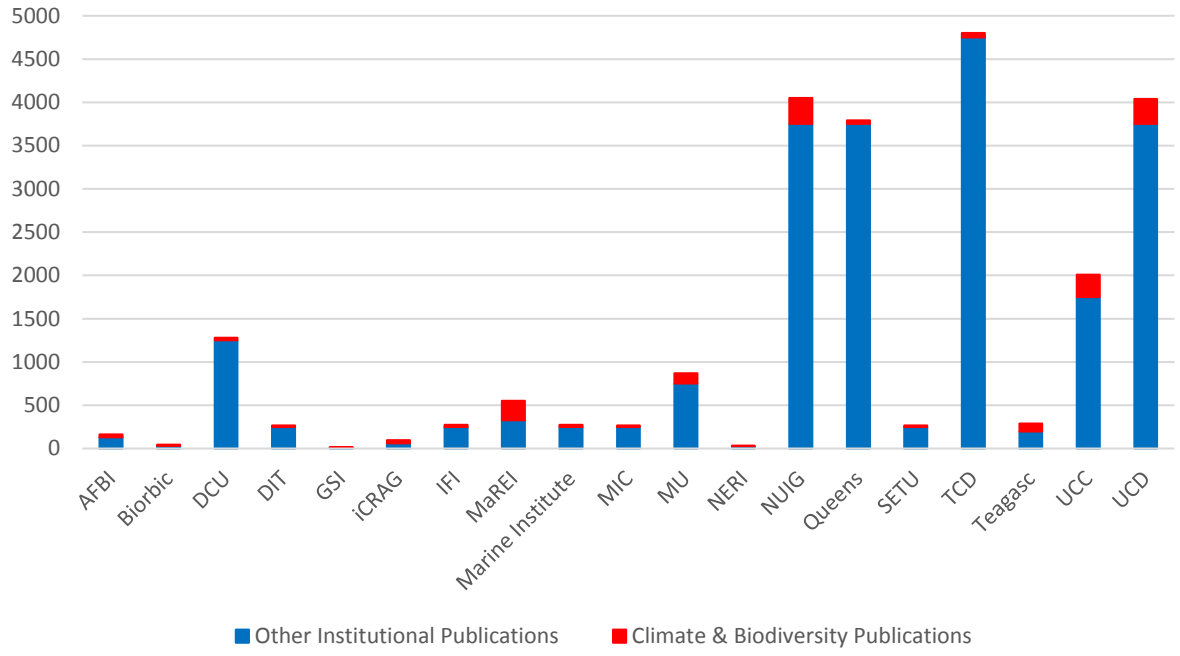


Figure 3.50 Total institutional versus unit, climate and biodiversity publications in 2021.

Figure 3.51 groups funding into three categories (with near equal number of units in each) and displays the amount of research output for each grouping. As expected, units with larger funding amounts (> 6.5 million in 2021) consistently had the greatest research output across categories. Notably however, combined climate and biodiversity and non-climate and biodiversity research output was greater for units with funding < 1.5 million euros compared to funding for bodies between 1.5 million and 6.5 million euros. For the latter grouping however a greater percentage of climate change related research was published compared to the other groupings (48% of total research vs 26% for funding > 6.5 million euros vs 26% < 1.5 million euros).

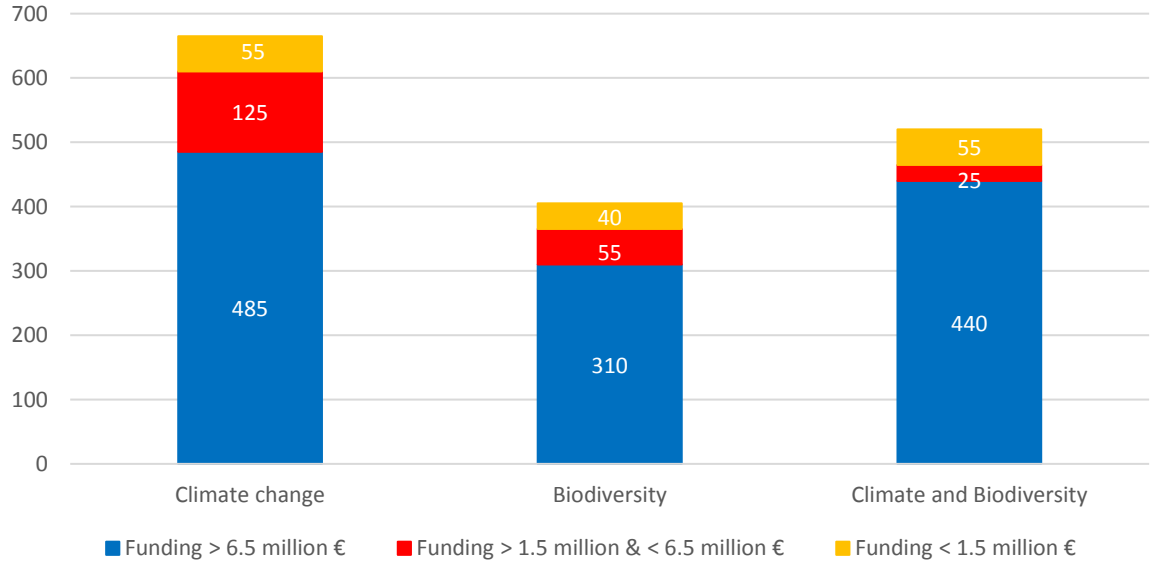


Figure 3.51 Total climate change, biodiversity, combined climate and biodiversity and non-climate and biodiversity research output by unit funding amount.

Publication output based on funder type was also investigated as part of this study with details extracted from survey responses. Figure 3.52 presents the results of this assessment with the amount of publications linked to the ranking of each of the respective funding agencies, with only ranks one, two and three included. Immediately apparent from the plot is the strong link between both Science Foundation Ireland and Horizon Europe/Horizon 2000 and climate change and biodiversity research output with the latter registering the most publications overall and the former producing the most publications from a first choice funder (in blue). The Environmental Protection Agency, the Department of Agriculture Environment and Rural Affairs and the Irish Research Council all are notably as important third most critical funding bodies.

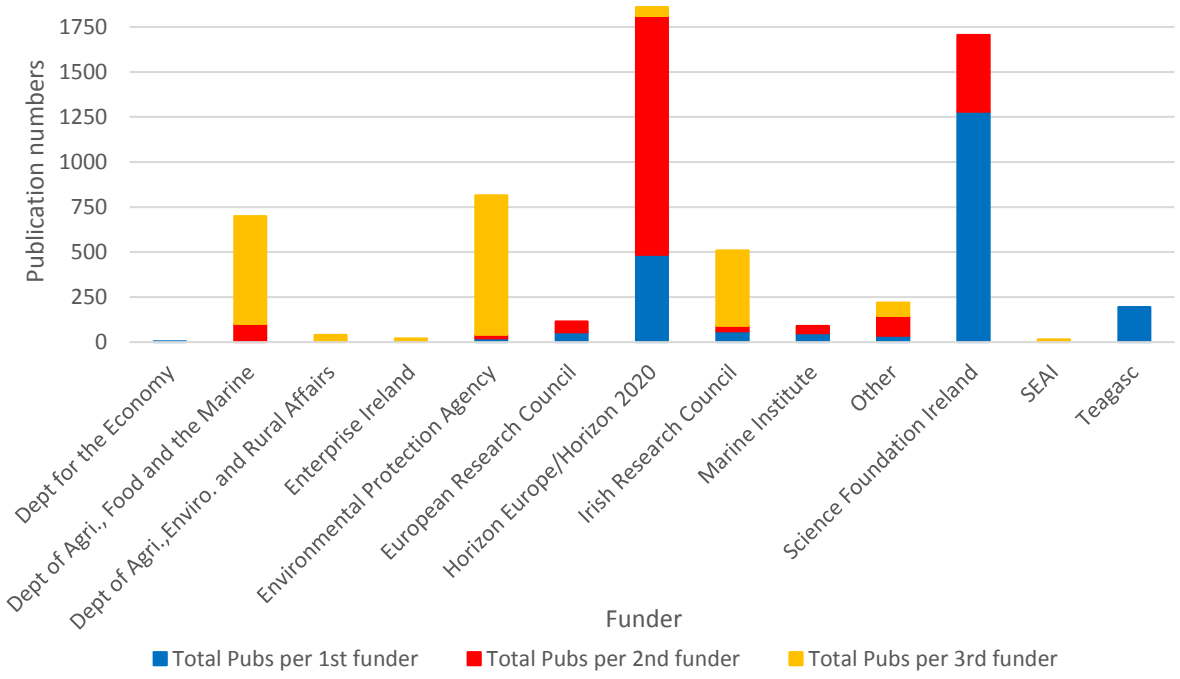


Figure 3.52 Total number of publications for units receiving funding from the top 3 funders across all related units.

3.2.3 Survey summary

The survey results have provided a good understanding of the number and type of research units on the island and related facilities. Great insight into the funding, staffing, expertise, educational, collaboration and publication outputs of these units has also been gained which has allowed for a cross examination of topics to help identify the most important aspects of climate and biodiversity research units that influence research output on the island. Whilst the data collected has been demonstrated to be highly useful it should be noted that its quality is dependent on the survey response rate and accuracy of the submitted information. This should remain front and centre in any subsequent analysis and decision making process made and will be considered further in the discussion of our findings presented in Chapter 4.

3.3 Interviews overview

Following on from the surveys, respondents were invited to take part in the interview process (see section 2.4). All commentary made in the interviews was anonymous, something that was both queried and requested on a number of occasions. As per the surveys, there were some inhomogeneities in the quality of the responses received from participants. This principally occurred as a result of some combination of delayed attendance at the online meetings, difficulties with the quality of the audio, some misunderstandings of what the purpose of the interviews was and participants not having the appropriate knowledge of the topics under discussion. The manner of conversation also differed between interviewees with some being very analogue in their responses whilst others being very descriptive, something that the semi-structured approach catered well for. Despite all of the above, the interviews were generally of a high quality with a great deal of extremely useful information garnered from the process.

3.3.1 Interview response rate

Each of the 34 survey responders were given the opportunity to take part in the interview process. Of those a total of 19 participants (56%) completed the interview process (Figure 3.53). A further 9 participants failed to respond to a follow up request to take part (26%), 3 decided not to take part (9%) and 3 submitted their survey responses at such a late stage that it excluded them from the interview process due to time constraints. It was important to include participants from a wide set of backgrounds, from different institutions, from Northern Ireland and the Republic of Ireland, from differing unit sizes and from both climate change and biodiversity research areas. All of these requirements were met in some way or form through the 19 interviews.

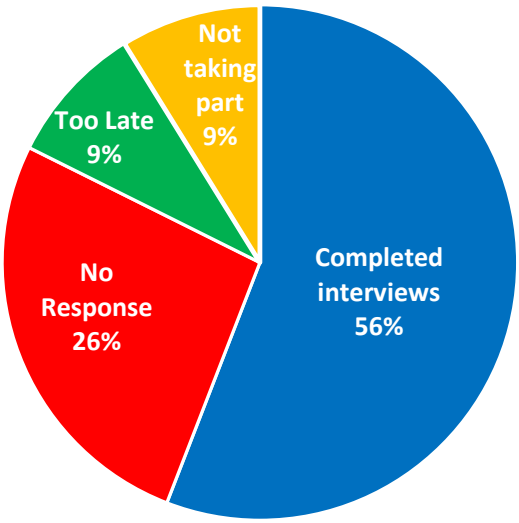


Figure 3.53 Interview response overview

3.3.2 Interview results overview

A total of nineteen interviews took place from the end of August till mid-October and were each an hour or so in duration. Table 3.3 provides an overview of the main responses received for each of the topics as outlined in Section 2.4, whilst in the following subsections a more detailed analysis of the most important points made for each topical area is given.

Table 3.3 Most common responses from the follow up interviews to surveys.

	Common Response No. 1	Common Response No. 2	Common Response No. 3
Top 3 Strengths of Unit	Large amount of collaborations	Diverse range of disciplines	Wide funding options (for SFI centres)
Top 3 Weaknesses of Unit	Unpredictable and insecure funding	Disciplines are too diverse	Equipment/lab space
Future opportunities	Increasing/strengthening expertise of unit	More collaborations	Happy with the current setup
Future risks	Sourcing funding including industry funding	Units future in university/politics	Growing administration burden/workload
Teaching & Sourcing PhDs / postdocs	Teaching is manageable	Cost of living affecting hiring/PhDs	Online teaching was beneficial
Collaborations	Strong interest in collaboration between groups/centres	Collaborations ease workload	Funding for collaborations generally supported
Required Institutional / Governmental Support	More administrative support – with funding	Problem of short term funding	More funding opportunities - collaboration / cross border
Advancing Climate and Biodiversity Research	New climate/biodiversity funding streams	Support for collaboration activities required	Biodiversity needs more attention
Top 3 Research Topics	Land use / Peatland	Marine / Ocean	Provision of baseline data

3.3.2.1 Unit strengths and weaknesses

Identifying the most important strengths of each of the units was seen as critical for building a picture of what interviewees see as valuable within their organisations. The three most common responses for unit strengths related to the large amount of collaboration work currently being undertaken within the relevant units, the diverse types of staff and researchers employed and the wide range of funding opportunities available for research. There was a general consensus in interviews that staff members were very willing to work across disciplines where possible and to collaborate with colleagues both on the island and further afield. There was also a broad recognition of the high quality expertise of staff members. Some discrepancies were identified however with some units praising the facilities, administrative support and funding available whilst others listed these as weaknesses. However, there was no clear link to unit type which accounted for these differences with the exception of positive commentary on funding mainly relating to larger units (SFI centres in particular).

By finding the most common weaknesses across units it was possible to identify options to tackle these problems therefore potentially improving the climate and biodiversity research environments in units across the island. Whilst funding opportunities had been praised in many larger units, in other smaller units access to funding and its unpredictable nature were seen as key weaknesses. The diversity of staff expertise was also seen as a problem in some units whereby core strengths were diluted by the broad range of disciplines covered by researchers within the unit. Lack of resources (equipment and lab space) were also both identified as a major weakness however these often related to smaller units. Internal conflict and politics were also seen as weaknesses with uncertainty associated with the future direction of the unit, as decided by the overarching school, department and/or institution are all feeding into this. Some of the most interesting quotations from the interview process relating to unit strengths and weaknesses can be seen in Table 3.4.

Table 3.4 List of some of the most interesting quotations relating to the interviews around the unit's strengths and weaknesses.

Strengths and Weaknesses
Strengths: • "We're highly, highly collaborative internally and externally." • "Our facilities are very, very good; we've got shared social spaces, so the option to actually collaborate between groups is a major thing." • "Our ability to do interdisciplinary research." • "We are a collaborative institute; we have these connections that are quite strong." • "Public engagement is probably the big strength; we do, like I said, hundreds of talks a year; we have expert speakers come in." • "Our scientists do work worldwide." Weaknesses: • "We're small, less than ten staff. " • "We don't have any ability to appoint staff [remains with school heads]. " • "You sometimes feel like you're chipping away and you're quite isolated within your work." • "It's very hard to get big funding; that's one of the big obstacles. " • "It's unpredictable and insecure funding. " • "The poor quality of lab space. "

- "A weakness is also probably diversity; it's a challenge because you're dealing with everyone from the lawyers to the pedagogies. "

3.3.2.2 Future opportunities and risks

Understanding what future opportunities the interviewees see for their unit helped to identify shared patterns in expectations for future directions of climate and biodiversity units across the island. The most common response to the question on future opportunities was that respondents want to expand the expertise of their units to include broader profiles of researchers. A strong desire for increasing collaborative efforts was also apparent with proposed collaborations in this instance not specifically referring to peer reviewed research but also with third parties such as local authorities to help tackle the climate and biodiversity crises at a local level. The third most common response was that the interviewees were happy with their unit in its current configuration and did not foresee any radical future changes. This response often coincided with the significant workloads of the individuals involved with it being stated a number of times that the interviewees were "maxed out".

As per future opportunities, understanding what future risks interviewees perceived for their units was recognized as being important so as to help address any potential widespread issues before their occurrence. The most common response for perceived future risks related to funding and the ability to attain funding over the medium to long term. Funding in this instance did not solely relate to that sourced from governmental agencies but also from industry. The current funding model was highlighted as being responsible for all other units of similar size being a potential threat as opposed to a potential collaborator. The second most important response received regarding potential future risks was with regard to the future strategy for the units within the overarching institution and how the unit is incorporated into those plans. In essence, the threat always exists that the unit may be shut down. Finally, the growing administration burden on researchers and associated workload was seen as a threat to the running of a number of units with the amount of time and effort required when applying for funding of particular concern. A selection of the most interesting quotations related to future opportunities and risks of units can be seen in Table 3.5.

Table 3.5 List of some of the most interesting quotations relating to the interviews around the unit's future opportunities and risks.

Future Opportunities and Risks
Future Opportunities: • "I'm happy with the group as is and the group will be maintained, but that doesn't exclude participating in other activities." • "We're planning to expand." • "There is a possibility to increase capacity to bring more collaborators into doing things." • "To increase funding for research but also lab space." • "We want to be the centre of excellence to try and drive that [humanities and social science impact] from an Irish perspective with colleagues from all across the island." • "We're very fortunate to have a president whose very committed to sustainability so we have a lot of open doors at the moment." • "There's never been such a good time to work in this area."

- "The new university strategy, means a possibly greater focus on sustainability or environmental stuff and maybe as part of that we can try and get more facilities."

Future Risks:

- "All other centres are seen as a threat in the country due to the funding model in place."
- "[Internal politics] It's probably our biggest threat."
- [Internal politics] Staff are afraid that if they mention the word politics, they may lose their jobs;
- "I would be loath to see every institution trying to be an expert in everything."
- "The threat that we will be shut down."
- "People are already maxed out with work."
- "We are constantly under pressure if we're not bringing in money, if we're not funding PhD students."
- "[Hard science and social science funding] is there going to be an equal split or again are we going to be disadvantaged."
- "There are challenges. It takes a lot of time, just the practicalities to prepare funding applications, they're very intensive."

3.3.2.3 Teaching and postgraduate commitments

It is often the case that balancing teaching responsibilities and generating high quality research conflict with each other in academic settings. To assess how this impacts the climate and biodiversity research interviewees were asked how their own and their colleague's research is impacted. The most common response to this question was that the interviewees were happy with their teaching workload with many in fact saying it was an important and beneficial part of their work. There was an acknowledgement however that administrative duties associated with teaching are an excessive burden on researchers. The second most highlighted issue regarding teaching and postgraduate commitments related to the hiring of PhDs (and Postdocs) and the very real effect the cost of living crisis is having in this area. Many interviewees stated that they were losing high quality potential international PhDs due to the high rent prices with Dublin based units most impacted. They suggested that greater funding was required for PhDs to address this issue. The third most raised point was regarding teaching methods and online teaching in particular with many disappointed that online teaching has been scaled back with a strong move towards face to face learning. As per the other topics, the most interesting quotations comments by interviewees is provided in Table 3.6.

Table 3.6 List of some of the most interesting quotations relating to the discussions around the unit's teaching and postgraduate commitments.

Teaching and Postgraduates
Teaching: • "I love the teaching. That's why I probably do the job." • "Research is the lifeblood of teaching." • "Teaching in your area, or even you know more broadly, is very good for sparking ideas." • "If my teaching load was any heavier than it is now, it would be too much." • "Teaching roles can be kind of costly in terms of time." • "Staff may want to be completely brought out of teaching and that's not always possible."

- "On new researchers: I really feel for these guys because they are still given this savage workload."
- "[Regarding online teaching] I could spend Monday and Tuesday recording a full block of two or three weeks' worth of lectures, and it really enabled me to focus on research."
- "We've pivoted back to a total face to face learning where we should be still keeping a little bit of online."
- "I often think the academics that are successful in research, are successful in spite of the system and in spite of having been given very large teaching hours."
- "Teaching physical hours in front of students, no, not a problem, most of us enjoy that, you know, but it's the administration and bureaucracy around that."

Postgraduates:

- "The Masters is very useful for bringing through students."
- "The amount [funding] that PhD students are given you know it's a big ask to try and manage."
- "The cost of living crisis, that's really affected our recruitment of PhD students; my PhD students aren't able to live on the stipends."
- "The question about what happens post PhD; there's no guaranteed sort of progression and so those pathways I think are equally important."
- "[Cost of living/accommodation] it's a huge problem, especially for PhD students at the moment."
- "[On supporting PhDs] They were already at the edge of what they could afford and now it's completely unattainable; it's going to change our PhD student profile massively and reduce the pool from which we can pull applicants."
- "It can be quite hard to fill postdoctoral positions; hard to get people, to retain people."
- "Dublin is so expensive; we've had to try and hire several people [postdocs] there in the last two years and we've lost several of our best candidates for exactly the same reason."

3.3.2.4 Potential for collaboration

One of the main findings of our analysis of climate change and biodiversity related research on the island of Ireland was that research output is low and that this is possibly linked to fewer collaborations overall compared to other similar sized countries. Survey results also show signs of more insular collaborative activities across the island, particularly in better funded, larger units. To assess this further interviewees were asked what their thoughts were on research collaborations and how they could be improved on the island of Ireland. Overarching support for collaboration activities was identifiable in almost all interviews with particular emphasis on potential collaborations with other "centres of excellence" on the island. However, few comments were made on potential future collaborations with international partners. The overall benefits of collaboration were the second most raised point with the sharing of administrative burdens associated with obtaining funding for collaborations seen as a major motivator for taking part in such activities. It was highlighted that, despite the goodwill, getting funding for collaboration efforts was still very difficult with strong competition particularly for European funding. The third most raised point was the overall strong support for targeted funding for those taking part in collaborative climate and biodiversity research activities, particularly so for initiatives that would encourage researchers in the Republic of Ireland and Northern Ireland to work together. It was noted however that "perverse incentives" must not arise from such activities that may take away

from the overall research goals. Quotations relevant to all the points raised above can be found in Table 3.7.

Table 3.7 List of some of most interesting quotations relating to the discussions around the unit's potential for future collaborations.

Potential for Collaboration
Overall: • "I think there's enormous goodwill within the community to work together." • "Bringing together people who are focused on, say, biodiversity and from lots of different perspectives, could be something really rich and valuable." • "Often you're in competition rather than collaboration." • "Collaborations I find worthwhile when you have a partner who will take those administrative burdens." • "If one is collaborating it shares the workload." • "[On linking collaborations to funding] you have to be careful that perverse incentives don't arise; when you're including institutions just for the sake of filling criteria, rather than actually a really good functional reason." Collaborations: • "Linking funding between north and south collaboration research is important and needs to be funded more." • "[On cross border collaboration] more coordination would be helpful; having some more administrative means of grouping those together would be helpful." • "Climate change or biodiversity; these are shared island issues regardless of your perspective." • "In ecological terms it doesn't really make sense to talk about the island of Ireland in terms of particular jurisdictions" • "We would be very much interested in community engagement." • "I don't understand why there's not more collaboration between local authorities who have these really pressing problems in the cities and counties." • "The ability to use facilities of other institutes is of great benefit." • "I have had smaller centres saying that it would be great to be able to collaborate through use of the facilities within institutions."

3.3.2.5 Required institutional and governmental supports

The actions institutions, governmental agencies and the government as a whole could make to help increase climate and biodiversity research output from each of the interviewee's units was also raised in each interview. The most common response related to administrative support for climate and biodiversity related research activities and the provision of greater support, particularly in relation to funding applications, which were found to take excessive amounts of time to complete with no guarantee of success. A strong desire for the streamlining of application processes for grants was evident with the hope of reducing the ask on overburdened researchers in terms of time spent on applications as well as reporting requirements. The second most raised issue related to short term funding and the difficulties that these grants cause, in terms of time spent on writing applications and the negatives of short term awards (of one year or less). Longer term funding awards were seen as much more desirable with an option to extend the grant being seen as important, particularly in some biodiversity related studies. The third most suggested

action was for increases in funding opportunities, particularly to encourage greater collaboration across the island of Ireland and with the United Kingdom. An emphasis was also put on helping early career scientists more with targeted funding, increased funding for PhDs and also the provision of funding that encourages collaborations between researchers and regional authorities. Some of the most interesting quotations relating to required institutional / governmental support can be seen in Table 3.8.

Table 3.8 List of some of most interesting quotations relating to the discussions around required institutional and governmental support.

Required Institutional / Governmental Supports
Institutional: • "We're the best paid secretaries in the universe. You pay somebody at a professorial rate to fill in forms and organise meetings; it's not an efficient use of time." • "The assignment of an administrative assistant; that would be a huge help." • "For getting into horizon funding and stuff like that; I think for that one needs to have a lot of time available to get on the ground, go to the brokerage events, do the networking; institutional support would be good." Governmental: • "If the Irish Government is really serious about funding biodiversity and climate change, they need a dedicated funding stream there." • "Streamlining the application process for grants and in particular the reporting process would help a lot." • "It would have been cheaper, open and more effective to just give everyone an equal piece of the funding." • "They should be giving us fixed funding that can be used and obviously monitor and make sure they're getting value for money." • "I think a lot of academics and researchers are really put off the [funding] application process." • "Lots of the grants these days are for like, one year, especially with industry as well. Sometimes they look like a six month postdoc and it's horrible for everybody involved." • "I would like, for example, technological universities to have block grant allocations dedicated to research." • "It would be great if a few, you know, if future dedicated funding streams could have built in requirements for someone from the humanities and social sciences."

3.3.2.6 Advancing climate and biodiversity research

Finding a means to advance climate and biodiversity research on the island of Ireland was one of the primary motives behind this study and in that regard the question was posed to interviewees on how to achieve this. The most common response was that new funding streams were required that specifically relate to climate and biodiversity related research topics. Furthermore, many stated that such funding streams needed to be less prescriptive (broader in scope) and require more engagement with the scientific community. The second most highlighted means for advancing climate and biodiversity research on the island related to encouraging collaboration. As well as dedicated funding streams, including for cross border initiatives, the governments north and south need to encourage and fund international conferences, stakeholder forms and other means of linking like-minded people together including networks such as the AICBRN. The third

most raised issue related to the deficiency of biodiversity related research on the island and the lack of funding supporting topics in this area. An emphasis was made on providing additional funding to encourage more biodiversity research with the provision of a dedicated funding stream being paramount. The common thinking was that biodiversity was undervalued due to the perceived lack of economic value.

Finally, it is worth highlighting that the provision of a new all-island centre specifically focused on climate change and biodiversity research topics was raised multiple times as part of this topic. Support for such a project between interviewees was mixed. The vast majority acknowledged that such a centre would most likely improve climate and biodiversity research output with some very keen to be part of such a project. However, others raised concerns for established units who may be side-lined in terms of funding and collaborative opportunities as a result of the establishment of such a centre. A virtual centre promoting collaborations between climate and biodiversity units already in place on the island was seen as a possible compromise in relation to this suggestion. An overview of the best comments made on advancing climate and biodiversity research including commentary on the proposed centre can be seen in Table 3.9.

Table 3.9 List of some of the most interesting quotations relating to the discussions around advancing climate change and biodiversity research on the island of Ireland.

Advancing Climate and Biodiversity Research
Overall: • "We fund things that are very insular, that are very short term, that are very small." • "It doesn't make sense for a small country to be so competitive; it should be set up to collaborate as opposed to fight for funding." • "A more open and transparent system of science, policy, interaction and dialogue is required." • "Climate and biodiversity has been paid lip service to for far too long." • "We can't be in silos anymore, especially if we argue the climate change and loss of biodiversity is absolutely the global challenge; we need to use our skillsets to try and find ways to help solve those problems." • "I think they should trust the research community a bit more; use their creativity and the ideas they have and all that knowledge to solve some of these challenges." • "Climate research in some ways isn't always immediately economically relevant." • "I think some more strategic thinking and maybe more engagement with the scientific community about where the real needs are is needed." Collaborations & funding: • "The government needs to put together stakeholder forums; there's a lot of learning that could be shared, a lot of common problems." • "One of the things that should be done is figure out ways and clever ways for fairs, workshops, conferences to get people to actually physically come together and understand what people are doing right and get people excited." • "I think that broader funding mechanisms are necessary that enable academics to use their imaginations and their creativity and their intellect to find pathways and solutions; that is really essential." • "On funding applications: they give you like a month or a month and a half … I don't think that's enough. Every call should be at least three or four months open and say give time to people to get themselves organised." Biodiversity:

- "I think we are too focused on climate, what about biodiversity?"
- "Biodiversity is certainly the 'poor cousin' in the Irish context; the benefits that biodiversity brings us to human health and well-being are not valued."
- "Biodiversity doesn't bring in the headlines that climate change does; I guess that's why it's funding has lagged behind it."
- "Hard science always gets funding; it's always about the economic imperative."

Climate and biodiversity centre:

- "I could imagine that maybe something which came in which was attempting to capture everything, runs the risk of treading on toes and not necessarily bringing people together."
- "I think it's a good idea. There is a need for a centre that can focus research in climate and biodiversity. A place a forum where research is discussed, where we can see what will be the future, what are the challenges."
- "A climate centre for the country in some ways would be great; administratively trying to do all those centres under one administrative umbrella."

3.3.2.7 Important climate and biodiversity research topics

The final question asked of interviewees related to what three topics in climate and biodiversity they believed should be considered a priority for future research. Whilst acknowledging a degree of bias in responses there was surprising agreement across interviewees. Overall, research on land use, including soils and peatland management, was seen as a priority, particularly considering peatland is seen as such a huge resource or potentially massive liability if not managed properly in the context of Ireland and its emission reduction targets. Marine research was noted as the second most important research topic specifically in connection to wind and wave energy development along with marine and related coastal ecosystems research. The third most important research topic related to baseline data and the continuous long term monitoring of such data, something that a number of interviewees stated was lacking on the island of Ireland. Finally, it is worth highlighting that the topics of food supply systems and carbon emissions from food production were both seen as requiring deeper research particularly considering the importance of the livestock industry in the context of Ireland. Interesting quotations relating to the most important research topics identified above are provided in Table 3.10.

Table 3.10 List of some of most interesting quotations relating to the discussions around staff teaching requirements and attracting postgraduates.

Important Climate and Biodiversity Research Topics
• "I'd like to see something around land use; how we can manage it economically, environmentally, socially." • "The calculation as to how the land use and economy and emissions tie up together is a huge research question." • "Our peat bogs are a huge, huge resource and a potential a massive liability if not managed properly." • "It's a speciality environment [peatlands], nobody else is going to do the research. We really have to lead the world and to get this right." • "The marine and coastal environment is completely under looked at the moment in terms of the climate change agenda and the biodiversity agenda." • "Monitoring both our onshore and offshore to understand presently what's happening with the climate is really, really important."

- "I'm a great believer in the continuous need to know where our baseline is to have people out in the ground there to have scientists trying to do the field work, in terms of environment or biodiversity or greenhouse gas emissions or water quality."
- "[Long term monitoring sites] there isn't really a good network of sites around the country."

3.3.3 Interview summary

Overall, the interviews were found to be an extremely useful means of finding qualitative information on the units carrying out climate change and biodiversity research on the island of Ireland. They also provided a broad holistic view of the climate change and biodiversity research environment on the island and helped identify the most important positive and negative aspects of this. The overriding perception arising from conversations was that there is a strong desire to carry out meaningful research and form strong progressive collaborations with like-minded colleagues in order to help address the climate change and biodiversity crises. Some of the most important actions required by both governmental and the units' parent institutions, to address identifiable shortcomings in current systems, were identified through the interview process, the most significant of which have been noted above. These suggestions along with an analysis of how they tie in to the quantitative results of the respondent's surveys are discussed in more detail in the next section.

Chapter 4 | Discussion and recommendations

4.1 Project summary

This study has generated new insights into climate and biodiversity research on the island of Ireland by: i) analysing historical records of climate and biodiversity research output; ii) carrying out a comprehensive quantitative assessment of unit structures and outputs, by means of the online survey; and iii) extracting important qualitative data on the overall climate and biodiversity research environment across the island of Ireland using semi-structured interviews. In particular this study has created a broader understanding of key characteristics of some of the most important units carrying out such research and provides some perspectives on what is helping and hindering climate and biodiversity research output on the island. This chapter aims to bring together the results obtained from these individual methodologies, outlining how they addressed the research aims and objectives, how the findings relate to each other and in the process derive a list of 26 evidence based recommendations as to how to improve research in the areas of climate change and biodiversity on the island.

4.2 Achieved objectives

The study was built around achieving five key objectives that address the overall aim of creating a better understanding of the climate and biodiversity research landscape on the island of Ireland and to assess the island's overall performance internationally in terms of climate and biodiversity research output. Here we list each of the key objectives and provide some brief background details on how each objective was met.

Objective 1. Identify key peer reviewed climate change and biodiversity research outputs from institutes across Ireland and analyse these outputs: By employing the Web of Science online research publication database, search terms relating to climate change and biodiversity and appropriate search filters it was possible to extract data relating to the world, the island of Ireland, Scotland and Denmark. These data were compared and contrasted to help identify the performance of the island compared to the other jurisdictions. Results showing the poor performance of the island compared to Scotland and Denmark justified the subsequent detailed assessment undertaken in this study.

Objective 2. Categorise and compare all-island research outputs to international numbers as well as some select European countries with similar population sizes to the island of Ireland: Carrying out a deeper analysis of what areas of research the island of Ireland excels in and what areas require further attention was also an important part of the publication analysis process. Using the available filters, provided on the Web of Science portal, it was possible to extract details on climate and biodiversity related research categories for the world, the island of Ireland and also for Scotland and Denmark. Again these data were compared and contrasted to help identify those categories in which the island of Ireland performed poorly in.

Objective 3. Find quantitative information on funding, expertise, staff, education, teaching, collaborations and publication numbers for climate and biodiversity units across the island of Ireland: Extracting some basic quantitative values relating to climate and biodiversity research units across the island of Ireland was seen as a fundamental component of the study as such information could be used to numerically compare performances of units across the island and in the process identify the strengths and weaknesses of each unit and how they relate to research

output. This information was derived from surveys which in this instance proved to be an extremely useful tool, gathering great insights into the 34 units that took part.

Objective 4. Identify the key strengths and weaknesses of climate and biodiversity research units across the island of Ireland: Whilst the surveys were extremely useful for categorising unit characteristics numerically they failed to find specific underlying issues that may be impacting units' performances and consequently climate and biodiversity research outputs. They also failed to identify potential future opportunities and risks relating to units but also more broadly across the climate and biodiversity research community. Semi-structured interviews were identified as the best means to extract this important information and were employed to great success in this study. The information derived from the interviews was possibly the most important part of the study with the quotes alone (see Sections 3.3.2.1 to 3.3.2.7) providing great insight into the thinking of interviewees with respect to their own units and the overall climate and biodiversity research environment on the island.

Objective 5. Make recommendations that would improve the climate change and biodiversity research environment on the island of Ireland: Having identified the overall performance of Ireland internationally, in respect of climate change and biodiversity publication outputs, and having carried out a more in-depth assessment of the performance of related climate change and biodiversity research units, through both surveys and interviews, a large amount of important information was derived. This information was subsequently employed to justify the making of a number of recommendations on what actions are required by governmental and institutional bodies to help address the large deficit in climate change and biodiversity research outputs on the island. A full breakdown of the 26 suggested recommendations can be found in Section 4.4.

4.3 Summary of findings:

4.3.1 Identifying climate and biodiversity research output

The analysis of climate change and biodiversity publications has resulted in new insights into how authors on the island of Ireland have contributed to research on the topics over the last 31 years. Compared to worldwide outputs the island has performed strongly based on population numbers, increasing from 0 to 0.9% over the period for both climate and biodiversity research (compared to 0.09% of worldwide population). However, concerning signs of a slowdown in growth are evident with little change in climate change publication numbers since 2006 and a decrease in the share of biodiversity output since 2014. Furthermore, when compared to other, smaller populated nations in Europe, i.e. Scotland and Denmark, the island has been shown to underperform considerably with two times less climate and biodiversity output on average. This finding should be a cause for concern for researchers in this area as in essence Ireland produces less than half the research output of these neighbouring nations despite having a greater population. Interestingly, the ratio between the Republic and Northern Ireland research output is quite close to those for population numbers (population: 5 million vs 1.9 million; climate change output: 1518 versus 581; for biodiversity: 795 versus 252) suggesting that the deficit in publication outputs is an island wide problem. There is evidence that the island of Ireland is performing better in recent years, with the rate of change in publications from Irish authors more on a par with Scotland and Denmark. However, there still remains a large gap between Irish output and that of our European colleagues which will take time to close, even with remedial actions.

Details regarding the type of climate and biodiversity research output were found from our analysis of Web of Science categories. Ireland failing to produce any published research in 50 climate change and 102 biodiversity related categories on Web of Science highlights considerable potential gaps in the research environment on the island. Furthermore, of the 30 most important global categories for climate and biodiversity research topics the island of Ireland consistently produced a lower percentage of articles compared to Scotland and Denmark (with the exception of *oceanography* and *soil science*). Of the most important worldwide climate categories, Ireland performs particularly well in *agriculture dairy animal science* with approximately 2% of worldwide output. However, publications related to this category are still outnumbered by Scottish outputs. For the equivalent biodiversity categories, Ireland performs well in *marine freshwater biology* with approximately 1.7% of worldwide output. However, this figure is still surpassed by both Scotland and Denmark. In terms of poorly performing output from the island that are of significant importance worldwide, *remote sensing* research for climate change related topics and *plant sciences* for biodiversity related topics stand out. Again Scotland and Denmark outperform the island of Ireland in these categories, by a factor of three times for *plant sciences* in the case of Scotland. Of the top 30 categories, the island of Ireland only publishes 17% of climate and 18% of biodiversity articles produced by Ireland, Scotland and Denmark combined, despite having a greater population than these other regions. The only positive to take from this part of the assessment is that Ireland excels in *film radio television*, *ethnic studies* and *language linguistics* in terms of climate related output and *literature*, *computer science engineering* and *rehabilitation* in terms of biodiversity related output. However, these are minor categories overall based on worldwide numbers. Finally, it is worth highlighting the poor performance of Ireland in *meteorology atmospheric sciences* (0.62% of worldwide climate change related output), with both Scotland and Denmark producing over twice the volume of these publications. This is of particular interest considering it is a fundamental aspect of climate change and relates strongly to impacts occurring on the island.

The findings above raise questions as to why the island underperforms in climate and biodiversity research. In terms of academic institutions, which are the source of the vast majority of climate and biodiversity research output, there are nine universities on the island of Ireland in total with Queen's University being the greatest producers/collaborators of such research followed closely by University College Dublin and Trinity College Dublin. In comparison, Scotland has 15 universities, which may offer some explanation as to the differences between both regions. However, Denmark, who often has twice the research output of Ireland, has only seven universities, equal to that of the Republic, which suggests other reasons are behind the difference. Whilst total research output from the island of Ireland is generally smaller than that from Scotland and Denmark (Ireland had 28,122 publications in 2021 compared to 32,980 for Scotland and 37,136 Denmark; as per Web of Science) the relative differences between values is a lot greater for climate and biodiversity outputs. For example, total climate change publication output in 2021 was 312 for the island of Ireland, 461 for Scotland and 504 for Denmark, with Ireland producing 68% of Scotland's and 62% of Denmark's publication numbers. That compares to 85% of Scotland's and 76% of Denmark's total publication numbers. For biodiversity, total output was 114 for the island of Ireland, 259 for Scotland and 221 for Denmark in 2021 with Ireland producing 44% of Scotland's and 52% of Denmark's total publication numbers. So despite the overall lower publication numbers (of all types), climate change research is notably underrepresented in island of Ireland research output and biodiversity research is severely underrepresented.

A likely explanation for the differences in research outputs relates to research funding and the funding models employed by the different countries/territories. The United Kingdom has been

identified as world leading when it comes to climate change and biodiversity research, however the most funded institutions appear to be in Great Britain. Scotland's University of Edinburgh, for example, has been identified as second best funded university in the world over the 1990-2020 period for social science energy and climate research (AbdulRafiu *et al.*, 2022) so is likely to perform extremely well in terms of research output. In that same study Aalborg University in Denmark was also found to be within the top 20 universities worldwide suggesting a high degree of climate research funding in that country. Hook *et al.* (2017) suggest that despite its small population Denmark has historically spent a considerable portion of national funding on research grants for climate change. Furthermore a large proportion of research funding for Danish universities comes from unconventional non-governmental sources including commercial foundations, traditional non-profits, independent foundations, fundraising and patient advocacy charities with natural and life sciences benefiting most (Lindorf, M., 2012), which undoubtedly positively impacts biodiversity publication numbers there. Whilst funding is likely the most important issue impacting Irish research outputs, legacy issues, teaching duties, staff numbers and expertise all have an influence. For this reason the employing of surveys and subsequent interviews of units generating climate and biodiversity related research in this study was of critical importance in helping to identify the reasons why the island performs so poorly and to find pathways to address these deficits.

4.3.2 Survey responses

Surveys of units producing climate and biodiversity research helped identify deficiencies in the all island research environment that are impeding research and were used as a means to ascertain how best to improve outputs. Quantitative information, relating to each of the units' backgrounds, facilities, expertise, funding details, staff numbers, educational commitments, collaborations and publication output, was extracted for each unit. As well as helping to determine topics for discussion in the follow up interviews, this information was used to help inform and justify overall recommendations. Of the 92 units identified as carrying out some degree of climate change and biodiversity related research on the island, 34 took part resulting in a submission rate of approximately 37%. Whilst this compares favourably to typical survey response rates a higher rate would have been desirable. Particularly as this means that the survey failed to pick up all available research facilities across the island along with all expertise that researchers excel in. One means to address this in future studies would be the development of a centralised database of all climate change and biodiversity units on the island of Ireland, which could be regularly updated to keep track of changes. The differing quality of the 34 survey responses should also be noted with some only supplying bare minimum details. The vast majority however completed the survey in its entirety attempting to answer all questions. Unit responses were compared for each of the survey sections when available. The quality of the responses remains somewhat indeterminable. However, as the option to leave a question blank was available to the respondents we would have confidence in the figures and findings derived for each.

The background assessment of each of the units in the survey provided very useful information on the overall amount of research being carried out in the units across the island, with approximately 16% of such units carrying out climate change and biodiversity research. Of these, 68% had access to research facilities with those being identified and listed in Table 3.1. Table 3.2 listed the facilities that were required by institutions. Whilst long term such facilities should be provided to the relevant units in the short term there exists the potential for collaboration between units to access such facilities. One of the findings of the analysis of the climate and biodiversity research output

was the consistently lower output of biodiversity compared to climate change research on the island (by a factor of 2:1). Survey responses also show that climate related research units dominate making up 45% of units compared to biodiversity at 27%. This was one of the first indications of systemic underinvestment in biodiversity research on the island. Whilst all unit sizes work more on climate change related topics a much greater proportion of biodiversity research (versus climate research) is carried out by smaller units (of < 33 staff) compared to larger units. This shows that biodiversity is potentially underrepresented in larger research units and that at this time smaller units have a more balanced approach to climate and biodiversity research. In terms of expertise, *adaptation*, *sustainability* and *water* were the most researched areas whilst *vector ecology*, *extinction* and *meteorology* were the least. The fact that biodiversity related topics generally fell in the lower categories as opposed to climate change topics highlights an apparent lack of researchers in this area and again highlights the poorer position of biodiversity research on the island. Of the climate change topics, *meteorology* is the most underrepresented in terms of climate change expertise and confirms findings from the publication assessment which identified *meteorology, atmospheric sciences* as a category which the island performs poorly in. Whilst Met Éireann has carried out significant research into meteorological related topics over the decades it is apparent that climate change related research has been lacking and is something that requires addressing.

Climate change and biodiversity related unit funding equated to approximately 10% of overall institutional funding for units assessed in this study with half of this going to larger units, mostly linked to universities. Smaller universities had notably less funding, as did smaller units (only 10% of climate and biodiversity unit funding). Furthermore smaller units spent proportionally more funding on climate and biodiversity research but this was mainly due to them being specialists in specific areas. Interestingly, smaller units (< 33 staff) relied heavily on < 0.5 million grants which more likely relate to PhDs stipends and short term postdoc contracts provided by the *Irish Research Council* and *other* funding sources. Bigger units availed of the larger grants (of up to > 5 million) provided by *Science Foundation Ireland* and *Horizon Europe/Horizon 2020.* For medium sized units (> 33 and < 66 staff) the *Environmental Protection Agency* was most important. The *Department of Agriculture, Food and the Marine* had the most balanced funding model in terms of allocations to different sized units suggesting their approach could be used as a template for others to follow. One finding of particular note is that increasing funding amounts to large established units produce greater research outputs compared to those from smaller sized units. This would suggest that targeted funding to such units is the most economical approach to generating more climate and biodiversity research outputs.

Staff numbers and how they related to research output was an important element in the survey, particularly as they were used as a precursor for measuring unit size and the overall importance of units in generating climate and biodiversity research. Across the institutions large climate and biodiversity related units represented 5% of total research staff, medium sized units represented 4% and small units represented 1%, matching equivalent figures for funding. This findings highlights the underfunding and staffing of smaller units and suggests that targeted supports are required for this grouping. Once again biodiversity related research was underrepresented within staff numbers with one third typically researching biodiversity compared to two thirds researching climate change. As was found for funding, smaller units had proportionally more biodiversity staff compared to medium and large units showing the importance of biodiversity research in smaller units along with the strong biases toward climate change research in larger units. As expected, large units consistently had the greatest number of staff per staff type and in absolute terms larger staff numbers were linked to greater publication outputs. Large units were also found to have a

disproportionate number of technicians, research assistants, postdoctoral researchers and administrative support staff with the latter being identified as having a notably large positive impact on climate and biodiversity research outputs of all staff types. In comparison, smaller units had proportionally lower numbers of these staff types with more lecturers overall highlighting that such units are more often related to university departments.

As per staff numbers and unit funding, climate change topics were most researched by PhD students (44% overall) with pure biodiversity research topics only making up 24% whilst combined topics made up 32%. Larger units were found to have the most PhDs, carrying out a greater amount of climate change research overall, whilst smaller units had a proportionally higher number of PhDs researching biodiversity topics. Small units had the most balance between PhDs researching climate, biodiversity and combined climate and biodiversity related topics. Total outputs of units strongly correlated with their PhD numbers, particularly for those researching combined climate and biodiversity topics, highlighting the importance of PhDs in the research environment. As per PhD numbers, the provision of biodiversity related Masters programmes was significantly less than for Climate Change Masters (3 times less). However, Masters' student numbers had limited impact on climate and biodiversity research output. Whilst the most common Masters modules were in *GIS and spatial analysis*, *climate resilience* and *sustainable development* the most interesting results related to those modules that were not provided. Zero modules were provided in the controversial but possible future approach to stabilising climate, i.e. *geo-engineering*. Also, very limited amounts of modules in the *economics of ecosystems and biodiversity* were given, which is interesting in the context of commentary provided in the interviews on the possible links between perceived lack of economic value in biodiversity research and the poor provision of funding in the area (see Section 4.3.3 and 4.4.4 for further discussion of this).

Total publication numbers from researchers on the island of Ireland were strongly influenced by the amount of collaborations they took part in. The assessment of collaboration numbers from research units helped to determine the degree to which such activities take place. Results showed that in 2021, 24% of collaborations were with other units on the island of Ireland whilst with the EU and more broadly internationally it was 20% and 22% respectively. The number of collaborations with the United Kingdom only made up 15% which is very surprising particularly given the strong links between Northern Ireland and the rest of the United Kingdom. It is unclear if 2021 was an anomaly in the long term record or if there has been a change in the amount of research done with the United Kingdom in recent times. However, as our nearest neighbour and given the historic research ties it would seem that addressing this shortfall would be important. Distinctive differences in collaboration numbers were also found based on unit size. Small less well funded units carried out a proportionally greater percentage of collaborations with the United Kingdom, for example, compared to the better funded larger units who appear to be more insular. This was also confirmed by our assessment of collaborative outputs based on staff numbers with collaborative activities across Ireland increasing at rate 1.7 times than those with the United Kingdom per unit increase in staff suggesting that larger units are much less inclined to take part in international climate change and biodiversity research than smaller units. This raises questions as to why larger units show less interest, something that is discussed further in Section 4.3.3 along with potential solutions in Section 4.4.3.

The final part of the survey related to the climate and biodiversity research publication numbers of each of the 34 units and how they relate to the previously covered topics. Once again the underperformance of biodiversity research was evident with biodiversity research only

representing 25% of output compared to 42% for climate and 33% for combined climate and biodiversity topics. Compared to institutional totals, climate and biodiversity research publications from all units represented approximately 7% of research output which is notably lower than the equivalent funding amount (10%) and staffing numbers (10%) however when non-climate and biodiversity research publications from all units are included this increases to 10%. Interestingly, large units with greater funding amounts produce 5% of publication output (7% when non-climate and biodiversity research is considered) compared to only 1% for medium and 1% for small units showing that they are the most efficient grouping at generating research. Medium sized units of between 33 and 66 staff produced less biodiversity research output than smaller units of < 33 staff highlighting the value of small units in terms of biodiversity research on the island. These figures were reconfirmed when the assessment was carried out based on funding received with biodiversity research output proportionally greater for units with <1.5 million in funding, which were generally small units. However, a much greater proportion of medium sized units outputs relate to climate change (67%, compared to 37% for large units and 36% for small units) highlighting their importance in respect of climate research. In terms of funding providers, the greatest research outputs came from units for whom Science Foundation Ireland and Horizon Europe/Horizon 2000 were the main funders. This may relate to both the larger funding amounts provided by these funders, particularly Science Foundation Ireland who are the main providers for some of the larger units with the greatest publication numbers. The Environmental Protection Agency, the Department of Agriculture Environment and Rural Affairs and the Irish Research Council all stood out as important providers of funding to units producing considerable research output which were typically of medium and small size.

4.3.3 Interview responses

By employing semi-structured interviews it was possible to extract extremely useful qualitative information from unit managers and researchers on the performance of their units, including what hinders their performance, the actions that could be taken to both improve their climate and biodiversity research collaborations and how best to increase climate and biodiversity publication outputs from their units and more generally across the research environment on the island. The responses received from the interviewees to the above topics of discussion were subsequently employed to help decide what recommendations should be made in terms of required organisational and governmental actions. By anonymizing the interviews, the interviewees were more honest and direct about difficulties they have encountered within their own organisations but also in respect of their perceptions of how best to improve the research environment. Whilst only nineteen interviews took place, the feedback from them was remarkably similar between units, particularly in terms of what the most important actions were that organisations and the government should take to address the identified weaknesses in climate and biodiversity research output on the island. As the interviewees were representative of a broad category of unit sizes, with expertise in a large array of both climate and biodiversity related topics, and being found in both the Republic and Northern Ireland there was confidence that the responses represented broadly accepted thinking across the island.

Overall commentary in the interviews regarding units' key strengths, weaknesses, opportunities and risks produced common patterns which could help identify solutions to ongoing problems as well as pathways to improving climate and biodiversity research on the island. Positive commentary relating to research funding was generally received from larger units who are the greatest benefactors of such funding. Conversely, for smaller units, lack of funding and its

unpredictable nature were seen as major weaknesses, something that larger SFI centres for example have less concerns about. The lack of resources (equipment and lab space) of units was again seen as a weakness, particularly for smaller sized units along with concerns regarding unit expertise. The overall disparity between funding amounts, available resources and, in some instances, staff expertise raises questions regarding the approach taken by both government and funders on how they prioritise funding. Internal conflict and institutional politics were also identified as weaknesses across a number of differing sized units with relations between the unit and parent institution often causing concerns for the unit's future viability. Whilst there were expectations from many that their units would expand into the future, increasing collaboration efforts along with their unit's expertise, a number of respondents stated that they were happy with their current setup and indicated that their lack of ambition often related to them being "maxed out" in terms of workload. Securing funding, both from industry and government bodies, was identified as a potential future threat over the medium to long term and again this largely related to small to medium sized units. This forced units to compete as opposed to collaborate, with many identifying the latter as a more sensible approach. Finally, the common issue regarding the growing burden of administrative duties was apparent across interviews and was identified as a significant future threat, particularly in terms of funding applications but also for institutional activities such as teaching and once again the threat was seen as more relevant in smaller institutions. The recommended actions derived from these findings are discussed further in Section 4.4.

Teaching duties along with responsibilities related to PhD students and postdoc researchers was an important part of the interview discussions, raising interesting observations regarding educational requirements. Overall teaching was seen as an important, beneficial component of interviewee's roles with broadly positive commentary except for some accounts of excessive associated administrative duties. Also some lamented the apparent push for a full return post-pandemic to face to face teaching which they stated was excessively time consuming compared to online teaching and as a result took away from research time. A little more flexibility on behalf of institutions was suggested with regard to such teaching so that lecturers can achieve the right balance between teaching and research. The biggest finding from the discussion regarding PhDs was the difficulties regarding attracting and keeping PhD students and postdoc researchers at the moment in some of the bigger urban areas, particularly in Dublin. The loss of potential high quality candidates due to rental prices and the cost of living crisis was identified on more than one occasion suggesting that research is currently being impacted by this. In the short term this could become a significantly negative strain on the island's climate and biodiversity research output and requires addressing. Increased funding and possibly more assistance from institutional bodies were identified as the best means to address this problem.

The discussion regarding the topic of collaborations with interviewees highlighted the overarching support for strong progressive collaborative activities across all units' types and sizes, in the Republic and Northern Ireland. The strongly positive benefits of such endeavours were identified, such as reduced research administrative requirements for obtaining funding, meant that such activities were strongly encouraged. Whilst there is very strong support for targeted funding for those taking part in collaborative climate and biodiversity research activities, particularly so for cross border funding initiatives, interest in increased international collaborations were less apparent. This correlates well with survey results which found that units, particularly larger units, were somewhat insular in terms of climate change and biodiversity research collaborative activities outside of Ireland, particularly with the United Kingdom. Interestingly, it was stated that getting funding for collaboration efforts was difficult with strong competition particularly for

European funding and may impact the interest of units in applying for such funding opportunities. In any event it is an important part of research and is essential for improving research output numbers on the island so encouraging collaborative activities should be considered a priority for funders and central government. Finally it is worth highlighting that considerable interest was shown for academics to play a more active part in tackling climate and biodiversity related issues at the local level. To that end, a number of interviewees were keen to take part in collaborations with local authorities and similar local third party groups and suggested that this should be encouraged more by government.

The most important and urgent governmental and institutional supports were also identified in the interview discussions. The most common request was that additional funding for climate and biodiversity research be made available, particularly for the latter which was seen as being underrepresented in funding calls. Suggestions were made to increase targeted funding for important research topics and that such funding be directed more so towards early career researchers and also to support PhD students during this cost of living crisis. Also, many interviewees suggested that grant applications should in general be greater than one year in length. The negatives associated with short term (of less than a year) grants were made apparent by a number of interviewees, which were described as undesirable in terms of the experience for researchers as well as value for money in terms of time spent on applications. In general longer term funding awards, with the option of extending such grants, were requested, particularly so for some long-term biodiversity related projects which often took extended periods to complete. There was also a strong agreement for the increased provision of grants that require collaboration activities, particularly between the Republic and Northern Ireland, which would foster stronger relationships between the two jurisdictions. The second topic that was consistently raised throughout the interviews was the required governmental and institutional support relating to grant applications, grant reporting and general administrative activities. As well as additional institutional support (extra administrative staff), simplification of grant application processes and reporting in general were the top requests by interviewees with many saying they found the excessive amounts of time required to complete such activities, particularly for grant applications where there was no guarantee of success, impacted other research outputs. The suggestion was made that streamlining the grant application process would make it a lot more accessible and would reduce the associated administrative burden. Further details on the required actions by government and institutions to address the shortcomings discussed here can be found in Section 4.4.

As representatives of some of the most important climate and biodiversity research units on the island of Ireland it was thought important to query what they would suggest are the best actions that the government and institutions could undertake to help improve climate and biodiversity research outputs, collaborations and the general research environment on the island of Ireland. One of the most frequently raised suggestions was for a greater focus on the provision of new funding streams which related to both climate and biodiversity research and that the topics for which the grants are provided be less prescriptive in nature allowing the researchers some flexibility in the topics researched with greater engagement with the scientific community as to what topics should be targeted for funding. Again, the undervaluing of biodiversity research was raised with the lack of funding support for research in this area being linked to its poorer performance in the terms of research output. Commitments were needed from government and / or funding bodies to provide new funding streams to encourage more biodiversity research. Efforts to encourage collaboration, particularly cross border collaborative initiatives, together with more collaborations with regional authorities and the sharing of available institutional

facilities were encouraged. Furthermore it was suggested that the government should encourage and fund more international conferences, stakeholder forums and other means of linking like-minded people together to help foster collaborations and increase climate and biodiversity research output. Interesting feedback in relation to the provision of an all island centre for climate and biodiversity research was also received. Overall, support for such a centre was evenly split between interviewees, with concerns regarding how such a unit would impact their own unit's access to funding in future together with potential collaboration opportunities. Despite this there was an almost universal acknowledgement that such a centre could possibly result in greater climate and biodiversity research output, something that our survey findings here also suggest would be the case. The proposal of setting up of a virtual centre that prompts strong collaborations between research staff in currently established units already in place on the island was one interesting suggestion that warrants further consideration.

Finally, all interviewees were asked what they considered the three most important climate and biodiversity related research topics that they believed should be prioritised. Land use, including peatlands, soils and land use change in general was the most suggested topic. This was followed by marine research including wave and offshore wind energy along with marine and coastal ecosystems, and the provision of baseline data through continuous long-term monitoring sites. Food supply systems and carbon emissions related to food production were also both seen as important research topics. Taking into consideration the central role agriculture, peatlands and renewable energy have in Ireland in terms of climate change action it is unsurprising that these topics arose. The survey analysis of unit expertise suggests however that considerable research is already occurring on topics in these areas with these amongst the top ten most researched areas on the island. The collection of observational data and continuous monitoring of such data are activities that cover a broad range of climate and biodiversity research disciplines and were identified as being extremely important in the interviews. The taking and monitoring of such observations plays a central role in deriving datasets that often are fundamental to other higher level research activities and are most often carried out by a network of semi state and other governmental related bodies. Simplifying the means by which such data could be accessed was seen as extremely important, particularly for datasets from outside the researcher's jurisdiction, i.e. in the Republic or Northern Ireland.

4.4 Recommended actions

The main findings from each of the three approaches taken to assess climate and biodiversity research on the island of Ireland (outlined in Section 4.3) raise questions regarding what actions are required to help increase total climate and biodiversity research publication numbers, to encourage greater collaborations not only across the island but also with the United Kingdom and more broadly internationally, and to improve the overall research environment for researchers working on these topics. Whilst the assessment of historical publication numbers clearly identified relatively low climate and, in particular, biodiversity outputs from the island of Ireland compared to Scotland and Denmark, it also found clear gaps in the research topics studied by researchers. An analysis of submitted surveys identified a number of indicators in the climate and biodiversity units' underlying data that would indirectly impact research output and may explain the poor performance of the island in respect of these areas of research. Feedback from the interviews helped confirm these findings, identifying a number of key underlying issues relating to units, from which suitable actions could be drawn up. In this section we discuss the findings from the

assessment and in the process present some recommended actions which should go some way to addressing the poor performance of Irish research in the areas of climate and biodiversity.

4.4.1 Funding

Overall, the provision of funding has been identified as the main cause of and possible solution to the lack of climate and biodiversity research output on the island, with interviewees noting the lack of funding and its unpredictable nature as major threats to units over the medium to long term, particularly for smaller units. To address this, on top of recently announced funding allocations by the government, new funding streams are required. Related grants should be less prescriptive in nature allowing some flexibility in the topics researched. For larger units that often focus more on climate change related research, securing funding was not as great of a concern, which is unsurprising as they receive at least half of allocated funding for climate and biodiversity research units on the island. Medium sized units also produce a considerable portion of climate change research output. However, larger units were the most efficient in terms of funding spent. Using funding as a tool for collaboration efforts was also identified as an effective way to increase collaborative activities on the island and further afield. Larger, better funded units were less likely to partake in international collaborations, particularly with the United Kingdom and within the EU, so future funding for such units should be linked to greater collaboration efforts in these regions. Interviewees also highlighted that early career researchers require additional funding supports and that grants shorter than one year were often being too costly to apply for (in terms of time) and very difficult on all parties involved due to their short nature. Such commentary raises questions regarding the type and performance of differing climate and biodiversity research awards and how they are applied by funding bodies, something that deserves further investigation.

Recommendation 1). Provision of additional funding for both climate and biodiversity research, targeting smaller research units for which precarity of funding is a particular concern.

Recommendation 2). Support greater all-island and international research efforts by use of conditional research grants particularly for larger funding allocations associated with medium to large sized units.

Recommendation 3). Extend the overall lengths of grants, reducing or removing those grants which are one year or less in length.

Recommendation 4). Continued funding of large units using the currently established Science Foundation Ireland model but with the requirement for a much greater amount of biodiversity research output.

Recommendation 5). Provision of new climate and biodiversity grants that are less prescriptive in nature allowing some flexibility in the topics researched and the possibility of the provision of set funding in particular to early career researchers.

4.4.2 Administration and staff

The growing burden of administrative duties on researchers was identified as a major cause of concern, particularly in relation to grant applications, grant reporting and teaching commitments. This was primarily found in small and medium sized units as opposed to larger units where greater

numbers of administrative staff were available. The survey results showed that administrative staff numbers had the greatest impact on research output with larger units linked to greater outputs as a result. By increasing the administrative staff available to researchers and decreasing their overall administrative burden this concern can be addressed. In terms of staffing, biodiversity staff numbers were found to be proportionally lower than those researching climate change in large and medium sized units whilst for smaller units the numbers were more balanced. As a result research output relating to biodiversity topics from larger and, in particular, medium sized units is notably lower than that for climate change related topics. The provision of further research roles in biodiversity topics, in both medium sized and larger units is the best means to address this issue.

Recommendation 6). Provision of additional administrative staff to medium and, in particular, smaller units and/or funding to facilitate this.

Recommendation 7). Simplification of grant applications and reporting requirements where possible for all grant types.

Recommendation 8). Provide funding for new biodiversity related research roles in established medium and large sized units across the island.

4.4.3 Collaborations

Encouraging collaborations was seen as the best means for increasing climate and biodiversity research output on the island of Ireland. Discussions in the interviews identified the strongly positive benefits of collaborations including the reduced requirement for administrative work, that was typically shared between the parties involved, and the greater potential for idea sharing and team building that came from such exercises. Whilst there was very strong support for collaborations it was noted that it often related to potential parties on the island of Ireland, particularly cross border initiatives, as opposed to international efforts. This finding was also supported by survey data which showed that collaborations with international partners were less common than those within the island, particularly for larger units, whereas smaller units were more inclined to carry out collaborations with the United Kingdom and the EU. It was highlighted that larger grants were difficult to attain, especially European grants, which may impact collaboration efforts there. Finally, a number of interviewees highlighted their desire to carry out more practical research with regional authorities so that academic institutions can play a greater role in tackling the climate and biodiversity crises in local communities. Grants specifically supporting such collaborative activities should be made available by funders.

Recommendation 9). Increase requirements for collaborative activities in larger units by linking future funding calls to collaborative research.

Recommendation 10). Generate new cross border funding schemes to continue to grow collaborations between the Republic and Northern Ireland. Consider targeting the rest of the United Kingdom in such schemes.

Recommendation 11). Provide support mechanisms in institutions to aid and encourage researchers to apply for larger European grants that require collaborative activities.

Recommendation 12). Generate new funding streams to help encourage climate and biodiversity related collaborative activities between units and local authorities and/or other local third party groups.

4.4.4 Biodiversity

One of the strongest findings of this study has been in relation to the nature of biodiversity research on the island of Ireland and the fact that it is severely underrepresented compared to research output from other European countries such as Scotland and Denmark. Whilst the lack of funding and support were seen as major causes of this, often as a result of the belief that there was little economic value in such research, some smaller units were quite successful at generating research output in this area. For large and, particularly, medium sized units biodiversity was underrepresented with clear biases towards climate related topics evident and this directly impacted biodiversity related research outputs. These findings were compounded by the fact that climate change research metrics outperformed biodiversity on all levels (i.e. publication numbers, staff, funding, etc.). Clear commitments from government and funders are identified as being required to address this imbalance with new biodiversity funding mechanisms being seen as the best approach to achieve this. Such schemes need to cater for the different research profiles related to biodiversity with flexible, longer term grants that cater for the occasionally unpredictable timelines of biodiversity research projects.

Recommendation 13). Implementation of new funding mechanisms that will drive an increase specifically in biodiversity related research across the island.

Recommendation 14). Provision of longer more flexible biodiversity research grants that are more suitable for certain long-term ecological projects.

Recommendation 15). Encourage the rolling out of new academic positions for biodiversity researchers to improve biodiversity expertise in units across the island.

4.4.5 Research topics

This project has helped identify the most important climate and biodiversity research topics both globally, by means of the review of the literature, and for units across the island, by means of surveys and interviews. Whilst the island of Ireland performs particularly well globally in research categories such as *dairy animal science* there are areas that we perform poorly in that require attention. These include *remote sensing*, *plant sciences* and *meteorology, atmospheric sciences* with the latter being of particular interest taking into consideration the impact climate change is having and will have on weather across the island. Whilst unit survey responses listed expertise in a broad array of disciplines of particular note are the most covered topics, which included *adaptation*, *sustainability* and *water,* and the least covered topics, which included *vector ecology*, *extinction* and *meteorology.* Whilst interviewees identified land use, peatlands, marine and coastal ecosystems as the most important research topics, these were found to be relatively well researched at this time. Long-term baseline data collected from continuous monitoring sites were also identified as critical to climate and biodiversity research. Continued support, especially for semi state and other governmental bodies who often carried out such activities, was identified as being extremely important. Furthermore, difficulties accessing such data, particularly cross border data, was identified as an issue. The implementation of an all island portal for accessing such data should be considered to address this.

Recommendation 16). Unit managers, where possible, should look into increasing research output in the areas of *remote sensing*, *plant sciences* and, in particular, *meteorology atmospheric sciences*.

Recommendation 17). Targeted funding for each of the main underrepresented research topics identified in this study (in the areas of *remote sensing*, *plant sciences* and *meteorology, atmospheric sciences*).

Recommendation 18). Greater collaborations between climate change units on the island and Met Eireann and the Met office should be considered to increase meteorology research outputs linked to all island research units.

Recommendation 19). Increase supports for governmental and semi state bodies producing baseline data, to increase the volume and type of data available, and consider the implementation of an all island portal for accessing such data from both jurisdictions.

4.4.6 Teaching commitments and PhDs

The impacts of teaching on research, the recruitment and research outputs of PhDs and the provision of Masters programmes were all assessed in the surveys and discussed, were applicable, in the interviews. Overall, teaching was seen as a very positive and important part of interviewee's roles which was beneficial for sparking research ideas. Despite this it was noted for being time consuming, particularly the administrative side, and there was some angst about the push for a return to full face to face learning, which some researchers saw as regressive. In terms of PhD's the outstanding issue raised multiple times in the course of interviews was the impact the cost of living crisis is having on hiring and keeping PhDs, particularly in larger urban areas. It was suggested that prompt actions were needed from government in order to avoid a loss of potential research talent. Also, the bias towards PhDs researching climate change topics was evident in survey responses suggesting that the underrepresentation of biodiversity research output is not only linked to research in general but also to postgraduate schemes.

Recommendation 20). Institutions to allow greater flexibility in respect of teaching duties to allow for some remote learning when possible.

Recommendation 21). Additional administrative supports to be provided by institutions to assist researchers with teaching related activities.

Recommendation 22). Immediate increases in stipend funding provided to PhD researchers together with targeted assistance to help address impacts from housing and cost of living crises.

4.4.7 General points

Topics around funding, collaborations, teaching, staff and research expertise all dominated in the interview discussions. Whilst the main recommendations of actions to take to address research deficiencies in each of these areas have been discussed in sections 4.4.1 to 4.4.6 above there were a number of other points that were raised that are worth highlighting for possible action. These included a means for keeping track of climate and biodiversity related research units across the island, the provision of a service to allow for shared facilities on the island, an update of the modules provided as part of climate and biodiversity related Masters programmes, politics and conflict between units and their parent institutions and excessive workloads. The suggested establishment of a centre (possibly virtually) to progress climate and biodiversity research on the island also received considerable attention. As survey data indicates that such a centre would be most effective at increasing both biodiversity and climate change related outputs it should be

considered in any future actions to address research deficits in the areas of climate and biodiversity.

Recommendation 23). The development of an online centralised database of all climate change and biodiversity units on the island of Ireland with it possibly linked to an online portal providing details on the availability of climate change and biodiversity related facilities (equipment and laboratories) for use by third parties

Recommendation 24). Masters programme coordinators should consider the inclusion of modules related to topics that are not well covered in current programmes including in *geo-engineering* and the *economics of ecosystems and biodiversity*.

Recommendation 25). Provision of better support infrastructure and conflict resolution facilities in institutions to address concerns regarding internal politics and difficulties that can arise between units and other bodies within the organisations.

Recommendation 26). Explore the feasibility of creating a virtual centre focused on climate change and, in particular, biodiversity related research.

Chapter 5 | Conclusions and future work

5.1 Overall conclusions

This study is the first to carry out an in depth analysis of climate change and biodiversity related research publication numbers from the Republic and Northern Ireland, comparing all island outputs to those globally and from other European countries of similar population sizes. It is also the first to assess the key characteristics of some of the most important climate change and biodiversity related research units on the island and the first to carry in-depth conversations with unit managers to help find the most important strengths and weaknesses of their respective units along with pathways to help improve climate and biodiversity research on the island of Ireland as a whole. In the process of carrying out the above activities the main aim of the project, i.e. to create a better understanding of the climate and biodiversity research activities on the island of Ireland, has been achieved and the five related key research objectives realised. Historical climate change and biodiversity research outputs from institutions across the island of Ireland, including categorised research output numbers, were analysed, quantitative information relating to funding, expertise, staff, education, teaching, collaborations and publication numbers for 34 of the principle climate change and biodiversity research units was collected and detailed insights into the strengths and weaknesses of those same units along with proposals for how to improve unit performance and the general climate and biodiversity research environment were found. Based on the findings of this analysis 26 recommended actions were derived (see Section 4.4). It is perceived that if governments, funders and relevant institutions across the island act upon these recommendations some of the main difficulties facing climate and biodiversity research units will be addressed resulting in a much more positive and active research environment on the island in the coming years.

5.2 Limitations and priorities for future work

The methodologies employed in this study have been shown to be both robust and effective and have resulted in the extraction and analysis of novel quantitative and qualitative data that has been used to help derive a number of recommended actions that when applied will help address the identified deficiencies that contribute to reduced climate and biodiversity research output from researchers on the island. Whilst there is strong confidence in the findings of the study some limitations do exist along with potential future work that can both address these limitations and improve the quality of and the confidence in the study's findings. Listed below are some of the main limitations, solutions and some possible future actions that could be taken.

1). When assessing research output numbers only the Web of Science database was employed using specific keywords. Other online databases of publications exist that could be included in any future analysis (e.g. Scopus). Using such alternative databases it would be possible to assess and confirm the findings of the original analysis and therefore should be considered a future action to take. Furthermore, the use of specific keywords inevitably means that only a subset of all relevant outputs were sampled (not all climate or biodiversity papers use the searched keywords in their titles and / or abstracts). However, assuming that there is no systematic difference in approach globally this yields a fair comparison. Other approaches could include counting outputs by journal for specialist journals or by expanding the keyword search terms.

2). Comparison of research outputs was limited to two European jurisdictions of similar population and GDP to Ireland. The possibility exists to compare outputs to other European

nations or average European output per head of population as opposed to total population sizes. This would give a broader, balanced assessment of the island's performance overall. Furthermore, whilst a general understanding of the differing funding models in place in the two jurisdictions were identified in this study this could be greatly expanded upon in any future analysis to include more detail on the amounts and mechanisms involved in funding climate and biodiversity research together with details on collaborative activities and the overall research environments in these and potentially other comparable jurisdictions.

3). In total 34 surveys were submitted and of the related units, 19 took part in follow up interviews. As 92 surveys issued in total, these responses only represent a subsample of climate and biodiversity research units on the island. With further prompting and additional time it would have been possible to increase these numbers, which in turn would have helped improve the overall accuracy and content of the study. A further round of surveys and follow up interviews could take place within the coming year to help improve these response numbers.

4). The quality of survey responses received from respondent units was difficult to determine. Only multiple responses from single institutions could be assessed, whereby details given regarding parent institutions could be compared between submissions to evaluate their accuracy. Overall differences between such submissions were limited suggesting that the data was accurate. Furthermore, the option to leave questions blank reduced the chances of the provision of incorrect figures. One means to improve any possible discrepancy in the data is to obtain a second independent clarification on figures from other departments within the units' host institution for example and / or organise direct visits to the units involved to ascertain figures on site. This should be considered as part of any future research in this area.

5). Interviews included subjective' commentary based on individuals' thinking and feelings regarding the topics. As a result they were open to both positive and negative biases which undoubtedly impacted the accuracy of responses. Options exist for addressing this limitation including interviewing more than one individual per unit, moving from semi-structured to structured interviews with set questions and / or grading candidates based on perceived biases in their responses. Alternatively, visits to the units in question could be arranged where much more in-depth conversations could be had and the unit's facilities and research output assessed in more detail. Future analysis related to this study should consider such approaches.

6). In this study all units were equated equally in terms of their roles in the Irish climate and biodiversity research environment. In reality however there are distinct differences in research outputs from each and how they relate to one another. For example, whilst often not publishing large amounts of peer reviewed publications, semi state and other governmental bodies play a crucial role in monitoring baseline data that are often fundamental to other academic research outputs. They also are extremely active in providing scientific support to the government to assist with environmental policy development, implementation and decision making. Such important activities were not adequately captured by this study. Future work could investigate in more detail the different activities of units and how they interrelate to other organisations. Creating a better understanding of each units' role and how they relate to other institutions on the island is important as it will help foster stronger relationships between such organisations, which is required to tackle the climate and biodiversity emergencies effectively.

5.3 Concluding remarks

Using an online database of categorised historical climate change and biodiversity publications, quantitative data extracted from online surveys of climate and biodiversity research units and qualitative information on the thinking of some of the most esteemed climate and biodiversity researchers from the Republic and Northern Ireland, this study has identified a severe gap in climate and biodiversity research output from units across the island of Ireland. In the analysis of data extracted from the surveys and from the discussions held with unit managers, ways and means to help improve the climate and biodiversity research landscape on the island and to help maximise the potential for research outputs on these topics have been identified. This assessment has, amongst other things, developed a list of 26 recommendations that if implemented would be likely to result in a much improved research environment on the island and could set researchers on the path to successfully increase their outputs and, in the process, generate knowledge that can effectively address the climate and biodiversity emergencies on the island of Ireland over the coming years.

References

AbdulRafiu, A., Sovacool, B.K. and Daniels, C., 2022. The dynamics of global public research funding on climate change, energy, transport, and industrial decarbonisation. *Renewable and Sustainable Energy Reviews*, 162, p.112420. https://doi.org/10.1016/j.rser.2022.112420

All-Island Climate and Biodiversity Research Network [AICBRN], 2020. *Leveraging Ireland's R&D for Successfully Tackling the Climate and Biodiversity Emergency*. The All-Island Climate and Biodiversity Research Network. Available from: www.aicbrn.net/_files/ugd/b1a920_4eb2218ff55240f9bda7614c232d4bb8.pdf [accessed 9 June 2022].

Blanchard, M., Bouchet-Valat, M., Cartron, D., Greffion, J. and Gros, J., 2022. Concerned yet polluters: A survey on French research personnel and climate change. *SocArXiv*. https://doi.org/10.31235/osf.io/j9smz.

Brudvig, L.A., 2011. The restoration of biodiversity: where has research been and where does it need to go? *American journal of botany*, 98(3), pp.549-558. https://doi.org/10.3732/ajb.1000285

Carlton, J.S., Perry-Hill, R., Huber, M. and Prokopy, L.S., 2015. The climate change consensus extends beyond climate scientists. *Environmental Research Letters*, 10(9), p.094025. https://doi.org/10.1088/1748-9326/10/9/094025

Daikeler, J., Silber, H. and Bošnjak, M., 2022. A meta-analysis of how country-level factors affect web survey response rates. *International Journal of Market Research*, 64(3), pp.306-333. https://doi.org/10.1177/14707853211050916

DiCicco-Bloom, B. and Crabtree, B.F., 2006. The qualitative research interview. *Medical education*, 40(4), pp.314-321. https://doi.org/10.1111/j.1365-2929.2006.02418.x

Environmental Protection Agency (EPA), 2021b. *EPA Research 2030: A Framework for EPA Research 2021-2030*. Environmental Protection Agency, Marine Institute and Met Éireann, Dublin. Available from: https://www.epa.ie/publications/research/epa-research-2030/EPA-Research-2030-Framework_Final.pdf [Accessed on the 28 November 2022].

Environmental Protection Agency (EPA), 2021a. *The Status of Ireland's Climate 2020*. Environmental Protection Agency, Marine Institute and Met Éireann, Dublin. Available from: https://www.epa.ie/publications/research/climate-change/Research_Report_386.pdf [Accessed on the 27 November 2022].

Fang, Y., Yin, J. and Wu, B., 2018. Climate change and tourism: A scientometric analysis using CiteSpace. *Journal of Sustainable Tourism*, 26(1), pp.108-126. https://doi.org/10.1080/09669582.2017.1329310

Fu, H.Z. and Waltman, L., 2022. A large-scale bibliometric analysis of global climate change research between 2001 and 2018. *Climatic Change*, 170(3), pp.1-21. https://doi.org/10.1007/s10584-022-03324-z

Government of Ireland, 2019a. *Biodiversity climate change sectoral adaptation plan*. Dublin: Department of Culture, Heritage and the Gaeltacht. Available from: https://www.chg.gov.ie/app/uploads/2019/10/doc-7-climate-change-sectoral-adaptation-plan-for-biodiversity.pdf [Accessed on the 28 November 2022].

Government of Ireland, 2019b. *Climate action plan 2019 to tackle climate breakdown*. Dublin: Department of Culture, Heritage and the Gaeltacht Available from: https://assets.gov.ie/10206/d042e174c1654c6ca14f39242fb07d22.pdf [Accessed on the 27 November 2022].

Government of Ireland, 2022. *Climate Research Coordination Group Third Report on Activities January 2020–December 2020*. Environmental Protection Agency. Available from: https://www.epa.ie/publications/research/climate-change/Climate_Research_Coordination_Group_3rd_Report_on_Activities_July_2021_final.pdf [Accessed 25 November 2022].

Green, E.J., Buchanan, G.M., Butchart, S.H., Chandler, G.M., Burgess, N.D., Hill, S.L. and Gregory, R.D., 2019. Relating characteristics of global biodiversity targets to reported progress. *Conservation Biology*, 33(6), pp.1360-1369. https://doi.org/10.1111/cobi.13322

Hook, D., Adams, J. and Szomszor, M., 2017. *The landscape of climate research funding*. Digital science research reports. Holtzbrinck Publishing Group, London, UK

Houses of the Oireachtas, 2019. *Climate change: A cross-party consensus for action. Report of the Joint Committee on Climate Action*. Dublin: Houses of the Oireachtas. Available from: http://opac.oireachtas.ie/AWData/Library3/ClimateActionReportFinal28032019_100451.pdf [Accessed on the 26 November 2022].

Huang, L., Chen, K. and Zhou, M., 2020. Climate change and carbon sink: a bibliometric analysis. *Environmental Science and Pollution Research*, 27(8), pp.8740-8758. https://doi.org/10.1007/s11356-019-07489-6

Jones, S.A., Fischhoff, B. and Lach, D., 1999. Evaluating the science-policy interface for climate change research. *Climatic Change*, 43(3), pp.581-599. https://doi.org/10.1023/A:1005495119477

Kappelle, M., Van Vuuren, M.M. and Baas, P., 1999. Effects of climate change on biodiversity: a review and identification of key research issues. *Biodiversity & Conservation*, 8(10), pp.1383-1397. https://doi.org/10.1023/A:1008934324223

Klein, R.J.T., Adams, K.M., Dzebo, A., Davis, M. and Siebert, C.K., 2017. *Advancing climate adaptation practices and solutions: Emerging research priorities*. Stockholm Environment Institute. Working Paper 2017–07.

Leal Filho, W., Morgan, E.A., Godoy, E.S., Azeiteiro, U.M., Bacelar-Nicolau, P., Ávila, L.V., Mac-Lean, C. and Hugé, J., 2018. Implementing climate change research at universities: Barriers, potential and actions. *Journal of Cleaner Production*, 170, pp.269-277. https://doi.org/10.1016/j.jclepro.2017.09.105

Li, F., Zhou, H., Huang, D.S. and Guan, P., 2020. Global research output and theme trends on climate change and infectious diseases: a restrospective bibliometric and Co-word biclustering investigation of papers indexed in PubMed (1999–2018). I*nternational journal of environmental research and public health*, 17(14), p.5228.

Lindorf, M., 2012. *Private foundations - a unique player in Danish research funding*. Tænketanken DEA, København. Available from: https://www.datocms-assets.com/22590/1587548527-privatefoundations.pdf [Accessed 25 November 2022]

Masud, M.M., Azam, M.N., Mohiuddin, M., Banna, H., Akhtar, R., Alam, A.F. and Begum, H., 2017. Adaptation barriers and strategies towards climate change: Challenges in the agricultural sector. *Journal of cleaner production*, 156, pp.698-706. https://doi.org/10.1016/j.jclepro.2017.04.060

Neßhöver, C., Timaeus, J., Wittmer, H., Krieg, A., Geamana, N., van den Hove, S., Young, J. and Watt, A., 2013. Improving the science-policy interface of biodiversity research projects. *GAIA-Ecological Perspectives for Science and Society*, 22(2), pp.99-103. https://doi.org/10.14512/gaia.22.2.8

Olisah, C. and Adams, J.B., 2021. Analysing 70 years of research output on South African estuaries using bibliometric indicators. *Estuarine, Coastal and Shelf Science*, 252, p.107285. https://doi.org/10.1016/j.ecss.2021.107285

O'Neill, S.J., Osborn, T.J., Hulme, M., Lorenzoni, I. and Watkinson, A.R., 2008. Using expert knowledge to assess uncertainties in future polar bear populations under climate change. *Journal of Applied Ecology*, 45(6), pp.1649-1659. https://doi.org/10.1111/j.1365-2664.2008.01552.x

Phillips, H., 2015. The capacity to adapt to climate change at heritage sites—The development of a conceptual framework. *Environmental Science & Policy*, 47, pp.118-125. https://doi.org/10.1016/j.envsci.2014.11.003

Rahmann, G., 2011. Biodiversity and organic farming: what do we know? *Agriculture and Forestry Research*, 3, pp.189-208. https://doi.org/10.3390/ijerph17145228

Sangam, S.L. and Savitha, K.S., 2019. Climate change and global warming: A scientometric study. *Journal of Scientometrics and Information Management*, 13(1), pp.199-212. https://doi.org/10.1080/09737766.2019.1598001

Sovacool, B.K., D'Agostino, A.L., Meenawat, H. and Rawlani, A., 2012. Expert views of climate change adaptation in least developed Asia. *Journal of environmental management*, 97, pp.78-88. https://doi.org/10.1016/j.jenvman.2011.11.005

Sternberg, M., Gabay, O., Angel, D., Barneah, O., Gafny, S., Gasith, A., Grünzweig, J.M., Hershkovitz, Y., Israel, A., Milstein, D. and Rilov, G., 2015. Impacts of climate change on biodiversity in Israel: an expert assessment approach. *Regional Environmental Change*, 15(5), pp.895-906. https://doi.org/10.1007/s10113-014-0675-z

Stork, H. and Astrin, J.J., 2014. Trends in biodiversity research—a bibliometric assessment. *Open Journal of Ecology*, 4(07), p.354. https://doi.org/10.4236/oje.2014.47033

Vishnevsky, T. and Beanlands, H., 2004. Qualitative research. *Nephrology Nursing Journal*, 31(2), p.234.

Wang, B., Pan, S.Y., Ke, R.Y., Wang, K. and Wei, Y.M., 2014. An overview of climate change vulnerability: a bibliometric analysis based on Web of Science database. *Natural hazards*, 74(3), pp.1649-1666. https://doi.org/10.1007/s11069-014-1260-y

Watson, R., 2015. Quantitative research. *Nursing Standard (2014+)*, 29(31), p.44. http:// doi.org/10.7748/ns.29.31.44.e8681

Zyoud, S.H. and Fuchs-Hanusch, D., 2020. Mapping of climate change research in the Arab world: a bibliometric analysis. *Environmental Science and Pollution Research*, 27(3), pp.3523-3540. https://doi.org/10.1007/s11356-019-07100-y

Appendix I Research analysis - additional data

Table S1 Web of Science climate change article categories having no island of Ireland entries.

Discipline	Worldwide Articles
Psychology Multidisciplinary	448
Nanoscience Nanotechnology	385
Religion	308
Engineering Marine	293
Engineering Industrial	262
Engineering Aerospace	254
Mathematical Computational Biology	250
Demography	222
Spectroscopy	212
Physics Condensed Matter	211
Health Care Sciences Services	172
Materials Science Paper Wood	142
Mineralogy	141
Mining Mineral Processing	140
Nursing	137
Women's Studies	133
Pharmacology Pharmacy	124
Social Sciences Biomedical	107
Chemistry Inorganic Nuclear	98
Endocrinology Metabolism	98
Materials Science Coatings Films	94
Social Work	89
Paediatrics	86
Psychology Clinical	78
Mathematics	77
Materials Science Composites	76
Medical Ethics	73
Respiratory System	72
Medicine Research Experimental	71
Chemistry Organic	65
Linguistics	64
Criminology Penology	61
Chemistry Medicinal	60
Materials Science Characterization Testing	56
Industrial Relations Labour	51
Theatre	50
Psychology Educational	49
Asian Studies	41
Obstetrics Gynaecology	39
Physics Nuclear	38
Family Studies	37
Materials Science Biomaterials	37
Psychology Biological	36
Acoustics	33
Crystallography	33
Emergency Medicine	33
Sport Sciences	31
Medicine Legal	30
Clinical Neurology	28
Gerontology	28

Table S2 Web of Science biodiversity article categories having no island of Ireland entries.

Discipline	Worldwide Articles
Horticulture	316
History Philosophy Of Science	295
Biochemical Research Methods	284
Computer Science Interdisciplinary Applications	217
Hospitality Leisure Sport Tourism	183
Ethics	180
Chemistry Applied	173
Integrative Complementary Medicine	172
Mathematics Interdisciplinary Applications	141
Materials Science Multidisciplinary	137
Humanities Multidisciplinary	113
Architecture	91
Computer Science Artificial Intelligence	84
Physics Mathematical	84
Public Administration	83
Information Science Library Science	79
Physics Applied	79
Physics Multidisciplinary	79
History	64
Mathematics Applied	61
Reproductive Biology	59
Psychology Multidisciplinary	57
Developmental Biology	56
Art	55
Construction Building Technology	53
Endocrinology Metabolism	51
Business Finance	48
Chemistry Physical	48
Physics Fluids Plasmas	48
Gastroenterology Hepatology	46
Astronomy Astrophysics	44
Oncology	44
Operations Research Management Science	44
Instruments Instrumentation	43
Anatomy Morphology	39
Materials Science Paper Wood	39
Medical Laboratory Technology	39
Nanoscience Nanotechnology	36
Telecommunications	36
Cultural Studies	30
Mining Mineral Processing	30
Paediatrics	30
Mechanics	29
Polymer Science	29
Thermodynamics	29
Spectroscopy	27
Dermatology	24
Chemistry Organic	22
Demography	22
Pathology	22
Social Sciences Biomedical	22
Social Sciences Mathematical Methods	22

Transportation	21
Allergy	20
Ethnic Studies	20
Materials Science Biomaterials	19
Mathematics	19
Mineralogy	19
Engineering Mechanical	18
Medical Ethics	17
Transportation Science Technology	17
Automation Control Systems	16
Criminology Penology	16
Health Care Sciences Services	16
Metallurgy Metallurgical Engineering	16
Engineering Geological	15
Language Linguistics	15
Materials Science Textiles	14
Optics	14
Acoustics	13
Engineering Biomedical	13
Linguistics	13
Medicine Legal	13
Microscopy	13
Engineering Petroleum	12
Asian Studies	11
Haematology	11
Chemistry Inorganic Nuclear	10
Engineering Aerospace	10
Psychology Social	10
Computer Science Hardware Architecture	9
Nuclear Science Technology	9
Physics Condensed Matter	9
Psychology Biological	9
Urology Nephrology	9
Clinical Neurology	8
Electrochemistry	8
Engineering Manufacturing	8
Nursing	8
Radiology Nuclear Medicine Medical Imaging	8
Respiratory System	8
Women S Studies	8
Computer Science Cybernetics	7
Geriatrics Gerontology	7
History Of Social Sciences	7
Obstetrics Gynaecology	7
Psychology Experimental	7
Cardiac Cardiovascular Systems	6
Cell Tissue Engineering	6
Education Special	6
Gerontology	5
Psychology Clinical	5

Appendix II Survey questions, correspondence and additional data

Survey questions:

AICBRN RESEARCH SURVEY

Thank you for agreeing to take part in the AICBRN research survey. Please note that one survey will issue to each centre/institute, identified as carrying out climate change and/or biodiversity related research, in your organisation/university. Here, climate change and biodiversity research is defined as active studies being carried out relating to climate and ecological change and related impacts (historical, current and future change in environmental, social and economic conditions). Please answer the questions below from the perspective of the centre/institute you represent (as confirmed in the cover email) but note that some questions do request information relating to your organisation/university. Your personal details will remain anonymous at all times. If you do not have the exact information to answer a question below then please leave the response blank. Please note that you can add to or edit your responses up until 18:00 (GMT) on Sunday 31st July 2022.

*Required

1. Email *

BACKGROUND DETAILS

2. Please confirm the name of your organisation/university. *

3. Please confirm the name of your centre/institute. *

4. How many centres/institutes are there in your organisation/university?

5. Please list by name the centres/institutes at your organisation/university that focus specifically on climate change and/or biodiversity research?

SELF-DECLARED EXPERTISE

6. Which of the disciplines listed below does your organisation/university carry out climate change and/or biodiversity research in?

Tick all that apply.

- [ ] Agriculture
- [ ] Agronomy
- [ ] Anthropology
- [ ] Archaeology
- [ ] Architecture
- [ ] Biochemistry Molecular Biology
- [ ] Biodiversity Conservation
- [ ] Biology
- [ ] Biotechnology Applied Microbiology
- [ ] Business
- [ ] Chemistry Multidisciplinary
- [ ] Chemistry Physical
- [ ] Communication
- [ ] Construction Building Technology
- [ ] Development Studies
- [ ] Ecology
- [ ] Economics
- [ ] Educational Research
- [ ] Energy
- [ ] Engineering Chemical
- [ ] Engineering Civil
- [ ] Engineering Electrical Electronic
- [ ] Engineering Environmental
- [ ] Engineering Multidisciplinary
- [ ] English/Film Studies
- [ ] Entomology
- [ ] Environmental Sciences
- [ ] Environmental Studies
- [ ] Evolutionary Biology
- [ ] Fisheries
- [ ] Food Science Technology
- [ ] Forestry
- [ ] Genetics Heredity
- [ ] Geochemistry Geophysics
- [ ] Geography Human
- [ ] Geography Physical
- [ ] Geology
- [ ] Geosciences Multidisciplinary
- [ ] Green Sustainable Science Technology
- [ ] History
- [ ] History Philosophy Of Science
- [ ] Imaging Science Photographic Technology
- [ ] International Relations

- [ ] Landscape Architecture
- [ ] Law
- [ ] Limnology
- [ ] Management
- [ ] Marine Freshwater Biology
- [ ] Materials Science Multidisciplinary
- [ ] Mathematics
- [ ] Meteorology Atmospheric Sciences
- [ ] Microbiology
- [ ] Multidisciplinary Sciences
- [ ] Oceanography
- [ ] Paleontology
- [ ] Philosophy
- [ ] Plant Sciences
- [ ] Political Science
- [ ] Public Administration
- [ ] Public Environmental Occupational Health
- [ ] Psychology
- [ ] Regional Urban Planning
- [ ] Remote Sensing
- [ ] Social Sciences Interdisciplinary
- [ ] Sociology
- [ ] Soil Science
- [ ] Thermodynamics
- [ ] Toxicology
- [ ] Urban Studies
- [ ] Water Resources
- [ ] Zoology
- [ ] Other: _____

7. Which keywords below best describe the climate change/biodiversity research expertise in your centre/institute?

Tick all that apply.

- [ ] Adaptation
- [ ] Agricultural
- [ ] Air quality
- [ ] Biodiversity loss
- [ ] Carbon emission supply chains
- [ ] Carbon Footprint
- [ ] Carbon offsetting/credits
- [ ] Carbon Sequestration
- [ ] Climate change legislation
- [ ] Climate communication
- [ ] Coastal Erosion
- [ ] Corporate Governance
- [ ] Detection and attribution
- [ ] Developing countries
- [ ] Ecosystems
- [ ] Environmental protection
- [ ] Extinction
- [ ] Extreme weather events
- [ ] Finance
- [ ] Fisheries
- [ ] Forestry
- [ ] Freshwater ecosystems
- [ ] Future scenarios
- [ ] Governance
- [ ] Green infrastructure
- [ ] Greenhouse gas emissions
- [ ] Human health
- [ ] Industry
- [ ] Land use change
- [ ] Meteorology
- [ ] Mitigation
- [ ] Modelling
- [ ] Oceanography
- [ ] Paleoclimatology
- [ ] Peatlands
- [ ] Phenology
- [ ] Precipitation
- [ ] Renewable Energy
- [ ] Resilience
- [ ] Risk management
- [ ] Sea level rise
- [ ] Soils
- [ ] Species loss

- [ ] Streamflow
- [ ] Sustainability
- [ ] Time series analysis
- [ ] Urbanisation
- [ ] Vector ecology
- [ ] Vulnerability
- [ ] Water
- [ ] Other: _____

8. Does your centre/institute have specialist laboratories/facilities specifically for climate change/biodiversity research? (E.g. a sediment core analysis lab).

   Mark only one oval.

   - ◯ Yes
   - ◯ No
   - ◯ Other: _____

9. If you answered yes to the question above then please provide some detail (i.e. list the laboratory/facility types).

   _____
   _____
   _____
   _____
   _____

10. Does your centre/institute require further specialist laboratories/facilities specifically for climate change/biodiversity research? (please list required laboratories/facilities).

    _____
    _____
    _____
    _____
    _____

FUNDING

11. Approximately how much research funding (externally sourced research grants) was your organisation/university in receipt of in 2021? (overall annual figures in euros).

Mark only one oval.

- 0 - 10 million
- 10 - 20 million
- 20 - 30 million
- 30 - 40 million
- 40 - 50 million
- 50 - 60 million
- 60 - 70 million
- 70 - 80 million
- 80 - 90 million
- 90 - 100 million
- > 100 million
- No funding

12. How much research funding (externally sourced research grants) was your centre/institute in receipt of in 2021? (overall annual funding in euros).

Mark only one oval.

- 0.0 - 1.0 million
- 1.0 - 2.0 million
- 2.0 - 3.0 million
- 3.0 - 4.0 million
- 4.0 - 5.0 million
- 5.0 - 6.0 million
- 6.0 - 7.0 million
- 7.0 - 8.0 million
- 8.0 - 9.0 million
- 9.0 - 10.0 million
- > 10.0 million
- No funding

13. Please provide a breakdown of the number of research funding streams (from external sources) for climate and/or biodiversity research in your centre/institute that fall within the following monetary ranges (overall annual funding in euros).

Mark only one oval per row.

	0	1	2	3	4	5	6	7	8
0	◯	◯	◯	◯	◯	◯	◯	◯	◯
1 - 500,000	◯	◯	◯	◯	◯	◯	◯	◯	◯
500,001 - 1,000,000	◯	◯	◯	◯	◯	◯	◯	◯	◯
1,000,001 - 1,500,000	◯	◯	◯	◯	◯	◯	◯	◯	◯
1,500,001 - 2,000,000	◯	◯	◯	◯	◯	◯	◯	◯	◯
2,000,001 - 2,500,000	◯	◯	◯	◯	◯	◯	◯	◯	◯
2,500,001 - 3,000,000	◯	◯	◯	◯	◯	◯	◯	◯	◯
3,000,001 - 3,500,000	◯	◯	◯	◯	◯	◯	◯	◯	◯
3,500,001 - 4,000,000	◯	◯	◯	◯	◯	◯	◯	◯	◯
4,000,001 - 4,500,000	◯	◯	◯	◯	◯	◯	◯	◯	◯
4,500,001 - 5,000,000	◯	◯	◯	◯	◯	◯	◯	◯	◯
> 5,000,000	◯	◯	◯	◯	◯	◯	◯	◯	◯

14. Please rank the top five providers of funding (by total grant amount) for climate change and/or biodiversity research in your centre/institute.

Tick all that apply.

	First	Second	Third	Fourth	Fifth
Bord Iascaigh Mhara	☐	☐	☐	☐	☐
Dept for the Economy (DfE)	☐	☐	☐	☐	☐
Dept of Agriculture, Environment and Rural Affairs (DAERA)	☐	☐	☐	☐	☐
Dept of Agriculture, Food and the Marine	☐	☐	☐	☐	☐
Dept of Business, Enterprise and Innovation	☐	☐	☐	☐	☐
Dept of the Environment, Climate and Communications	☐	☐	☐	☐	☐
Economic and Social Research Institute	☐	☐	☐	☐	☐
Enterprise Ireland	☐	☐	☐	☐	☐
Environmental Protection Agency	☐	☐	☐	☐	☐
European Research Council	☐	☐	☐	☐	☐
Geological Survey Ireland	☐	☐	☐	☐	☐
Health and Social Care (HSC) R&D Division of the Public Health Agency	☐	☐	☐	☐	☐
Health Research Board	☐	☐	☐	☐	☐
Higher Education Authority	☐	☐	☐	☐	☐
Horizon Europe/Horizon 2020	☐	☐	☐	☐	☐

IDA Ireland	☐	☐	☐	☐	☐
Industrial Development Agency Ireland	☐	☐	☐	☐	☐
Innovation Boost	☐	☐	☐	☐	☐
Invest NI	☐	☐	☐	☐	☐
Ireland-Northern Ireland-National Cancer Institute	☐	☐	☐	☐	☐
Irish Agriculture and Food Development Authority	☐	☐	☐	☐	☐
Irish Cancer Society	☐	☐	☐	☐	☐
Irish Fulbright Commission	☐	☐	☐	☐	☐
Irish Research Council	☐	☐	☐	☐	☐
Marine Institute	☐	☐	☐	☐	☐
National Economic and Social Council	☐	☐	☐	☐	☐
National Institute of Food and Agriculture (NIFA)	☐	☐	☐	☐	☐
National Institutes of Health (NIH)	☐	☐	☐	☐	☐
National Science Foundation (NSF)	☐	☐	☐	☐	☐
Royal Irish Academy	☐	☐	☐	☐	☐
Science Foundation Ireland	☐	☐	☐	☐	☐
Sustainable Energy Authority of Ireland	☐	☐	☐	☐	☐
Teagasc	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐

STAFF NUMBERS

15. Approximately how many staff members are working in your organisation/university? (Academic/research staff only).

Mark only one oval.

- 1 - 500
- 501 - 1000
- 1001 - 1500
- 1501 - 2000
- 2001 - 2500
- > 2500

16. How many academic/research staff members are carrying out research in your centre/institute...

Mark only one oval per row.

	0	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
...in total?									
...on climate change related topics?									
...on biodiversity related topics?									
...on climate change and biodiversity related topics?									

17. Please complete the table below providing a breakdown of the number of staff working in the areas of climate change and/or biodiversity in your centre/institute at each of the listed grades.

Mark only one oval per row.

	0	1 - 5	6 - 10	11 - 15	16 - 20	21 - 25	26 - 30	31 - 35	36 - 40
Professor	◯	◯	◯	◯	◯	◯	◯	◯	◯
Senior lecturer	◯	◯	◯	◯	◯	◯	◯	◯	◯
Lecturer	◯	◯	◯	◯	◯	◯	◯	◯	◯
Research fellow	◯	◯	◯	◯	◯	◯	◯	◯	◯
Postdoctoral researcher	◯	◯	◯	◯	◯	◯	◯	◯	◯
Research assistant	◯	◯	◯	◯	◯	◯	◯	◯	◯
Technician	◯	◯	◯	◯	◯	◯	◯	◯	◯
Administrative support	◯	◯	◯	◯	◯	◯	◯	◯	◯
Other	◯	◯	◯	◯	◯	◯	◯	◯	◯

EDUCATION

18. Approximately how many PhD candidates does your organisation/university currently have?

Mark only one oval.

- 0
- 1 - 200
- 201 - 400
- 401 - 600
- 601 - 800
- 801 - 1000
- 1001 - 1200
- 1201 - 1400
- 1401 - 1600
- 1601 - 1800
- 1801 - 2000
- > 2000

19. How many PhD candidates are currently enrolled in your centre/institute...

Mark only one oval per row.

	0	1 - 5	6 - 10	11 - 15	16 - 20	21 - 25	26 - 30	31 - 35	36 - 40
...altogether?									
...and researching climate change related topics?									
...and researching biodiversity related topics?									
...and researching climate change and biodiversity related topics?									

20. Does your organisation/university have a Masters programme(s) specific to climate change and/or biodiversity?

Tick all that apply.

- [ ] Climate change related Masters.
- [ ] Biodiversity related Masters.
- [ ] Combined climate change and biodiversity Masters.
- [ ] No climate change and/or biodiversity Masters.

21. If your organisation/university has a Masters programme(s) specific to climate change and/or biodiversity then please confirm the total number of students who were enrolled in the 2021/22 academic year?

Mark only one oval.

- ◯ 0
- ◯ 1 - 10
- ◯ 11 - 20
- ◯ 21 - 30
- ◯ 31 - 40
- ◯ 41 - 50
- ◯ 51 - 60
- ◯ 61 - 70
- ◯ 71 - 80
- ◯ 81 - 90
- ◯ 91 -100
- ◯ > 100
- ◯ Not applicable

22. Which of the topics below are taught as part of the climate change and/or biodiversity Masters course(s)?

Tick all that apply.

- [ ] Advanced GIS and Spatial Analysis
- [ ] Advanced Quantitative Methods
- [ ] Atmosphere and Ocean Dynamics
- [ ] Biodiversity: Ecosystems and Conservation
- [ ] Biodiversity: Taxonomy, Knowledge of Species
- [ ] Climate Change and Biodiversity
- [ ] Climate Change Communication
- [ ] Climate Change Mechanisms and Tipping Points
- [ ] Climate Models and Observations
- [ ] Climate Resilience
- [ ] Computational Geophysics
- [ ] Corporate responsibility
- [ ] Earth System Modelling
- [ ] Economics of Climate Change
- [ ] Economics of Ecosystems and Biodiversity
- [ ] Ecosystem Services
- [ ] Energy Systems
- [ ] Environment and Health
- [ ] Environmental Governance and Development
- [ ] Environmental Impact Assessment
- [ ] Environmental policy-making
- [ ] Ethics, Environment and Society
- [ ] Extreme Weather
- [ ] Freshwater Ecosystems
- [ ] Geoengineering
- [ ] Global Environmental Change and Food Systems
- [ ] Hydrology and water systems
- [ ] Impacts, Adaptation and Mitigation
- [ ] Landscape dynamics
- [ ] Legal frameworks, negotiations, and politics
- [ ] Oceanography
- [ ] Paleoclimatology
- [ ] Remote sensing
- [ ] Research Methods and Professional Skills
- [ ] Rewilding
- [ ] Sustainable development
- [ ] Urban climatology
- [ ] Urban Ecologies
- [ ] Urban Water and Wastewater
- [ ] Water, Climate and Society
- [ ] Other: _____

COLLABORATIONS / PUBLICATIONS

23. Approximately how many publications (articles, books, proceedings and data papers) were published by researchers (lead or co-authors) from your organisation/university in 2021?

Mark only one oval.

- ◯ 0
- ◯ 1 - 500
- ◯ 501 - 1000
- ◯ 1001 - 1500
- ◯ 1501 - 2000
- ◯ 2001 - 2500
- ◯ 2501 - 3000
- ◯ 3001 - 3500
- ◯ 3501 - 4000
- ◯ 4001 - 4500
- ◯ 4501 - 5000
- ◯ > 5000

24. What is the total number of publications (articles, books, proceedings and data papers) issued by researchers (lead or co-authors) in your centre/institute in 2021 that...

Mark only one oval per row.

	0	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
...relate to climate change?	◯	◯	◯	◯	◯	◯	◯	◯	◯
...relate to biodiversity?	◯	◯	◯	◯	◯	◯	◯	◯	◯
...relate to climate change and biodiversity?	◯	◯	◯	◯	◯	◯	◯	◯	◯
...are unrelated to climate change or biodiversity?	◯	◯	◯	◯	◯	◯	◯	◯	◯

25. How many publications (articles, books, proceedings and data papers), specific to climate change and/or biodiversity, issued in 2021 that involved researchers from your centre/institute and...

Mark only one oval per row.

	0	1 - 10	11 - 20	21 - 30	41 - 50	51 - 60	61 - 70	71 - 80
...other centres/institutes within your organisation/university?	◯	◯	◯	◯	◯	◯	◯	◯
...other organisations/universities across Ireland?	◯	◯	◯	◯	◯	◯	◯	◯
...other organisations/universities within the United Kingdom?	◯	◯	◯	◯	◯	◯	◯	◯
...other organisations/universities within the EU?	◯	◯	◯	◯	◯	◯	◯	◯
...other international organisations/universities?	◯	◯	◯	◯	◯	◯	◯	◯

FINAL COMMENTARY

26. Would you and/or a colleague agree to be contacted by a researcher in early September to answer further questions on the topics covered in this questionnaire? (Giving your consent does not commit you to anything, you will simply be offered an invitation). *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Other: _____

27. Do you wish to receive a copy of our final report when our analysis is completed?

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Other: _____

28. If you answered yes to either question directly above then please provide your email address below (If applicable and with their approval, please include a colleague's email address).

_____

29. Do you have any final thoughts on the survey or its contents?

_____

_____

_____

_____

_____

That's it! Thanks for contributing to this research, your time is very much appreciated. You will be emailed a copy of your response. Please note that you can amend your response to any survey questions up until 18:00 (GMT) on Sunday 31st July 2022.

Survey correspondence I

AICBRN survey of Climate Change and Biodiversity Research at Institutes across the island of Ireland

Dear Colleague,

I am contacting you today on behalf of the All-Island Climate and Biodiversity Research Network (www.aicbrn.net).

We are carrying out a study on climate and biodiversity research on the island of Ireland with the goals of identifying strengths and weaknesses in the current research environment, overall gaps in research output, possible funding and facilities deficiencies and potential collaboration opportunities for researchers across the island.

We invite you to contribute to our online climate and biodiversity survey that forms a central part of the study, which we believe will be of benefit to both your work and to XXX, particularly as the findings of the study will be published and submitted to relevant governmental departments for consideration.

You can access the survey at the following link: XXX

The survey should take around ten minutes to complete when data is to hand (a copy of the survey questions is attached to help facilitate this). Please note that the survey is largely quantitative in nature and therefore no personal details will be disclosed. All personal data will be kept confidential unless directed otherwise. The survey will close at 18:00 (GMT) on Sunday 31st July 2022 (responses can be edited until this time).

More in-depth follow up interviews will take place in September 2022 in which qualitative information will be gathered. You will be given the opportunity to be included in the follow up interviews at the end of the survey.

If you have any questions, please do not hesitate in contacting me at the email address provided below.

Many thanks for participating in this survey, your time is very much appreciated.

Kind regards,

Paul O'Connor on behalf of the AICBRN
mrpaul.oconnor@mu.ie

Survey correspondence II

AICBRN survey of Climate Change and Biodiversity Research at Institutes across the island of Ireland

Dear Colleague,

Today is the last day for submitting a response to the AICBRN survey on climate and biodiversity research in Ireland (see email below and attached). I note from our records that

we have not yet received a submission from your institute/centre (XXX). We would encourage all institutes/centres to take part in the survey as the results will form part of a report that will be published and submitted to relevant governmental departments for consideration.

To give your institute/centre a chance to be part of the survey we have now extended the closing date till Sunday the 7th August 2022. Any survey received post this date will not be included in the study.

The survey can be found at XXX

If you have any queries please do not hesitate in contacting me.

We look forward to receiving your response.

Kind regards,

Paul O'Connor

Survey correspondence III:

AICBRN survey of Climate Change and Biodiversity Research at Institutes across the island of Ireland

Dear Colleague,

Having reviewed our records we note that your centre/institute (XXX) has not yet submitted a response to the AICBRN survey on climate and biodiversity research in Ireland (see email thread below and attached). We acknowledge that the time of year may have hindered your centre's/institute's ability to submit a response and therefore we are extending the submission date by a further week.

We would strongly encourage everyone to take part in the survey, particularly AICBRN members, as it will be used to help identify and address deficiencies in the climate and biodiversity research environment including the provision of resources and funding.

To give your institute/centre a chance to be part of the survey the closing date of submissions is now Sunday the 21st August 2022. Any survey received post this date will not likely be able to be included in the study, which is time limited to 6 months in total.

The survey can be found at XXX

If you have any queries please do not hesitate in contacting me.

We look forward to receiving your response.

Kind regards,

Paul O'Connor
mrpaul.oconnor@mu.ie

Survey additional data

Table S3 Keywords best describing each unit's climate change/biodiversity research expertise.

Topic	Survey Numbers
Sustainability	21
Adaptation	21
Water	19
Climate communication	19
Renewable Energy	18
Peatlands	18
Mitigation	18
Land use change	18
Environmental protection	18
Resilience	17
Modelling	17
Greenhouse gas emissions	17
Biodiversity loss	17
Agricultural	17
Time series analysis	16
Carbon Sequestration	16
Freshwater ecosystems	15
Governance	14
Future scenarios	14
Climate change legislation	14
Forestry	13
Ecosystems	13
Soils	12
Coastal Erosion	12
Sea level rise	11
Risk management	11
Oceanography	11
Green infrastructure	11
Extreme weather events	11
Carbon Footprint	11
Fisheries	10
Carbon emission supply chains	10
Air quality	10
Vulnerability	9
Urbanisation	9
Paleoclimatology	9
Human health	9
Streamflow	8
Phenology	8
Other	8
Finance	8
Developing countries	8
Carbon offsetting/credits	8
Species loss	7
Industry	7
Precipitation	5
Meteorology	5
Corporate Governance	5
Vector ecology	4
Extinction	4
Detection and attribution	4

Appendix III Interview correspondence

AICBRN survey of Climate Change and Biodiversity Research at Institutes across the island of Ireland

Dear XXX,

Recently, you submitted a response to the AICBRN survey on climate and biodiversity research in Ireland on behalf of the XXX in which you noted that you and/or a colleague would be willing to take part in a follow-up interview.

I would now like to formally offer you the opportunity to take part in that interview with me in which we will discuss the topic in more detail along with specific details relating to your XXX. The meeting will take place on Microsoft Teams and will be approximately one hour in length and will be recorded to allow me the opportunity to review the commentary afterward. Comments made in the interview will remain anonymous with the recording deleted once the relevant data assessment has been completed.

If you are still willing to take part then please let me know and also please provide me with a suitable date and time so that we can try to organise the meeting (I am attempting to carry out two interviews per day, one in the morning and one in the afternoon).

Looking forward to receiving your response.

Kind regards,

Paul O'Connor
mrpaul.oconnor@mu.ie

Appendix IV Glossary of acronyms

Acronym	Full Title
AFBI	The Agri-Food and Biosciences Institute
ATU	Atlantic Technological University
DCU	Dublin City University
DKIT	Dundalk institute of technology
EPA	Environmental Protection Agency
ESHI	Environmental Sustainability and Health Institute
GSI	Geological Survey Ireland
ICARUS	Irish Climate Analysis and Research UnitS
ICHEC	Irish Centre for High-End Computing
iCRAG	the Science Foundation Ireland Research Centre in Applied Geosciences
IFI	Inland Fisheries Ireland
MaREI	MaREI Centre for Energy, Climate and Marine
Marine Institute	Marine Institute
MIC	Mary Immaculate College
MFRC	Marine and Freshwater Research Centre
MU	Maynooth University
NERI	Nevin Economic Research Institute
NUIG	National University of Ireland Galway
Queens	Queen's University Belfast
SETU	South East Technological University
TCD	Trinity College Dublin
Teagasc	Teagasc, the Agriculture and Food Development Authority
TUD	Technological University Dublin
UCC	University College Cork
UCD	University College Dublin
UL	University of Limerick

This page was intentionally left blank