iCRAG White Paper

iCRAG RESEARCH WILL AID EUROPEAN EFFORTS ON GLOBAL CHANGE

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iCRAG RESEARCH FOR EUROPE

People, especially young people, across Europe and around the world are demanding urgent action to address climate change. On March 15th, 2019, as part of the initiative #FridaysForFuture, at least 1.6 million school-going children and teenagers took part in climate action strikes in more than 125 countries. On 9th May 2019 Ireland became the second country in the world (after the UK) to declare a climate and biodiversity emergency. A recent report from the Irish parliament's committee on climate action noted that "climate change is not tomorrow's problem. Decisions taken today will significantly impact the climate […]".[1]

Policy makers, civil society, and scientists are seeking ways to adapt to and mitigate changes in in the earth system[2], including climate and environment, and to reach the UN Sustainable Development Goals (SDGs).

iCRAG, the SFI Centre for Research in Applied Geosciences, conducts multidisciplinary earth system science research that transcends industry and academia boundaries in the fields of earth system change, energy security, raw materials supply, groundwater protection, safeguarding the geomarine environment, and protection from the Earth's hazards. Funded by Science Foundation Ireland and co-funded by the European Regional Development Fund, Geological Survey Ireland and by industry partners, iCRAG's research findings support evidence-based policy options and decision-making on matters of urgent societal concern, such as climate change and the resources required to address the climate change issue across both European and global communities.

The European Union faces unprecedented challenges in order to sustain viable societies while maintaining economic growth and development, creating employment, and supporting the health and well-being of people. The EU's commitment to addressing these challenges is clearly expressed in a range of policy initiatives put forward for the next budget period, the Multiannual Framework Programme for the European Union from 2021 to 2027. Chief amongst these are climate, the environment, energy, and the digital agenda as well as those policies which specifically support innovation and the solutions for society through collaborative research and development, principally through the Horizon Europe framework programme for research and development.

Horizon Europe will address a broad spectrum of global challenges from climate change (35% of Horizon Europe budget) to health and the environment to security and defence. Other programmes relevant to iCRAG that support EU research, development and innovation include: the European Union Space programme, especially Copernicus and Galileo; the Digital Europe programme; the European Regional Development Fund (ERDF); and the Neighbourhood, Development, International Cooperation Instrument (NDICI).

This paper sets out iCRAG's capabilities and presents a number of recommendations which can optimise the outputs of Horizon Europe in terms of applicable innovation.

[1] Irish Parliamentary Report (March 2019). Report of the Joint Committee on Climate Action: Climate Change: A Cross-Party Consensus for Action. p. 2.

[2] Earth system science considers interactions between the Earth's "spheres"—atmosphere, hydrosphere, cryosphere, geosphere, pedosphere, and biosphere as well as the impact of human societies on these components.

iCRAG *(Irish Centre for Research in Applied Geoscience)*

Established in 2015, iCRAG is **Ireland's national geosciences research centre**. iCRAG is funded by Science Foundation Ireland and co-funded under the European Regional Development Fund with support from Geological Survey Ireland and a wide range of industry partners. Comprising more than 150 researchers in eight research institutions and collaborating with more than 60 industry partners, iCRAG's mission is to transform Irish geoscience by driving research and discovery, delivering economic and societal benefits, and advancing public understanding. A second, six-year phase of funding for iCRAG, to run from 2021 to 2026, in tandem with Horizon Europe, is currently under review. The goal of Phase 2 of iCRAG is to build on existing achievements and deliver more extensive, integrated research on the earth system to facilitate environmentally sustainable development of the earth resources required for decarbonized economies, and to promote understanding of how people react to and manage our relationship with the earth. iCRAG2 will focus on developing collaborations with European partner groups and synergies with relevant programmes at both EU level and globally.

United Nations Sustainable Development Goals (SDGs)

In September 2015, the United Nations General Assembly adopted the 2030 Agenda on Sustainable Development, including the 17 Sustainable Development Goals (SDGs). The SDGs connect the urgent challenges of our times and offer a framework for the implementation of sustainable development worldwide. The SDGs are intended to be universal, while at the same time allowing each country to develop its own approach to implementation. The adoption of the SDGs represents a paradigm shift in how development is considered in every aspect of society. It represents a change in thinking about domestic and international development, about economics, environment, and society, and a transformation of those towards sustainability. With this shift in thinking must come a shift in how we govern societies and implement solutions to these global challenges.

Crucial for achievement of the SDGs are some of the key principles:

- **Interconnectedness, indivisibility, and universality** – The 17 SDGs need to be considered in their entirety and require a strong level of policy integration, coherence, and coordination. Agenda 2030 is applicable to all countries and thus requires consideration of the interconnectedness of the internal and external policies implementing the SDGs.
- **Inclusiveness and Leaving no one Behind** – Participation by all segments of society to ensure that no segment of society, or even an individual, is left behind in the process, taking particular care of the most vulnerable.
- **Partnerships** – Establishment of multi-stakeholder partnerships within and between countries to mobilise and share knowledge, technology and other resources.

iCRAG can make an important contribution to the SDGs. Its diversity of approach and ability to manage inter-disciplinary research activities and resulting knowledge, means it is well positioned to contribute to a variety of the SDGs (Figure 1).

Fig. 1: iCRAG will address three interrelated challenges: Earth System Change; Earth Science in Society, and Earth Resources. This research relates directly to many of the UN Sustainable Development Goals.

iCRAG and Horizon Europe

"**Observatory Ireland**"

Ireland is strategically located in the North Atlantic. It provides an ideal location to observe and understand earth system changes and develop successful mitigation and adaptation strategies that can have global impact. Ireland's diverse geological and environmental systems and its relatively small area and population provide a range of venues to test hypotheses and technologies, including a number of Horizon Europe focus areas — adaptation to climate change, oceans and waters, soils, carbon-neutral cities. This natural endowment, combined with Irish government support and European collaborations, make iCRAG a natural hub for integrative scientific research designed to address many of the complex issues associated with climate change and other changes in the earth system.

Energy sources

The EU Energy Union aims to make energy more secure, affordable and sustainable throughout Europe. New sources of energy are required in Europe to achieve a renewable future consistent with the 2050 Energy Strategy. Currently Europe imports more than half of all the energy it consumes with a total import bill of more than €1 billion per day.

Accelerating the transition to a zero-carbon economy is a key challenge for Europe. iCRAG's work with industry to discover and develop additional **natural gas** resources is a key part of this strategy. Natural gas will be a vital source of energy in Europe for decades before a full transition to a zero-carbon energy system is technically and economically viable. Petroleum will remain essential until the development of alternative sources of petrochemicals and plastics required throughout society. Depleted offshore natural gas fields provide the

geologically ideal sites for **carbon sequestration** — iCRAG is working with industry to develop and commercialize this carbon storage option.

iCRAG's work on the geological framework and architecture of Ireland is helping to evaluate the potential for **geothermal direct heating** and **power generation** with a low environmental footprint. Work by our scientists and engineers in the marine realm is helping to ensure that offshore wind energy, which promises to be a major contributor to energy security, can be developed safely and economically iCRAG research is also providing the data critical to determining the feasibility of other forms of marine renewable energy technology.

iCRAG's energy and related environmental research aligns with Horizon Europe and is readily transferrable throughout Europe.

Raw materials for the energy transition

Renewable energy technologies and sustainable agriculture both require a fair and sustainable supply of **minerals and metals**. At least 30 million jobs in the EU depend on reliable and unhindered access to raw materials. Their importance is underscored by the European Commission's Raw Materials Initiative and the European Innovation Partnership on Raw Materials. Currently global per capita usage of a wide range of metals doubles every decade and a half. Metals not only are the foundation for the transition to a zero-carbon energy future but are critical throughout the economy. For instance, the "cloud" utilized by the IT sector and increasingly throughout the economy is made primarily of metal. It is thus critical to expand raw materials research into raw material supply and resource efficiency. These areas have been central to iCRAG's research to date, but iCRAG is now pivoting from a focus primarily on Ireland to a global view of critical elements with special focus on Africa. It is also extending its research collaborations at EU level.

Although primary sources of many raw materials will predominate the economy to 2050, Europe must strive for a more **circular economy**. iCRAG research is now utilizing its world-class analytical facilities to investigate innovative secondary sources of critical raw materials that could be extracted and recycled from a variety of waste streams from throughout the economy.

Innovation in the raw materials area involves not just technologies but model frameworks. For instance, few geological models exist for the formation of cobalt deposits. However, with cobalt now a critical element for battery development the search for new sources outside traditional, often problematic, areas have intensified. iCRAG is a world leader in developing such geochemical and geological models that can be translated to industry to ensure Europe maintains a constant supply of this energy-critical element as the EU transitions to a renewable future.

Water quality and quantity

Water has always been critical to life, but economic development combined with climate change is placing ever greater demands on its **supply and quality**. The increasing demand by European citizens for cleaner rivers and lakes, groundwater, and coastal beaches has been clearly recognized by the EU Water Framework Directive and is the focus of Horizon Europe's 'healthy oceans and natural waters' mission area. iCRAG research is confronting these challenges both above and below ground and at the interface between terrestrial and marine environments. Further integration of iCRAG's Irish water research with research from throughout Europe will help to address annual European damages due to river floods that could

reach €112 billion with significant global warming[3], from the current €5 billion, and the damages from droughts that profoundly affect agriculture as well as human health. iCRAG's geochemical research on groundwater and soils provides important data for evaluating health outcomes of plants, animals and humans throughout Europe and addresses Horizon Europe's 'adapting to climate change' and 'soil health and food' missions. iCRAG research is also directly applicable to challenges in the Sahel and other regions in Africa.

Reducing risk to people and property

Mitigation and adaptation to natural hazards such as floods, landslides, ground subsidence, and sea level change require **engineering solutions grounded in earth systems.** iCRAG's integration of science and engineering identifies cost-effective solutions that can be utilized by communities. In addition, understanding how society views and adapts to a changing world is crucial to successfully implementing solutions and reducing risk to the most vulnerable. This research, together with that outlined below, is pivotal to the social transformation element of Horizon Europe's 'adapting to climate change' mission.

Owen Daugherty, Thousands skip school in Belgium, for fourth-straight week to attend climate march, The Hill, 31st January 2019,https://thehill.com/policy/international/europe/427871-thousands-of-students-skip-school-for-fourth-straight-week-for

Science and society

iCRAG strives to improve the **visibility of science in society** and is becoming a leader in interdisciplinary, integrated physical and social science research. In this era of **'fake news'**, the active engagement of citizens in science is becoming more critical, especially as societal decisions are made about climate change, energy security, and resource efficiency. It is critical that Europeans examine how society perceives both the scientific underpinning of climate change as well as its ability to undertake the required behavioral modifications. The mitigation and adaptation required throughout society requires deep understandings of the relevant social perspectives as well as technical challenges. iCRAG is tackling this through **integrated**

[3] EU, 2018, A Clean Planet for all, A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy; Communication from the Commission to the European Parliament, the European Council, the European Economic and Social Committee, the Committee of Regions and the European Investment Bank.

physical and social sciences and humanities research on the social understanding of science, public science literacy, and scientific recognition of earth resources (raw materials, energy, and water) among the public as well as the degree of societal understanding of scientists and engineers. Engagement with and understanding by policy and decision-makers is also an important objective. iCRAG's mandate includes **skill development to aid industry in Europe** as well as development of **European academic capital,** thus helping to strengthen the European Research Area.

iCRAG hosted the first **Researching Social Theories, Resources, and Environment (ReSToRE) international summer school** at University College Dublin on 1-5 July 2019. Following a competitive selection process, 42 early career geoscientists and social scientists convened to tackle the question of how society should meet the challenge of providing water, energy, and mineral resources in a sustainable way. The participants **represented 28 nationalities, the majority of which (19) are developing countries,** a quarter came from industry, the rest from academia and government agencies, and over a third were women.

The outcome of the week's discussions highlighted the necessity for a long-term, adaptive and continuous program of activity to address the sustainable and equitable sourcing of earth resources, with particular emphasis on comprehensive stakeholder engagement, multidisciplinary approaches, and the creation of a global perspective on these issues. iCRAG is working with partner organisations to develop **new capacity building initiatives** based on these recommendations.

Six ReSToRE particpants from all over the world: from left to right, in back row: Emilio Castillo (from Chile), Halleluya Ekandjo (from Namibia), Muhammad Tahir (from Afghanistan), Geertje Schuitema (Director of ReSToRE). Front row: Laura Berdi (from Hungary), Josphat Nguu (from Kenya) and Sarah Caven (from Northern Ireland).

Additional Key Programmes Relevant to iCRAG that Support EU Research, Development and Innovation

European Union Space Programme

The European Commission has proposed a total budget allocation of €16 billion to finance space activities in the period 2021-2027. The key aims of this ambitious new space programme

are to secure EU leadership in space activities and foster innovative industries. Whilst the bulk of the funding is earmarked for Satellite Navigation Systems, a projected €5.5 billion will be allocated to Copernicus, the European Union's Earth Observation programme. Earth Observation is a key element of current and future activity in iCRAG, particularly through its 'Observatory Ireland' initiative, exposing strong synergies with the goals of the Space Programme. The Commission's desire to foster innovative industrial applications of space-based technology also maps to the ambitions of iCRAG industry partners (e.g. Transport Infrastructure Ireland) as they seek novel methodologies for risk mitigation. iCRAG's early interventions using Copernicus Sentinel data are already opening new horizons for industry in how to reduce risks associated with infrastructure failure.

Digital Europe Programme

The Digital Europe programme will support the digital transformation of Europe's societies and economies. Launching in 2021 it will include provision of funding (€9.2 billion) for projects in five key areas: supercomputing, artificial intelligence, cybersecurity, advanced digital skills and ensuring wide use of digital technologies across the economy and society. Three of these areas directly impact Earth System Science research and the way in which we fold society into our research programmes. iCRAG has a rapidly growing appetite for computation as we build more sophisticated multi-physical-chemical interactions models, in order to make more accurate estimates of the future. In parallel iCRAG scientists are looking to Artificial Intelligence in the search for correlations in large multi-disciplinary datasets, to extract hidden information of societal and industrial value. The citizen as a science collaborator, a key objective in iCRAG, requires widespread use of digital technologies in society, as envisaged by Digital Europe. iCRAG will be an enthusiastic partner in the Digital Europe Programme

European Regional Development Fund (ERDF)

From 2021 the European Regional Development Fund (ERDF) will focus on research and development and innovation to promote synergies with, and follow on from, Horizon 2020 and connect with Horizon Europe. iCRAG can play an important role in achieving these objectives in Ireland and elsewhere in Europe, including in the newer EU Member States that have a higher level of ERDF funding. In Ireland, the EU Commission reports that synergies between Horizon 2020 and ERDF funds have been poor in the past. This presents a ready opportunity for iCRAG to extend funding options as well as supporting key EU objectives at national level.

Neighbourhood, Development, International Cooperation (NDICI)

The 'Neighbourhood, Development and International Cooperation Instrument' is aimed at promoting the EU's interests, objectives and values in neighbouring and partner countries. The programme will contain:

- **Geographic programmes** (GPs). The GPs will receive the most amount of funding from the NDICI and are set to be carried out through multiannual and multi-country programmes. The programming documents for the GPs are expected to be built on strategies and objectives, for example national or regional development plans. Funds are expected to be distributed to the following regions: Neighbourhood, Sub-Saharan Africa, Asia and the Pacific, as well as Americas and the Caribbean.

- **Thematic programmes**. These will provide financial support to Human Rights & Democracy, Stability Peace, and the SDGs. The global challenges element of this theme is expected to have a budget of €3 billion for climate change and environment projects.
- **Rapid Response Programme.** This programme will allow for quick responses, to enable the EU to (i) contribute to stability and conflict prevention in situations of urgency, in emerging crisis, in crisis and in post-crisis situations; (ii) contribute to strengthening resilience of states, societies, communities and individuals, and to linking humanitarian aid and development action; and (iii) more generally address foreign policy needs and priorities.

iCRAG is conducting geological research on raw materials throughout southern Africa. We will utilize our exiting knowledge and collaborations to work with **The Neighbourhood, Development and International Cooperation Instrument (NDICI)** to address challenges, to Africa and Europe.

iCRAG Recommendations:

1 Establish an EU Earth Systems Observatory

The observatory model developed for Ireland can be applied at European Union level. This could be achieved through a research infrastructure mechanism or similar amalgamation of European Union actors and stakeholders, who together can create a reference \observatory in order to supply the European Union with valuable and timely information and data, including that necessary for policy-making and programme evaluation.

This observatory infrastructure will be crucial to European research through the specific partnerships and missions including Horizon Europe which iCRAG can support with added value intelligence and analysis, therefore becoming a service provider. This will be explored within the context of the proposed Horizon Europe missions and institutionalised partnerships

2 Develop an ESFRI research infrastructure

ESFRI continues to be an important structure to support collaborative research in the European Union. The current roadmap contains more than 100 infrastructures at different stages of development. However, none of the existing or proposed research infrastructures provide the comprehensive observatory approach and function that iCRAG provides. This suggests that a mechanism could be created to link iCRAG with a range of ESFRI roadmap infrastructures to enhance the ESFRI value proposition. The value proposition will also be defined with reference to the missions and to institutionalised partnerships, including Europe's response to the SDGs

3 Promote a data cloud for earth systems

The European Commission aims to create a fit-for-purpose pan-European federation of research data infrastructures, with a view to moving to a situation where data is easy to store, find, share and re-use. The current implementation roadmap gives and overview of six actions lines for the implementation of the European Open Science Cloud (EOSC): architecture, data, services, access and interfaces, rules and governance. This presents an opportunity for iCRAG to both develop an earth systems data cloud compliant with EOSC as well as developing connections to other thematic data domains, such as climate, environment, amongst others. This will allow iCRAG to have a structured engagement and to have an observatory approach to the EOSC.

This would become increasingly important as Horizon Europe evolves and increasingly differentiated data is placed in EOSC. iCRAG is moving to collaborate with data analytics and machine learning experts in Ireland as its data production increases. Both machine learning and

artificial intelligence will play an important role in how iCRAG can contribute to this emerging and increasingly important data infrastructure, enabling more extensive research collaborations and outputs for earth systems research.

4 Explore Mechanisms to link EDRF and Horizon Europe

The Commission services have made clear that the next generation of the ERDF will be more intimately linked with the Horizon Europe programme. Specifically, the Commission want two thirds of future ERDF funds to be dedicated to supporting innovation and used to extend and add value to initiatives developed in Horizon Europe. iCRAG can work with relevant Irish authorities in this area. This model may be applicable to newer EU member states that have a higher level of ERDF funding.

5 Links and collaboration with Africa

International cooperation will feature more in Horizon Europe than in any previous framework programme. In addition, science is becoming relevant to many international cooperation initiatives advance by the European Union. The most striking example of this is the importance given to science in the Commission's proposal for the forthcoming Neighbourhood Development, International Cooperation Instrument (NDICI) which will form the main engagement platform for relations with Africa. The last European Union-African Union summit gave prominence to science as a driver for economic development in Africa. In addition, South Africa has a dedicated science and technology cooperation agreement with European Union and iCRAG will contribute to its implementation through a range of cooperation activities and data and best practice sharing. As part of its engagement in southern Africa iCRAG will explore whether to develop its Observatory model to support the implementation of the NDICI.

6 Provide SDG Implementation Mechanism

The European Union will develop strong links and collaborations with the United Nations SDGs. This is clear in the commitment to the SDGs in many policy areas including Horizon Europe. Europe will have a strong presence at the SDG summit which takes place within the context of the United Nations General Assembly (UNGA) in September 2019. The European Union recognises the contribution of science in attaining the SDGs. iCRAG can contribute to this process by extending its Observatory to the implementation of the SDGs involving climate change, water, soil, the environment, including the built environment, energy and raw materials. This will be done in cooperation with the European Union, in effect extending the European open science cloud and research infrastructure approach to include the SDGs. This will also form part of Ireland's whole of government policy initiative, *A Better World*, which outlines Ireland's vision of a more equal, peaceful and sustainable world.

iCRAG EU roadmap 2019 – 2020

July

- Circulation of iCRAG White Paper to MEPs, Commission and Council officials and incoming members of the European Parliament in advance of the Strategic Planning process for Horizon Europe
- Contact with EU institution working group involved with the Horizon Europe Strategic Planning process
- Develop iCRAG input to Irish Delegation's Contribution at UN SDG Summit, UNGA taking place in September 2019

August

- Consolidate strategic partnerships in anticipation of Horizon Europe.

September

- iCRAG concept model for supporting the SDGs
- Aim to have iCRAG included in the Irish Government's intervention at the UN SDG Summit
- iCRAG attendance at the 24th to 26 September meeting where the Mission boards will be announced

December

- iCRAG 2019 conference in Dublin to highlight iCRAG achievements and future goals for Irish MEPs and others.

January 2020

- iCRAG Horizon Europe seminar to promote iCRAG's future partnerships for Horizon Europe and investigate means for iCRAG to join other planned initiatives

iCRAG welcomes inquiries about any aspect of its activities, including from potential research partners and from policymakers who are interested in how Earth Systems science is evolving.

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