



2023 EPA-GSI (Groundwater) Project funded

Evaluating the vulnerability of aquifer recharge to changing climate across Ireland

Patrick Morrissey, University of Dublin, Trinity College (TCD)

This proposal aims to develop and implement a methodology to evaluate the vulnerability of groundwater recharge to a changing climate in Ireland. Historically, research on the impact of climate change on groundwater resources has been relatively limited, as reflected in the IPCC Fourth Assessment Report which identified a knowledge gap in this area (Kundzewicz et al., 2007). In Ireland, climate studies have primarily focussed on surface waters (Steele-Dunne et al., 2008; Bastola et al., 2012; Broderick et al., 2019; Gleeson et al., 2013; Murphy et al., 2023), while groundwater studies have tended to be small scale assessments rather than quantitative research applicable at the national scale (Cantoni, 2020; Morrissey et al., 2021). The proposed collaboration between Trinity College Dublin (TCD) and South Eastern Technical University (SETU) Carlow, with partners in the Irish Centre for High End Computing (ICHEC), Talamhireland and Geological Survey Ireland, will strengthen partnerships between the institutions and open new research opportunities in the fields of climate change adaptation, groundwater resource monitoring and management. The project remit is to establish a practical, repeatable methodology for the estimation of historic and future groundwater recharge rates to better understand the factors impacting on and the likely trends in future groundwater recharge. The research project, AQCLIMATE, will be completed over a tight 24-month timeframe. To achieve this there are four main objectives:

- 1) Review quantitative approaches for the spatial and temporal mapping of groundwater recharge and evaluate climate change impacts on groundwater recharge in Ireland
- 2) Develop a methodology to generate national groundwater recharge maps capable of producing:
 - i. An average annual groundwater recharge map for WMO Period 1990-2020;
 - ii. Seasonal and annual/hydrological year groundwater recharge maps for various climatological periods (e.g. 1990-2020 or 1960-1970 etc.)
 - iii. Seasonal and annual groundwater recharge for future climate change scenarios
- 3) Validation of the methodology to ensure the efficacy of the approach (an iterative approach to model re-calibration may be required) Output of relevant GIS datasets/maps, Python scripts, input variables and detailed reporting which will allow Geological Survey Ireland (or others) to repeat or modify the process in the future as new data become available.

Start date March 31st 2024, 24 month duration

Total value of the project: €299,847.05

Total funding to Irish partners from GSI: €99,949.02

2022 EPA-GSI (TELLUS) Project funded

Characterising and mapping relationships between Tellus soil geochemistry data and rapidly assessed soil biodiversity in Ireland (TellSoilBio)

Olaf Schmidt, University College Dublin (UCD)

The EU Soil Strategy for 2030, describes a target of achieving healthy soils by 2050, with concrete actions by 2030. In Ireland, there is a commitment in the Programme for Government 2020 to develop a National Soils Strategy leading to a comprehensive legislative framework for soil. Healthy soils are essential in achieving climate neutrality, reversing biodiversity loss, providing healthy food and safeguarding human health.

The main aim of the TellSoilBio project is to increase our scientific knowledge of soils in Ireland leading to better protection of soils and their biological diversity and quality. Specifically, the TellSoilBio project will, for the first time, quantify spatial correlations between soil geochemistry and soil biodiversity and will provide mapped information on “hot spots” and “cool spots” in soil biodiversity in relation to soil geochemical patterns. This will be done in a spatially explicit, realistic and achievable manner at a regional, sub-national scale primarily using existing soil geochemical data from the ongoing Tellus Project (topsoil multi-elemental dataset) and new soil biodiversity data on microbial and faunal taxa, as well as functional genes, to be generated by the project with rapid and high-throughput techniques (DNA sequencing, deep learning image analysis).

By identifying “hot” and “cool” spots in soil biodiversity in relation to soil geochemical patterns using hot spot analysis and related spatial analysis tools supported by Geographical Information Systems, the project will improve our understanding of natural patterns in soil biodiversity, as well as agricultural productivity and the suitability of land for uses that rely on soil biological activity (e.g. landspreading of industrial organic wastes). The mapped outputs from the project will inform the development of a sustainable soil protection strategy in Ireland by enabling policy makers to modify, tailor and better spatially target any measures and management recommendations. This will improve the effectiveness of soil protection, nature conservation and soil-derived ecosystem services (including agricultural production); for example, protection measures could be concentrated on areas that are soil biodiversity hotspots.

Addressing other aspects of the call, the project will also analyse newly generated and historic soil biodiversity data from Ireland in order to identify the best indicator taxa and the techniques to monitor them. Furthermore, the project will review and synthesize information on how to reduce the impacts of environmental degradation and land use practices on soil biodiversity in Ireland. The review will focus on chemical pollution (including landspreading of sewage products); intensive agriculture (including soil compaction); and land use change from grassland to coniferous plantations. TellSoilBio is a medium sized collaborative project of 36 months, comprising four academic staff and two postdoctoral researchers from two UCD schools and NUIG. The project team combines distinctive scientific expertise (in soil biodiversity and in spatial geochemistry), it will co-design and communicate with stakeholders, and it will disseminate and transfer project results widely to deliver successful outcomes and impacts.

The project acronym encapsulates the project’s ambition to characterise and map the relationship between TELLus SOIL geochemistry data and rapidly assessed soil BIOdiversity in Ireland – TellSoilBio!

Start date March 1st 2022, 48 month duration

Total value of the project: €249,602.79

Total funding to Irish partners from GSI: €82,368.92

2021 EPA-GSI (groundwater) Project funded

Groundwater Age DistributionS for the Sustainable MAnagement of gRoundwaTer reSources in Ireland (GRADS & SMARTS)

Carlos Rocha, University of Dublin, Trinity College (TCD)

GRADS&SMARTS will constitute the first targeted effort at groundwater dating in Ireland using environmental tracers. The research will employ a combination of environmental 'age' tracers ($\delta^{18}\text{O}$, $\delta^2\text{H}$ in water, CFC-11, CFC-12, SF₆, 3H and 3H-3Hetrit, ²²⁸Ra, ²²⁶Ra, ¹⁴C-DIC) to resolve a wide range of groundwater ages (1->10,000 years) in selected catchments and therefore provide an improved understanding of the lag times of nitrate pollution in representative hydrological settings within Ireland.

The main outcomes of the project will be the provision of a) average groundwater residence times (GRTs) and mean groundwater travel times (GTTs) in selected Irish catchments, and b) the first spatially continuous and seasonally dynamic water isoscape for the country, linking the atmospheric and continental water cycles. Laying the foundation for our approach is a comprehensive sampling programme across the island of Ireland for $\delta^{18}\text{O}$, $\delta^2\text{H}$ in precipitation, groundwater, and surface water.

This initiative will leverage two important resources: the high-throughput, relatively low-cost analytical capacity provided by the stable isotope CRDS (Cavity Ring Down Spectroscopy) systems installed at TCD, and the extant precipitation, surface and groundwater monitoring programmes conducted by the EPA, Met Eireann and the GSI. Because regular water sampling activities already cover a significant extent of the national hydrological network, arranging the collection and delivery of extra samples for isotopic analysis at TCD will guarantee national coverage on a seasonal and multiannual basis while providing data that complements existing water quality databases. The data collected this way will add to existing datasets (GNIP Valentia, IAEA-Armagh, GSI-IsoMech, etc) and allow for the construction of a high resolution, seasonally dynamic isoscape (isotopic landscape) for the water cycle in Ireland, from recharge to discharge. To increase geographical coverage, and simultaneously generate interest in STEM subjects and ensure community engagement with stewardship of national water resources, we will develop a network of citizen scientists ('the Water Seekers') in the form of junior and senior cycle students throughout the country that led by their teachers and supported by learning materials provided by project scientists will collect water samples from their regions and actively contribute to the mapping of Irelands isotopic landscape.

Start date March 31st 2022, 48 month duration

Total value of the project: €499,950

Total funding to Irish partners from GSI: €249,975

2021 EPA-GSI (Minerals) Project funded

Critical Raw Materials for Ireland for a Resource Efficient Circular Economy (CIRCLE)

Inam Ul Ahad, Dublin City University (DCU)

Raw materials are backbone of manufacturing industry. The advancements in the manufacturing of high quality products resulted in increased demand of new and innovative high value products. This in turn has increased the demand for raw materials and multimode by the digital revolution and efforts for transitions towards low-carbon economy. The EU policies, UNSDGs, and Ireland's ambitious targets for 2030, 2040 and 2050 has driven the industry sectors to focus on use of clean and green materials and manufacturing processes to achieve the climate neutral status. These conditions have made several raw materials critical due to several factors associated with their supply and economic importance.

This project aims to identify and provide a list of critical raw materials (CRM) required for Irish economy growth and sustainable competitiveness to the relevant stakeholders. The project will focus on nonenergy extractive industry raw materials (NEEI-RM) that are crucial to "Electrical and Electronics", "Medical Devices", and "Manufacturing" industrial sectors in Ireland. The project will respond to the key CRM issues in these industrial sectors from supply chain point of view, considering the mining, processing and possible recycling routes of these materials.

The project will respond to the key challenges in the methodology to identify the CRM and formulate a comprehensive methodology focusing on Irish needs. European Commission's method to create a list of CMR list is based on calculating a score using two parameters, economic importance (EI) and supply risk (SR). A threshold is then applied to the achieved score in order to include or exclude a particular raw material from the CRM list. The score calculations made by the EC for raw materials are based on data available from the last 5 years. The project will conduct a review of the "Best Practice" for CRM list creation methods and identify parameters not included in the EU methodology. Building up on European Commission's methodologies to create list of CRM, this project will develop a method which better suits Ireland's economy, include the parameters used by EU countries relevant to Irish situation and use the data from the last 10 years. The national and international sources of the data will be identified and a CRM list will be created. The project will review the available database platforms and upload the data achieved in the project for open access to stakeholders and general public. The project will liaise with the Geographical Survey Ireland (GSI) in order to provide guidance to the relevant stakeholders and recommendations for a national database.

The CRM list will reinforce Ireland's efforts in protecting the key natural resources, reducing waste, increasing recycling and consider substitution alternatives where possible. The project outcomes will assist the relevant stakeholders to develop informed policies for further technology developments, regulations and standards and will guide the markets towards sustainable competitiveness. The project will strengthen the Ireland's Environmental Protection Agency activities towards a resource-efficient, green and competitive low-carbon economy.

Start date January 10th 2022, 12 month duration

Total value of the project: €100,000

Total funding to Irish partners from GSI: €50,000

2021 EPA-GSI (Fast Track for Policy - Soils) Project funded

Mapping Understanding and Current Knowledge: Irish Soils (MUCKISOILS)

Maria McNamara, University College Cork (UCC)

Soil is a critical resource that regulates fundamental water- and geochemical cycles that maintain key components of biodiversity and global climate. From a human socioeconomic perspective, soils represent essential natural capital that underpin the security of the global food chain for people and animals, the production of fibre and the provision of environments that facilitate health and wellbeing. Soils are also essential to discourse regarding major topical issues such as climate change, carbon sequestration, nutrient availability, pollution and remediation and equitable economic development. Soils, however, face major stressors and threats, relating to shifting biomes, changes in temperature and precipitation patterns, erosion, fertiliser application, over intensification of agriculture and contamination by metals, VOCs and other organics. Soil quality (the characteristics and dynamics of its physical and chemical properties and biology) and soil health (the functional ability of soil to provide ecosystem services and management outcomes) are therefore of critical concern and should be key elements of any framework relating to soils and soil management. In sum, soil is essential to discourse on biodiversity, food security and climate change, which therefore requires effective frameworks for assessing soil quality, health and threats, in addition to remediation practices.

In Ireland, soil has historically featured as an element of various research and policy strands and themes but has not yet achieved prominence as a dedicated policy or strategy. This is essential to consolidate knowledge on the status of, and threats to, Irish soils and to protect, maintain, and remediate soil quality and health for future generations. The production of a National Soils Strategy is a welcome commitment in the Programme for Government 2020 to effectively and responsibly balance the competing demands, functions and impacts of soil and soil use. This strategy is imperative to the formation of holistic legislative framework for soil in Ireland, not least as a mechanism for responding to the EU Roadmap New Soil Strategy – healthy soil for a healthy life due for adoption in 2022 and the forthcoming EU Soil Strategy.

The current project will systematically review the existing scientific literature on Irish soils and will summarise the key findings in an accessible format via the production of an Evidence Report and associated visuals. The report will span key thematic areas relating to soil quality, health, damage, management, remediation, biodiversity and climate change, and will encompass soils in urban, agricultural and other rural settings. The project will develop appropriate strategies for literature search and evaluation plus data collation and interrogation, and will produce the first holistic overview of Irish soil research. The Report will identify key threats and risks to Irish soils and strategy and critical knowledge gaps, and will frame this in the context of research and policy relating to soils in other European states. Finally the Report will provide a new roadmap for future research on Irish soils by identifying national priority areas relating to the findings above and relating to new emerging EU policy.

Start date November 29th 2022, 4 month duration

Total value of the project: €29,991.07

Total funding to Irish partners from GSI: €14,995.54

2018 EPA-GSI (water) Project funded

GRACE Monitoring of Groundwater over Ireland (GRAIL)

Aaron Golden, National University of Ireland Galway (NUIG)

Gravity Recovery and Climate Experiment (GRACE) and Gravity Recovery and Climate Experiment-Follow On (GRACE-FO) mission utilises a pair of co-orbiting spacecraft whose variation in position between them as they track the same orbit meridian allows researchers to map gravitational anomalies on the Earth's surface. This project aims to determine the feasibility of using GRACE data products in conjunction with freely available climatic data combined with existing and on-going monitoring programmes by the EPA/GSI to derive meaningful information on Ireland's ground water bodies, and their associated changes at large and fine scale resolution, by implementing a data science based software solution. The GRAIL project will deliver software infrastructure that will yield monthly maps of ground water body change across the Republic of Ireland over the period 2002-2010 which can be directly compared with previously field-based assessment by the regulatory authorities so as to determine GRAIL's efficacy, in addition to being able to identify 'outliers' in the current network of ground water wells whose measured 'ground truth' data consistently differ from that predicted by the GRAIL model. Such deviations can be assessed and may provide evidence-based justification for limitations in the GRAIL model at these locations due to context specific constraints (location near surface water bodies, fault lines etc.) or alternatively could provide the motivation for reconsidering the spatial distribution of the existing well network. Evidence of success and the availability of a functioning open-source software stack would provide great flexibility for further more sophisticated and cost-effective development of the GRAIL concept and its future use in regulatory oversight and in the monitoring of Ireland's ground water bodies across the State.

Start date November 1st 2018, 12 month duration

Total value of the project: €87,648

Total funding to Irish partners from GSI: €40,000

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2018 EPA-GSI (Sustainability) Project funded

Cumulative health effects of Metall(oids) through Aggregate Environmental Pathways. MAP

Enda Cummins, University College Dublin

Metals are an essential requirement for plant and crop growth, however, inherent background levels of many metals in regional soils coupled with (loids) (e.g. diffuse, regional land application of biosolid products) has resulted in elevated levels of some metal(loids), which in turn has given cause for concern regarding environmental and human health effects. This study will: (1) undertake a thorough review of the levels of metal(l oid)s likely to be present in soil and potential anthropogenic sources, and 2) analyse human exposure and adverse health impacts using a source-pathway-receptor conceptual modelling and risk assessment approaches.

Start date November 1st 2018, 24 month duration

Total value of the project: €61,038.16

Total funding to Irish partners from GSI: €30,000

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2016 EPA-GSI (water) Project funded

High-Resolution Gridded Datasets of Hydro-Climate Indices for Ireland

Paul Nolan, Christopher Werner (ICHEC) and Dr Owen Naughton (TCD)

The overall aim of the project is to produce a 'definitive' gridded dataset of hydro-climate variables such as Potential Evapotranspiration (PET), Actual Evapotranspiration (AET) and Soil Moisture Deficits (SMD) for Ireland, covering the period 1981-Present. This will be achieved by comparing the output of three downscaled ERAInterim climate simulations:

- i. ICHEC WRF with 2-km grid spacing
- ii. ICHEC COSMO-CLM5 with 1.5-km grid spacings
- iii. Met Éireann re-analysis (MÉRA) with 2.5-km grid spacings

with observations in order to quantify the uncertainty of individual climate fields. A comprehensive statistical analysis will be undertaken in order to validate the datasets and assign error estimates to the climate fields. The climate data, together with the uncertainty estimates, will be made publicly available so that researchers, policy makers, Irish industry and the general public can utilise the datasets.

It is envisaged that the high-resolution datasets will lead to a better understanding, not only of the physical climate system, but also of the interaction of climate and Irish society. The datasets will allow for an assessment of the impact of resolution, data assimilation, and NWP model choice on simulation accuracy. In addition, it is envisaged the datasets will be used as a basis for more-focused hydro-climate impact studies.

Start date January 1st 2017, 24 month duration

Total value of the project: €74,745,20

Total funding to Irish partners from GSI: €37,372.60