British Geological Survey

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Year 4 progress report for the BGS International Geoscience R&D programme

K Upton, CJ Mitchell, J Williams, S Sargeant, & MJ Watts

Editor

M Heintz

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British Geological Survey offices

Nicker Hill, Keyworth,
Nottingham NG12 5GG
Tel 0115 936 3100

BGS Central Enquiries Desk
Tel 0115 936 3143
email enquiries@bgs.ac.uk

BGS Sales
Tel 0115 936 3241
email sales@bgs.ac.uk

The Lyell Centre, Research Avenue South,
Edinburgh EH14 4AP
Tel 0131 667 1000
email scotsales@bgs.ac.uk

Natural History Museum, Cromwell Road,
London SW7 5BD
Tel 020 7589 4090
Tel 020 7942 5344/45
email bgslondonstaff@bgs.ac.uk

Cardiff University, Main Building, Park Place,
Cardiff CF10 3AT
Tel 029 2167 4280

Geological Survey of Northern Ireland, 7th Floor,
Adelaide House, 39-49 Adelaide Street, Belfast, BT2 8FD
Tel 0289 038 8462
www2.bgs.ac.uk/gsni/

Natural Environment Research Council, Polaris House,
North Star Avenue, Swindon SN2 1EU
Tel 01793 411500 Fax 01793 411501
www.nerc.ac.uk

UK Research and Innovation, Polaris House,
Swindon SN2 1FL
Tel 01793 444000
www.ukri.org

Website: https://www.bgs.ac.uk
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Executive Summary

Purpose of this report

This report provides an overview of the achievements of the NERC National Capability (NC) funded BGS International Geoscience Research and Development (IGRD) programme. The IGRD programme ran from 2022-26 with a budget of ~£8.1M.

The IGRD Programme

The intended impact of BGS' IGRD programme (see Section 1) was to facilitate the sustainable use and secure supply of Earth's natural resources and increased community resilience to natural and anthropogenic hazards. The programme's multifaceted pathways to impact are outlined in a Theory of Change (ToC) (see Appendix 1), which defined how the programme aimed to transition from a series of outputs, through to outcomes and, ultimately, the long-term impact that the programme sought to contribute towards. This ToC provided the basis for a logical framework (Logframe) against which progress is monitored and evaluated (see Section 3 and Appendix 3).

Progress and outcomes to end of Year 4

During Year 4 of the programme, there were significant scientific advances and a clear shift along the project pathways to impact with around 40 evolving stories of change to partner capacity and stakeholder decisions, policy, and practice – both in the country of focus and beyond.

There is growing evidence of **research uptake by partners and external stakeholders,** including the application of models and tools to inform decision-making and influence on national policy and practice. An increasing number of projects are demonstrating **influence and outcomes at a global scale**, i.e. beyond an individual country of interest, including the translation of BGS tools and expertise to different global contexts, provision of expert advice through participation in global networks and international events, and citation of IGRD research in global policy and practice documents. **Section 3.2 of the report** provides a synthesis of the key outcome successes in Year 4.

The **research evidence base created by the programme continued to expand** through the publication of academic and non-academic outputs, focussed on communication and uptake of science across the challenge areas. At the close of the programme, there were 77 academic publications, which have been cited more than 2000 times within the wider academic literature, 33 non-academic outputs (e.g. policy briefs and blogs), 149 presentations at conferences and workshops, 29 data products and tools, 63 secondments of partners and their students to BGS, and >300 engagement activities with partners and external stakeholders made by the programme. **Section 3.3 of the report** provides a full breakdown of the number and types of outputs delivered cumulatively to Year 4.

The IGRD programme helped to leverage >£16M of **new funding to grow and extend aligned research** activities with partners globally (principally in Africa, Asia, Europe), with several more proposals of ~£2M pending a decision. This includes funding from UK Government departments (e.g. FCDO), UKRI programmes, international development banks, UN agencies, and commissioned research, demonstrating strong confidence in the programme's approach and enabling continuation and scaling of key research themes.

IGRD Partnerships

Partnerships have been key to the success of the IGRD programme. During Year 4, there was a focus on understanding our partners' perspectives of working with BGS, and of the outcomes the programme has had on them personally, their organisations, and more broadly in-country. Feedback from partners, obtained through a survey and online workshop, highlighted several common themes which describe the experience of working with BGS. These included friendship, continuity, impactful research, and connecting stakeholders – from the community level to national or international decision makers. The key message from our partners is that: *"sustained partnerships, not short-term projects, deliver lasting scientific, policy and societal impact"*.

Structure of the Report

Section 1 of this report provides an overview of the IGRD programme, its theory of change, mechanisms for delivery, and the monitoring, evaluation and learning (MEL) process. Key highlights of the programme are provided in Section 2, which are elaborated in Sections 3 and 4 of the report. Section 3 provides a report against the programme's logical framework, providing specific examples of outcomes and outputs and demonstrating how these have evolved over the four-year duration of the programme. Section 4 provides a summary of the programme's successes under the themes of multi-hazard resilience, sustainable resources and energy transition, and water, land and urban resilience. Section 5 presents the results of a partnership summary and key messages from our partners on the successes of the IGRD programme. Section 6 of the report provides a forward look.

1 Overview of the IGRD Programme

The IGRD programme was funded from the NERC NC International initiative from 2022-2026. The budget for the programme was £8.1M. The programme aimed to facilitate the sustainable use and secure supply of Earth's natural resources and increase community resilience to natural and anthropogenic hazards by addressing three global environmental challenges: (1) adaptation and resilience to natural hazards; (2) sustainable and secure resources for the future; and (3) sustainable land management and climate change adaptation.

To respond and deliver solutions to these challenges, the programme was organised into three corresponding Research and Innovation Challenges (RICs), each with clearly defined goals:

- RIC 1 Living in multi-hazard environments: Geoscience data, information and knowledge are used to improve the detection and forecasting of hazards, and understanding of multi-hazard environments, to support disaster risk management (DRM).

- RIC 2 Resources for the future: Geoscience data, information and knowledge are used to determine how global demand for resources (water, food, energy, minerals) can be met with minimal environmental and social impact, while addressing the energy transition to net-zero.

- RIC 3 Sustainable land management and climate change adaptation: Geoscience data, information and knowledge are used to provide solutions to counter the negative impacts of land use change and urban development and help communities adapt to climate change.

Each of the RICs comprised of several projects, each with their own research questions, novel research methodologies and geographical focus, which contributed to the objectives outlined above. Projects were co-designed with partners in locations where the environmental, societal and policy context made them most relevant to the challenge being addressed to generate outcomes for local practitioners while also providing the basis for translation to global impact where appropriate. Several projects explicitly built on previous initiatives delivered during BGS' precursor 'Geoscience for Sustainable Futures' (GSF) NC programme, which ran from 2018 to 2022. The GSF programme had an explicit focus on Official Development Assistance (ODA), whereas IGRD sought to deliver research excellence that could be nationally/ internationally translatable, while also responding to NERC's ODA commitments. The rest of the projects were based on BGS staff collaborations and/or existing commissioned projects, all with varying degrees of in-depth collaboration and shared history. All projects aligned to the BGS strategy and to the 2021 UK Government review of international priorities (Global Britain in a competitive age, 2021).

A key requirement of the IGRD programme was the delivery of global public good, whereby science is undertaken to serve common interests and produce public value from which many individually benefit. The International Science Council defines two key attributes of science as a global public good: "… that knowledge claims and the evidence on which they are based are made openly available to scrutiny, and that the results of scientific research are communicated promptly and efficiently so that all who may wish or need to access those results can do so."[1]

[1] Boulton, G.S. 2021. Science as a Global Public Good. International Science Council Position Paper, 21pp

This was delivered by the programme through the generation of openly available data, tools and evidence that can be applied beyond individual projects or geographies. This includes informing international policy frameworks, supporting low- and middle-income countries in decision-making, and enabling equitable access to geoscience knowledge to address shared environmental challenges.

Recognising the inherent synergies and overlaps across the three RICs, mechanisms were in place to facilitate cross-programme exchange and learning throughout the programme. This was achieved through biannual in-person workshops, supported by a team of experienced Co-Investigators with expertise in particular geographical settings or areas of science that connect the RICs described above.

Pathways towards achieving the aims and objectives described above are outlined in a programme Theory of Change (ToC) - see Figure 1 and Appendix 1. The ToC defined how the programme intended to transition from delivering a series of outputs, to a series of outcomes, whereby programme outputs could be used by partners and external stakeholders to inform decision making and practice, whether at a sub-national, national or international level. These outcomes were one of many prerequisites for achieving the desired impact and are the primary focus for evaluating success of the programme, recognising that impact is likely only measurable over much longer timescales and is dependent on a wider array of interventions (political, socio-economic, environmental etc) than can be delivered by BGS alone. The chance of achieving lasting impact will be maximised by activities designed to translate findings and outcomes to a wider audience, building on our links to international initiatives, overseas governments, supported by key links to UK Government, e.g. Foreign, Commonwealth & Development Office (FCDO); global financial initiatives, e.g. World Bank and Bill & Melinda Gates Foundation; and long-standing involvement in multi-lateral organisations, e.g. Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP), Food and Agriculture Organization of the United Nations (FAO-UN), and the African Ministers' Council on Water (AMCOW).

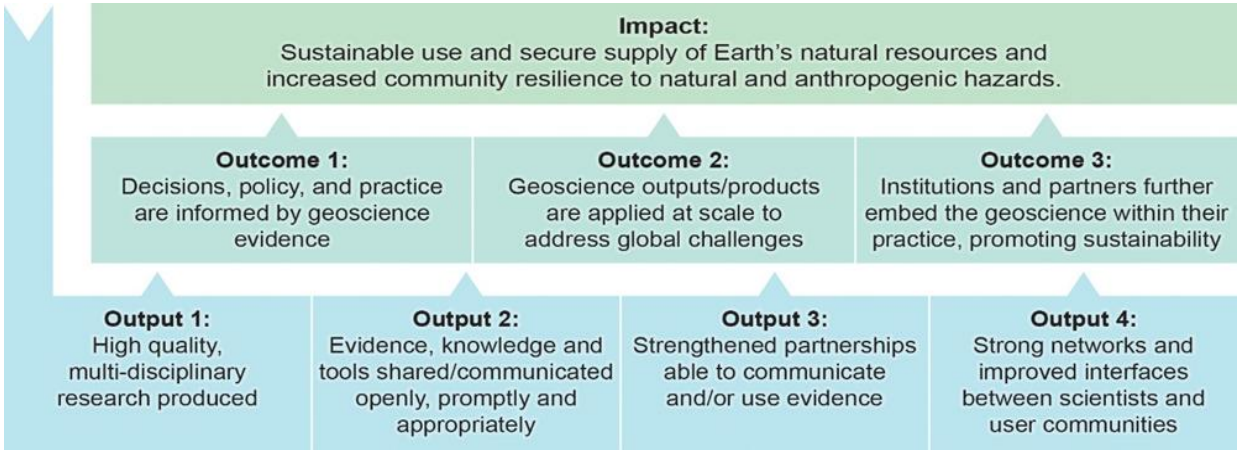


Figure 1. Summary of IGRD Theory of Change

Staff from across BGS contributed, to varying degrees, across the four years of the IGRD programme, spanning the full breadth of BGS capability. It was designed in consultation with staff and the BGS senior leadership team with activities that complement and support the BGS strategy. A leadership team managed the finances, staff resourcing and project activities within the three RICs. A small group of Co-Investigators (Co-I) assisted the management team in the

programme design and during the first two years of the programme to identify synergies between projects and effective ways to achieve outcomes in the wider geoscience community.

Monitoring, Evaluation and Learning (MEL) for the programme was a continuous process (explained further in Appendix 2), guided by the ToC. The ToC formed the basis for a Logframe (see Appendix 3), which defined a series of indicators against which qualitative and quantitative evidence was collected. This was used to measure progress, highlight successes, identify areas for improvement, and guide year-on-year resourcing. In 2025/ 26, two programme-wide workshops were held: the first in September 2025 was aimed to reshape the programme to bid for a one-year extension to NERC for funding, with a budget of ~£1M, by coalescing the diverse activities into three hub projects to promote inter-disciplinary geoscience packages to stakeholders. The second, in March 2026, aimed to celebrate four years of partnerships and progress, comprising short video testimonials from our IGRD project partners to discuss the benefits of international collaboration for achieving lasting outcomes.

2 IGRD highlights

Year 4 marked the successful culmination of the IGRD programme, which has delivered world-leading geoscience research with clear evidence of uptake into policy and practice, application at regional and global scales, strengthened international partnerships, and more than £16M of leveraged funding to extend impact.

Under the theme of multi-hazard resilience, the programme made significant advances into the detection and understanding of hazards, enabling better disaster preparedness and response. AI approaches were developed and applied for earthquake detection and landslide and subsidence mapping, while new datasets and models were developed for multi-hazard environments such as Indonesia and the UK Overseas Territories. Examples of uptake include application to inform decision-making during the response to the Santorini seismic crisis, contributions to Indonesia's national seismic hazard model, and input into global frameworks and guidance through engagement with partners such as UNESCO, UNDRR and WMO. See Sections 3.2, 4.1 and 4.2 for further detail.

The programme provided geoscience evidence to support sustainable resource extraction and net zero energy systems through the development of new monitoring tools for mine waste and tailings stability, improved understanding of critical minerals, novel approaches for geothermal exploration, and earth observation methods to quantify global sand use and material flows. Examples of uptake include input to the Zambian National Critical Minerals Strategy, contribution to India's CCUS roadmap, and increased visibility in global policy and practice on sustainable resource management through engagement with partners such as UNEP and UNECE. See Sections 3.2, 4.3 and 4.4 for further detail.

Through the development of novel monitoring, mapping, and modelling approaches, the programme generated a body of evidence that supports sustainable land and water management and resilient urban development under climate change. New groundwater mapping and modelling approaches were developed and subsequently applied through multiple UNICEF and World Bank funded projects. Advances in our understanding of waterpoint functionality informed global initiatives aimed at improving rural water service provision. Novel workflows for modelling urban geology were applied in rapidly urbanising settings, and multi-stakeholder platforms enabled new approaches to land management and translation of learning to new contexts. See Sections 3.2, 4.5, 4.6 and 4.7 for further detail.

A key highlight of the IGRD programme has been the breadth and depth of partnerships that has enabled scientific excellence and translation of scientific evidence into outcomes across multiple scales. This was evident in the feedback from our partners, which highlighted how the programme has delivered impactful international geoscience collaboration dependent on long-term relationships and trust, shared ownership and co-design, capacity building and knowledge exchange, strong science-policy integration, and investment in future generations of researchers. See Section 5 for further detail.

3 Logframe Report

3.1 IMPACT

In responding to the global challenges described above (see Section 1), the long-term impact that the IGRD programme aims to contribute towards is:

Sustainable use and secure supply of Earth's natural resources and increased community resilience to natural and anthropogenic hazards in: (1) the urbanising world; (2) resource rich emerging economies; and (3) communities on the climate change frontline.

This impact spans across BGS' capabilities within the geosciences, reflected in the range of projects and tasks within the programme, and across a broad spectrum of beneficiaries, reflected in the range of partners involved in the research. Narratives towards achieving the intended impact, where the IGRD programme played a significant role in effecting change, are developing in several key thematic areas, as described in Section 6 above. Progress towards impact was monitored as part of the ongoing MEL process, however, evaluation was primarily undertaken at the outcome level, recognising that impact are likely to happen over much longer timescales due to a wider array of interventions (political, socio-economic, environmental etc).

3.2 OUTCOMES

The IGRD programme worked towards three key outcomes that focused on the uptake and use of IGRD research by various stakeholders, providing multiple pathways towards achieving the impact described above. Further description of these outcomes within the context of the three RICs is provided in the ToC (Appendix 1). Within each outcome, progress is being monitored against a series of indicators, as outlined below. Detailed evidence for each indicator can be found in the full Logframe document.

Table 1. IGRD programme outcomes

Outcome	Indicator	Number delivered Year 1	Number delivered Year 2[1]	Number delivered Year 3[1]	Number delivered Year 4[1]
O1. Decisions, policy and practice are informed by geoscience	O1.1. Number of citations of IGRD research (papers / datasets / tools / reports) within policy or practice documents	0	1	2	3
	O1.2. Number of media reports (written articles, TV, radio) mentioning IGRD research	7+[2]	19+[2]	77+[2]	282+[2]
	O1.3. Number of stories of change to stakeholder decisions, policy, practice, or public awareness / understanding of an issue influenced by IGRD research	0	2	8	10
	O1.3a. Number of *developing* stories of change to stakeholder decisions, policy, practice, or public awareness / understanding of an issue influenced by IGRD research	5 (5)[3]	19	10	3

O2. Geoscience research is applied at scale to address global challenges	O2.1. Number of citations of IGRD research (papers / datasets / tools / reports) within policy or practice documents *beyond project localities*	3	4	5	9
	O2.2. Number of academic citations	n/a[4]	330	1,150	2,164
	O2.3. Number of stories of change to stakeholder decisions, policy, practice, or public awareness / understanding of an issue *beyond project localities influenced* by IGRD research	0	5	12	12
	O2.3a. Number of *developing* stories of change to stakeholder decisions, policy, practice, or public awareness / understanding of an issue *beyond project localities* influenced by IGRD research	9 (4)	5	7	1
O3. Institutions and partners further embed the geoscience within their practice, promoting sustainability	O3.1. Number of partners who report a change in their capacity (e.g. stronger networks/additional funding success/position of responsibility/ research outputs)	n/a[4]	23 (100% of respondents)	n/a[4]	21 (100% of respondents)
	O3.2. Number of instances of participation (by partners) in relevant stakeholder meetings / forums[5]	*n/a*	*n/a*	*n/a*	*n/a*
	O3.3. Number of stories of change to the capacity or working practices of institutions and partners as a result of IGRD research	3	8	15	12
	O3.3a. Number of *developing* stories of change to the capacity or working practices of institutions and partners as a result of IGRD research	6 (2)	15	5	1

[1]note numbers are cumulative; [2]this evidence relies on project reporting and BGS media monitoring, but issues with monitoring for international media mean numbers are likely underestimated; [3]a(b): a is the number of developing stories of change with clear pathways to outcome/impact; b is the number of potential developing stories of change where the pathway to impact is less clear; [4]not monitored in Years 1 and 3; [5]indicator removed as project partners are generally involved in all project stakeholder meetings.

At the outcome level, all active projects have demonstrated pathways to impact, with evidence of **research uptake by partners and external stakeholders.** Overall, there was an increase in the number of citations of IGRD research across academia, policy, and the media. The reduction in the number of stories of change reported in Year 4 reflects the discontinuation of projects within the context of funding reductions. Across all active projects, partnerships and networks continued to strengthen in Year 4 and additional funding has been leveraged to allow the expansion of work beyond IGRD. Some examples of research uptake by partners and external stakeholders are summarised below.

Application of models and tools to inform decision making

1) The AI for Seismology methodology was applied during the Santorini seismic crisis that began at the start of 2025. It provided new insights into the physical processes driving the earthquakes, which helped to inform disaster management decision making for the island.
2) BGS' PRIME system has been purchased and installed by UNITEN on a critical slope above one of the largest hydroelectric dams in Malaysia, allowing risk assessment and mitigation of slope failure to protect power generation and downstream populations.
3) Salinity data from the Indo Gangetic Basin, alongside salinity work in Africa, is contributing to a new global groundwater salinity map being developed by UNESCO's International Groundwater Resource Assessment Centre
4) Landslide mapping portal developed in IGRD is being applied in another FCDO project, which is enabling landslide tracking alongside an estimation of impact.

Influence on national policy and practice

1) BGS led the publication of an FCDO-supported White Paper on UK-Indonesia partnerships for advancing geohazard science for disaster risk assessment in Indonesia and as a result were invited to be on the scientific advisory board for the Integrated Disaster Risk Management (IDRiM) Society meeting to be hosted in Indonesia (Bali) in 2026
2) The Govt. of India's Department of Science and Technology (DST) published its Research and Development Roadmap for CCUS with the identified research priorities for CO2 storage heavily inspired by BGS' work with the DST-funded Centre of Excellence in CCUS at the Indian Institute of Technology Bombay, who led development of the geological storage aspects of the report. India recently announced significant funding of c. £1.6 bn to develop its CCUS programme, and the roadmap will be key to identify prioritised research topics to support the implementation programme. Furthermore, on the strength of BGS' collaborative relationships with key organisations in India, the British High Commission opted to include a new CCS pillar within the Net Zero Innovation Partnership, a joint Indo-UK partnership.
3) Following specific reference to graphite (and BGS) in the UK-Zambia Memorandum of Understanding on critical minerals, and by President Hakainde Hichilema in his address to the Mining Indaba in Cape Town in February 2024, IGRD and related FCDO-funded research into graphite and critical minerals in Zambia informed the Zambian National Critical Minerals Strategy, which was published in mid-2024. In 2026, BGS delivered a briefing on critical minerals to the British High Commission who supported the launch of the Critical Minerals for Zambia guide in Lusaka in February 2026. The guide is likely to form a key tool in the development of critical minerals policy in Zambia.

Several projects are demonstrating **influence and outcomes at a global scale**, i.e. beyond an individual country of interest, which has been enabled by strengthened collaboration across the programme. Examples are provided below.

Translation of BGS tools and expertise to different global contexts

1) BGS contributed to the to the high profile 'Sand and Sustainability' report published by the United Nations Environment Programme (UNEP) report, which provides a key document for informing policy and best practice for sand and aggregate extraction.
2) Strong collaboration across the programme is developing new opportunities for earth observation and hazard science to inform dynamic multi-hazard risk assessment across different geographies. For example, novel methodologies developed under IGRD for

assessing landslide hazards are now being incorporated into work in the Philippines and Malaysia, while the UK Mining Remediation Authority have requested training on the use of ground motion data to monitor coal field hazards.

3) IGRD research on mine waste in the Philippines has led to discussions with the Council of Scientific and Industrial Research (CSIR) in India to explore collaboration on sustainable mining and processing of chromite ore.
4) BGS' groundwater mapping methodology, developed for basement aquifers in Africa under the IGRD programme, is being extended and applied to map groundwater potential across East Africa under work funded by UNICEF, the World Bank, and BGR.
5) A major new publication on water point functionality is informing the preparation of a handbook and guidelines on handpump borehole diagnostics for rural water supply through the Stop the Rot project.
6) Through engagement with the NGO Train My Generation, understanding from the Winam Gulf (Kenya) of the significance of soil erosion and land to lake transfers of sediment for lake ecological health is being translated across the Lake Victoria Basin in East Africa.
7) Through engagement with CCOP, BGS tools, methodologies and workflows for 3D geological modelling are being applied in Malaysia and South Korea. Opportunities for translating work on sand and sustainability and landslide trigger thresholds to Malaysia are also being explored through engagement with CCOP.

Provision of expert advice through participation in global networks and advisory groups, for example:

- European Volcano Observatory Network, which BGS helped to establish, to move towards harmonized reporting of volcanic hazards; ARISTOTLE advisory group; WMO Ash Advisory Group; and International Civil Aviation Organisation.
- UNESCO working group on urban subsidence
- UN Economic and Social Commission for Asia and the Pacific (ESCAP) and UN-Habitat Sinking Cities Community of Practice
- UNECE UK International Centre of Excellence on Sustainable Resource Management (UK ICE-SRM)
- International Lithium Association (ILiA), including work on a guidance document on assessing the water use impacts of lithium production which will be key for informing policy development
- Lake Victoria Advisory Group
- Global Soil Partnership of the FAO-UN
- CCOP (BGS has been elected co-Chair of the CCOP advisory group and member of the steering committee from 2026) and the EGS Urban Geology Expert Group
- Global advisory group on groundwater capacity building; advisory group to GEF-funded Groundwater for Deep Resilience in Africa project and World Bank-funded Horn of Africa Groundwater for Resilience programme; and AMCOW's Strategic Continental Groundwater Programme.

Citation of BGS research in **global policy and practice, the wider academic literature** and **media reports**, for example:

- In their regional and continental consultations on the post-2025 Africa Water Vision and Strategic Continental Groundwater Programme, AMCOW highlight BGS as a key international partner and cite the Africa Groundwater Atlas as an important resource that should be maintained to support sustainable groundwater development on the continent.

- Academic publications from the IGRD programme have now been cited more than 2000 times in the wider academic literature.
- IGRD work was featured in numerous media reports, particularly related to critical minerals in Zambia.

Overall, there have been 55 successful **funding applications to grow and extend research activities**, leveraged from the IGRD programme – some of which are BGS-led, while others are led by partners – and examples of partners attracting their own funding, expanding their capacity to carry out aligned work. This equates to £16.3M overall and £7.1M directly to BGS.

3.3 OUTPUTS

The IGRD programme worked towards four key outputs that build the foundation for achieving outcomes and impact, from the scientific evidence base to the partnerships needed to translate that evidence for uptake to effect change. Further description of these outputs is provided in the ToC (Appendix 1). Within each output, progress was monitored against a series of indicators, as outlined below. Detailed evidence for each indicator can be found in the full Logframe document.

Table 2. IGRD programme outputs - [1]note numbers are cumulative

Output	Indicator	Number delivered Year 1	Number delivered Year 2[1]	Number delivered Year 3[1]	Number delivered Year 4[1]
P1. High quality, multi-disciplinary research is produced by the IGRD programme	P1.1. Number of academic publications	9	36	55	77
	P1.2. Number of products and tools	2	6	16	29
P2. Dissemination of research	P2.1. Number of non-academic outputs (e.g. policy briefs, webpages, blogs)	1	14	25	33
	P2.2. Number of presentations at conferences / workshops	25	89	130	149
P3. Strengthened partnerships able to communicate and/or use evidence	P3.1. Number of collaborations and partners	tbc	59	No update	52
	P3.2. Number of co-produced outputs and activities (including partner meetings, training and capacity building activities)	34	56	57	67
P4. Strong networks and improved interfaces between scientists and user communities	P4.1. Number of external stakeholder workshops and networks engaged with	46	126	230	263

As is evident in the table above, the research evidence base expanded further in Year 4 with 22 new journal articles, 19 additional presentations at conferences and workshops, and the release of 13 new products and tools. The 77 papers now published by the programme have been cited >2000 times within the wider academic literature (as of March 2026). There were 10 co-produced partnership activities, such as meetings, workshops and capacity building activities (although this is likely underestimated due to a lack of reporting of smaller partnership meetings/activities), and 33 new external engagement activities in Year 4, which are generally attended by BGS staff and partners.

3.4 CHALLENGES

Several common challenges were identified by researchers within the IGRD programme during Years 3 and 4. These included:

- technical difficulties and data sensitivities
- keeping momentum with partners, particularly where there is a high turnover of staff in partner institutions
- the time required to manage complex stakeholder relationships, and
- addressing complex issues and working within socioeconomic and/or geopolitical contexts where geoscience is one (often minor) component.

Many of these challenges were foreseen within the project pathway to impact plans and programme risk register; however, where unforeseen challenges have arisen, project leads were supported by the IGRD management team to manage and mitigate any associated risks. Due to budget reductions, some of these challenges became more acute during Years 3 and 4 of the programme.

4 Thematic Narratives

The narratives below provide a summary of the key scientific advancements, outcomes and uptake of the programme. Longer narratives, which have been developed over the duration of the four-year programme are provided in Appendix 4.

4.1 RIC 1: NOVEL DETECTION AND FORECASTING OF HAZARDS

Over the course of the programme, RIC1 has demonstrated how advances in data-rich geoscience and artificial intelligence are transforming the detection, forecasting and understanding of natural hazards, enabling faster, more accurate and more actionable information for disaster risk management globally.

Significant technical advances were achieved through the development and application of machine learning (ML) and deep learning (DL) approaches to large geoscience datasets. In seismology, DL-based workflows were developed and deployed in both cloud-based and on-premises environments, enabling near-real-time processing of seismic data across diverse settings, including high seismicity (Italy) and lower seismicity (UK) environments. These approaches can detect up to an order of magnitude more earthquakes than traditional methods, providing substantially enhanced earthquake catalogues and improving understanding of seismic processes.

Comparable advances were made in the analysis of Earth Observation data. ML-based approaches have enabled automated detection and monitoring of processes such as subsidence and landslides at unprecedented spatial and temporal scales. Libraries of subsidence signals were developed and applied in cities across Southeast Asia, enabling identification of hazard patterns in rapidly urbanising environments. Similarly, automated landslide detection from satellite imagery has allowed rapid generation of landslide inventories following major events, supporting emergency response and recovery.

These technical developments have translated into clear outcomes and uptake. ML-based seismic analysis was applied during the 2025 Santorini seismic crisis, providing insights into earthquake processes that informed decision-making by authorities. Landslide mapping tools have been adopted in FCDO-funded projects to support hazard assessment and response, while subsidence research has contributed to international initiatives such as UNESCO's Land Subsidence International Initiative (LaSII). Across these applications, the ability to rapidly generate and interpret large datasets has supported more informed and timely risk management decisions.

The work has also catalysed significant partnerships and future research opportunities. Engagement with international organisations, including UNESCO, the European Environment Agency and UN initiatives such as the Sinking Cities Community of Practice, has strengthened pathways to global impact. The research has also underpinned new funding opportunities, including large collaborative proposals and follow-on projects, and has stimulated multiple new research activities within BGS and with external partners. Overall, RIC1 has established a transferable and scalable framework for applying data-driven approaches to hazard detection and forecasting across diverse global contexts.

4.2 RIC 1: UNDERSTANDING AND MANAGING MULTI-HAZARD INTERACTIONS

RIC1 has also demonstrated how integrated, multi-hazard geoscience can support decision-making across scales, from local disaster response to national planning and global risk frameworks, by making geoscience information more accessible, usable and embedded in practice.

The programme generated high-quality, collaborative science focused on understanding complex hazard interactions, particularly in multi-hazard environments such as Indonesia and volcanic island settings. Research in Indonesia improved understanding of seismic hazards, volcanic activity and cascading hazard processes, including development of improved GNSS

monitoring approaches and new hazard models for volcanic flows. In parallel, work in UK Overseas Territories (UKOTs) developed baseline datasets, geological mapping and seismic catalogues to support hazard assessment and planning.

At the global scale, the Global Reporting project advanced methodologies for capturing, analysing and communicating volcano-tectonic activity and its impacts. This included contributions to international guidance and reporting frameworks, enhancing the availability and use of hazard information for global stakeholders.

These activities have resulted in clear outcomes. Research outputs have directly informed national-level decision-making, including contributions to Indonesia's national seismic hazard model and hazard communication strategies. In UKOTs, new evidence has supported scenario planning and land-use decision-making. At the international level, the work has contributed to global systems and guidance, including input to UN hazard frameworks and aviation safety protocols.

RIC1 has also demonstrated strong influence beyond individual project locations. The approach to multi-hazard assessment and communication is being applied in other geographical contexts, and the tools and methodologies developed are being taken forward through new research and operational activities. The programme has also supported emergency responses, for example in Ethiopia and Guatemala, demonstrating the practical value of its approaches in crisis situations.

This work has been underpinned by strong partnerships and has generated significant new opportunities. It has contributed to major new funding awards, including a £2.3M programme with FCDO, and strengthened collaborations with international organisations and national agencies. Engagement with global networks, including the UN Global Platform and emerging initiatives such as GeoRiskNet, has positioned BGS and its partners as leaders in multi-hazard risk understanding and communication. Overall, the RIC has demonstrated how integrated geoscience can move from research to real-world application in disaster risk management.

4.3 RIC 2: STRATEGIES FOR SUSTAINABLE MINING AND RAW MATERIAL SUPPLY

RIC2 has demonstrated how geoscience can support responsible and sustainable resource development, providing the evidence base required to balance resource demand with environmental and social considerations, particularly in the context of the global energy transition.

The programme delivered significant advances in understanding mineral systems, mine waste and material flows. In the Philippines, innovative geophysical monitoring (PRIME technology) was deployed to monitor tailings storage facilities, generating new insights into subsurface processes and supporting the development of tools for managing geotechnical stability. Research into nickel laterite deposits has improved understanding of critical metal distribution and environmental risks, providing a stronger foundation for sustainable extraction and processing.

In parallel, the Sand and Sustainability project developed new Earth Observation methodologies to quantify material flows and assess sand consumption, addressing a globally significant environmental challenge. Work on critical minerals in Zambia combined geological mapping, exploration and capacity-building to support national strategies for resource development. Research in South America advanced understanding of lithium brine systems, incorporating environmental, social and governance considerations to support responsible sourcing frameworks.

These scientific advances have led to clear outcomes and uptake. In Zambia, IGRD research informed the National Critical Minerals Strategy and supported engagement with government and international stakeholders. The PRIME technology and associated research have attracted interest from industry and are contributing to improved practices in mine waste management. The sand project has influenced international policy and practice, including contributions to UNEP global reports and adoption of methodologies by international organisations.

RIC2 has also generated significant visibility and influence. BGS was invited to contribute to high-level international initiatives and reports, and its expertise is increasingly recognised in

global discussions on sustainable resource management. Across projects, there is strong evidence of research informing policy, supporting decision-making and contributing to improved environmental outcomes.

The programme has also been highly successful in leveraging funding and strengthening partnerships. Research has underpinned multiple FCDO-funded projects and other international initiatives, supporting continued work beyond IGRD. Collaboration with governments, international organisations, industry and academia has created a strong platform for scaling research and impact. Overall, RIC2 has demonstrated how geoscience can support sustainable resource development while contributing to global public good.

4.4 RIC 2: ENERGY RESOURCE EVIDENCE FOR TRANSITION TO NET ZERO

RIC2 has shown how geoscience can underpin the transition to net zero by reducing uncertainty in subsurface resources, supporting investment decisions and enabling the deployment of low-carbon energy technologies.

The programme advanced methodologies for assessing geothermal and carbon storage resources. In Ethiopia, rock physics modelling and geophysical surveys were used to estimate geothermal gradients in volcanic settings, providing a novel approach for identifying high-potential geothermal resources in data-limited environments. In India, research addressed key challenges in carbon capture, utilisation and storage (CCUS), including site characterisation, storage integrity and monitoring techniques.

These technical advances have contributed to significant outcomes. The geothermal research provides a pathway for reducing risk in geothermal exploration, supporting investment and development of renewable energy resources. In India, the CCUS work has influenced national research priorities and contributed to the development of the UK–India Net Zero Innovation Partnership. The research has also established BGS as a trusted partner for CCUS development, with strong engagement from government, academia and industry.

The programme has also resulted in uptake through partnerships and knowledge exchange. Collaborative workshops, symposia and bilateral exchanges have supported the transfer of knowledge and adoption of best practices. Partners are actively applying methodologies developed under IGRD, and new projects are being developed to extend this work.

RIC2 has leveraged significant additional funding and established strong international collaborations. New research programmes, joint initiatives and institutional partnerships are being developed, providing a platform for continued impact beyond IGRD. Overall, this work demonstrates the critical role of geoscience in enabling the energy transition by providing robust, decision-relevant evidence.

4.5 RIC 3: UNLOCKING THE POTENTIAL OF GROUNDWATER

RIC3 has demonstrated how geoscience can support sustainable groundwater management and water security at local, national and continental scales, particularly in regions facing increasing pressure from climate change and population growth.

The programme delivered major advances in groundwater science, including new approaches to aquifer characterisation, waterpoint functionality and groundwater quality assessment. In sub-Saharan Africa, innovative mapping methodologies have improved understanding of basement aquifer productivity and groundwater availability, supporting large-scale assessments and decision-making tools. Research on waterpoint functionality has identified key drivers of failure and informed the development of diagnostics and interventions to improve rural water supply systems.

In South Asia, large-scale datasets and modelling approaches have transformed understanding of groundwater salinity and resource sustainability in the Indo-Gangetic Basin. Work in Southeast Asia and other regions has developed national-scale hydrological models and tools to assess water system resilience under future climate and development scenarios.

These advances have led to strong outcomes and uptake. Groundwater mapping approaches are being used by organisations such as UNICEF and the World Bank to inform water infrastructure investments. Research on waterpoint functionality is influencing international initiatives such as the Stop the Rot campaign and informing global discussions on rural water supply under SDG 6. Outputs such as the Africa Groundwater Atlas have become widely used resources, supporting decision-making across multiple stakeholder groups.

The programme has also strengthened institutional capacity and partnerships. Collaborations with governments, regional organisations and international donors have enabled the application of research at scale and supported capacity building among partners. Research findings are being translated into policy and practice, contributing to improved water management and resilience.

RIC3 has successfully leveraged additional funding and established a strong platform for future work. Projects funded by the World Bank, UNICEF, BGR and others are extending and scaling IGRD research. Overall, this RIC demonstrates how integrated geoscience can address critical water security challenges while delivering global public good.

4.6 RIC 3: GEOSCIENCE SOLUTIONS FOR SUSTAINABLE LAND MANAGEMENT

RIC3 has shown how geoscience can support sustainable land management by linking soil, water and ecosystem processes to inform decision-making that enhances food security, environmental protection and climate resilience.

The programme generated new scientific understanding of land degradation, soil erosion and land-to-water interactions. In the Lake Victoria Basin, research combined field measurements and modelling to quantify soil erosion and sediment transfer, providing insights into the impacts of land use on aquatic ecosystems. Work on conservation agriculture in sub-Saharan Africa examined the impacts of agricultural practices on soil health and groundwater recharge, contributing to improved understanding of sustainable land management approaches.

The programme has strengthened stakeholder engagement and pathways to impact. Multi-stakeholder forums have been established to connect researchers, policymakers and practitioners, enabling co-design of solutions and supporting uptake of findings. Outputs have been communicated through innovative formats, including documentary media, to reach broader audiences and attract further investment.

RIC3 leveraged additional funding and created new partnerships to extend this work. Collaboration with NGOs, academic institutions and government agencies is supporting the scaling of approaches to new regions and contexts. Overall, the RIC demonstrates how geoscience can inform integrated, sustainable land management strategies with benefits for both people and ecosystems.

4.7 RIC 3: GEOSCIENCE TO INFORM URBAN PLANNING

RIC3 has demonstrated how urban geoscience can support the development of safer, more resilient and sustainable cities by integrating subsurface knowledge into urban planning and infrastructure decision-making.

The programme advanced tools and methodologies for urban geoscience, including 3D geological modelling, subsidence analysis and urban groundwater assessment. Through collaboration with CCOP and national geological surveys, these approaches have been applied in rapidly urbanising settings across Southeast Asia. In Malaysia, co-developed systems for urban geological modelling are being implemented to support planning in Kuala Lumpur, while in South Korea, stochastic modelling approaches are informing national-scale geological models.

These advances have led to clear outcomes and uptake. BGS tools and methodologies are being adopted by partner organisations, influencing urban planning practices and standards. Engagement with national agencies has enabled direct input into policy and guidance, including site investigation standards. Research has also supported risk assessment and mitigation in

critical infrastructure, for example through deployment of monitoring systems on slopes affecting hydroelectric dams.

The programme has also facilitated integration across research themes. Urban projects have acted as a platform for translating work on hazards, groundwater and resources into urban contexts, demonstrating the interconnected nature of urban systems. This has enabled the development of integrated approaches to urban resilience.

Strong partnerships have been central to success. Collaboration with CCOP provided a key pathway for scaling and embedding research across the region, with BGS taking on a leadership role within the organisation. New partnerships with governments, development banks and other stakeholders are creating opportunities for further work, including the development of urban geoscience centres and new research programmes.

RIC3 has also leveraged additional funding and positioned BGS as a leader in urban geoscience. Overall, the work demonstrates how geoscience can be embedded in urban planning to support sustainable development and resilience in rapidly changing environments.

5 IGRD Partnerships

5.1 PARTNERSHIP SURVEY

A partnership survey was undertaken in December 2025 to provide a reflection of progress in comparison to the earlier 2023/24 survey. An online questionnaire, comprising 17 questions, was sent out to 51 partners representing 13 out of 16 projects within the programme. The survey is provided in Appendix 6. It was reviewed and approved by BGS' Ethics Committee and UKRI's data protection team.

We received responses from 20 participants (39% response rate – exactly the same as the 2023/24 survey). Just over half of the respondents were from research organisations (n=11, 55%), eight (40%) were from public sector or government organisations, and one was from a commercial organisation. Nine respondents identified as mid-career (45%), nine as late career (45%), and two as early career (10%). The majority of partners were actively involved in carrying out research (n=17, 85%), while some acted in an advisory role to a project or were engaged due to interest or aligned areas of work.

The Partnership with BGS

Overall, the responses to the survey provided a positive impression of partnering with BGS under the IGRD programme: all respondents either agreed (5%) or strongly agreed (95%) that partnering with BGS is delivering value to their research. This is a slight improvement on the results from the 2023/24 survey, which indicated that 87% of participants strongly agreed that partnering with BGS was delivering value to their research.

In 2023/24, a minority of respondents (n=2) indicated issues around clarity of the plan for the partnership (e.g. vision, objectives, responsibilities), availability of necessary resources for effective functioning of the partnership, effective knowledge sharing with BGS, and fair reflection of ownership/authorship of deliverables. These issues appeared to have subsided by the final year of the programme with all participants responding positively to the same questions regarding clarity of a research plan, availability of resources, effective knowledge sharing, and fair reflection of ownership of deliverables. As in 2023/24, all respondents to the survey either agreed or strongly agreed that problems are easy to discuss and are dealt with respectfully and constructively.

Impact of Projects on Partners and External Stakeholders

As in 2023/24, all participants indicated that involvement in the IGRD programme has resulted in positive change for them as individuals, their organisation, and external stakeholders. No respondents stated that involvement had resulted in negative change. For individuals, the nature of this change is primarily through new or expanded networks/partnerships, increased capacity due to training and skills development, and co-authoring outputs. For organisations, positive change is primarily related to new networks/partnerships, increased ability to advise stakeholders, and new working practices.

The type of stakeholders that have been influenced are primarily government departments, geological surveys and universities, most commonly through changes to practice, process or ways of working, increased awareness of issues, and new networks or partnerships.

5.2 PARTNERSHIP WORKSHOP

In March 2026, the IGRD programme ran an online meeting to celebrate four years of partnerships and progress comprising short video testimonials from our IGRD project partners to discuss the benefits of international collaboration and how the research will be used, supplemented with panel discussions. The workshop highlighted a number of common words and phrases to describe the experience of working with BGS: friendship, continuity, impactful research, and connecting stakeholders, from community to decision makers. The headline takeaway message from this meeting was that: *"sustained partnerships, not short-term projects, deliver lasting scientific, policy, and societal impact."* A summary of the key themes discussed is provided below.

What Makes Collaboration Successful? Participants consistently identified five critical ingredients:

- Shared vision and common purpose
- Leadership, commitment, and continuous communication
- Complementary expertise across partners, understanding the strengths and how we complement one another
- Clear roles and mutual trust
- Strong relationships and networks (*"Friendship is really like the oiling of international collaboration"*)

Impact on Science, Policy, and Practice. Participants consistently highlighted strong translation of science into action:

- Policy influence – research informing national strategies and local decision-making and adoption of recommendations by government stakeholders.
- Science-to-action approach – co-design with governments, NGOs, and communities, development of policy briefs and accessible outputs and regular stakeholder engagement before, during, and after projects (*"Co-design gives a sense of ownership… leading to implementable actions."*)

Knowledge Exchange and Capacity Building. Participants defined the following strengths of the programme:

- Two-way knowledge exchange between UK and international partners (*"Knowledge exchange both ways… building capability and relationships"*)

- Fieldwork, secondments, workshops, and joint publications
- Strengthening institutional capacity (labs, methods, data systems)
- Support for early career researchers and international networks

The role and importance of Early Career Researchers. Participants highlighted the success of building capacity of early career researchers:

- Central to delivery and long-term sustainability
- Enabled through co-supervision, international placements, and mentoring
- Key to maintaining collaboration beyond individual projects (*"We need to keep the regeneration process going… they are our future generation."*)

How do we respond to a Changing World? Participants highlighted rapidly increasing complexity:

- Growing multi-hazard and systemic risks
- Need for real-time data and new methodologies
- Integration of AI, remote sensing, and advanced modelling
- Strong emphasis on adaptability (*"The ability to pivot… to respond quickly to emerging challenges."*)

How do we sustain Long-Term Impact? To maintain momentum, the following were identified as essential:

- Institutional support (e.g. MOUs, long-term agreements)
- Ongoing funding and programme continuity
- Broad participation (not reliance on individuals)
- Strong networks and regular engagement activities (*"Friendship… but also institutional support is very crucial."*)

6 Forward Look

6.1 NERC FUNDING

A programme of work was submitted to NERC for 2026/27 comprising of a simplified programme comprising of three hub projects: Urban systems (Indonesia), Resource systems (Zambia) and Catchment systems (Kenya). These hubs represent a coalescence of activities from the 4-year programme to provide greater integration for interdisciplinary geoscience research as a demonstration of capability to stakeholders and funders; leverage further aligned funding and promote the impact of the research to date – improve visibility and usability of research gains. The one-year extension was requested from NERC with a guidance that a follow-on 4-year programme may be developed post government spending review (October 2026); hence the one-year extension proposal has considered how the coalescence of activities can progress to the next funding cycle.

As the research undertaken within the RICs has evolved, it has begun to highlight the complexity of the contexts – or systems - in which the research has taken place. For example, the interactions between rapid urbanisation and subsidence in Indonesia. These are systems where there are multiple interacting and competing demands on the physical environment: rapidly urbanising areas, regions where valuable resources are mined and those areas that are vital for food and water security. In 2026-2027, we will begin to consider how the different components of each of these systems interact and interconnect to better understand how one component of the system might interact with another or how change in an area might influence another area. We will also attempt to characterise some of the interactions between these systems. By taking a ‘systems thinking’ approach, our aim will be to try to see these systems in different ways and potentially identify new ways to tackle the environmental challenges that exist within them. This will only be possible by building on the research partnerships and findings from the last four years.

6.2 ALIGNED FUNDING

The 4-year programme (2022 to 2026) leveraged an additional £16M+ to BGS and its stakeholders, with an additional £2M pending on a decision from funders. This success provided a platform to integrate disciplines across the programme, an opportunity to scale-up to translate research to different scenarios, demonstrating public good and importantly a track record for a broad BGS team (and partners) to build a pipeline of aligned funding into the future for impactful research. The successful acquisition of aligned funding clearly demonstrates the value of investment in International National Capability funding, with several activities initiated early during the IGRD programme seeding larger projects augmented with funding from external sources. Whilst BGS and its partners have observed budgetary benefit, the wide range of aligned funding opportunities identified and delivered upon throughout the four-year programme brought additional and tangible benefits to wider UK research and development interests on the global stage.

7 Conclusions

Through to year 4, the IGRD community of project leaders had developed pan-BGS working ideas with new funding proposals that may benefit future BGS international leveraging of resources, particularly with the FCDO for critical minerals research in Africa and the ISPF funding calls. The programme-maintained momentum as highlighted by the March 2026 online workshop (section 5.2) at which progress was shared via pre-recorded testimonials from partners and 'live' discussion between BGS project partners on their thoughts for success involving international collaborative research to address environmental challenges. This workshop was a great success, in that a common theme from partners was in mentioning the strong relationships/friendships and equitable opportunities created amongst research leaders, technicians, students and early career researchers. Partners provided examples of how the research collaborations had evolved their pathway to impact to embed geoscience into decision making. All of the partners expressed enthusiasm to expand on the research partnerships to provide a sustainable platform to deliver multidisciplinary geoscience information to end-users, such as disaster response, urban, land and water management and resource planners, all reinforced with both UK and Internationally focussed spin out projects.

Our Monitoring, Evaluation and Learning (MEL) approach was important to the successes gained through the 4-year timeline, in that from the first month, it facilitated a cultural shift within BGS to shape excellent research to have an impact pathway that could be financially sustainable or at least leverage additional funds. The MEL process provided a feedback loop to all members of the programme to learn from and share best practice in how we measured and considered the societal and economic benefits of research. This approach contributed to greater inter-connected working across a multidisciplinary group of scientists (within BGS and with partners), demonstrated clearly by new funding (>£16M) for work in the UK, the overseas countries in which we were working and for translation of geoscience research to new regions.

Appendix 1 Theory of Change

The Theory of Change (ToC) approach adopted by the IGRD programme laid out the pathways linking the outputs the IGRD programme delivered through to the long-term changes that the programme aimed to facilitate. It was compiled in a series of discussions with the IGRD leadership team during 2022.

The theory of change is illustrated in a diagram overleaf, followed by a narrative description. The structure of the change pathways outlined in this document is used as the basis for a separate log frame. The log frame provides more details of how these changes were measured. It shows indicators of change, as well as milestones and targets against which progress was tracked. The programme is sub-divided into three research settings, namely: living in multi-hazard environments; resources for the future; and sustainable land management and climate change adaptation.

The impact that the programme aimed to facilitate is the secure supply and sustainable use of the Earth's natural resources and increased community resilience to natural and anthropogenic hazards. The focus of the programme was in three particular environments: i) the urbanising world; ii) resource rich emerging economies; and iii) communities on the climate change frontline. In order to achieve this long-term goal, there needs to be sustained action taken by many partners, together with a range of actors in the external environment. The external environment also needs to be conducive to such an impact. For example, economic and social crises do not constrain the partners ability to effect change. It is also important that partners and users of the products of this programme have the necessary influence and motivation to take up the research and catalyse changes in policy and practice at all levels, from community to government. It is assumed that the relevant stakeholders are currently constrained by the lack of geoscience knowledge.

The first objective at the outcome level relates to **decisions, policy and practice which are informed by geoscience evidence**. The programme and project partners, together with a range of external actors, articulate a voice of responsible advocacy through representative bodies and the leverage that they command through their networks of influence.

These outcomes were developed by each of the RICs across three key settings, as follows:

For Research and Innovation Challenges (RIC) 1 this relates to Disaster Risk Management (DRM) and/ or resilience-related decisions. The objective is that urban planners and infrastructure managers are informed by robust landslide hazard and risk analyses and by new evidence of subsidence rates. Responding organisations are able to act in a timely manner during earthquake sequences. DRM decisions taken by authorities and community decision makers are informed by new hazard analyses and scenarios. Geoscience knowledge and expertise supports people recovering after disasters in multi-hazard environments to become more resilient.

RIC 2 relates to sustainable natural resource supply decisions. In this case the objective is that decision makers in the public sector (including government ministries, resource licencing authorities and environmental agencies) and the private sector (including mining, power, and water supply companies) are using geoscience-based best practice to ensure sustainable development and use of natural resources. Informed policies and plans are put in place that assist the energy transition to net zero (including development of geothermal, solar pumping, carbon capture and storage, and Government critical raw materials strategies) and address

environmental, social and governance issues including mine tailings safety and utilisation, groundwater utilisation, sand extraction and Li-brine mining.

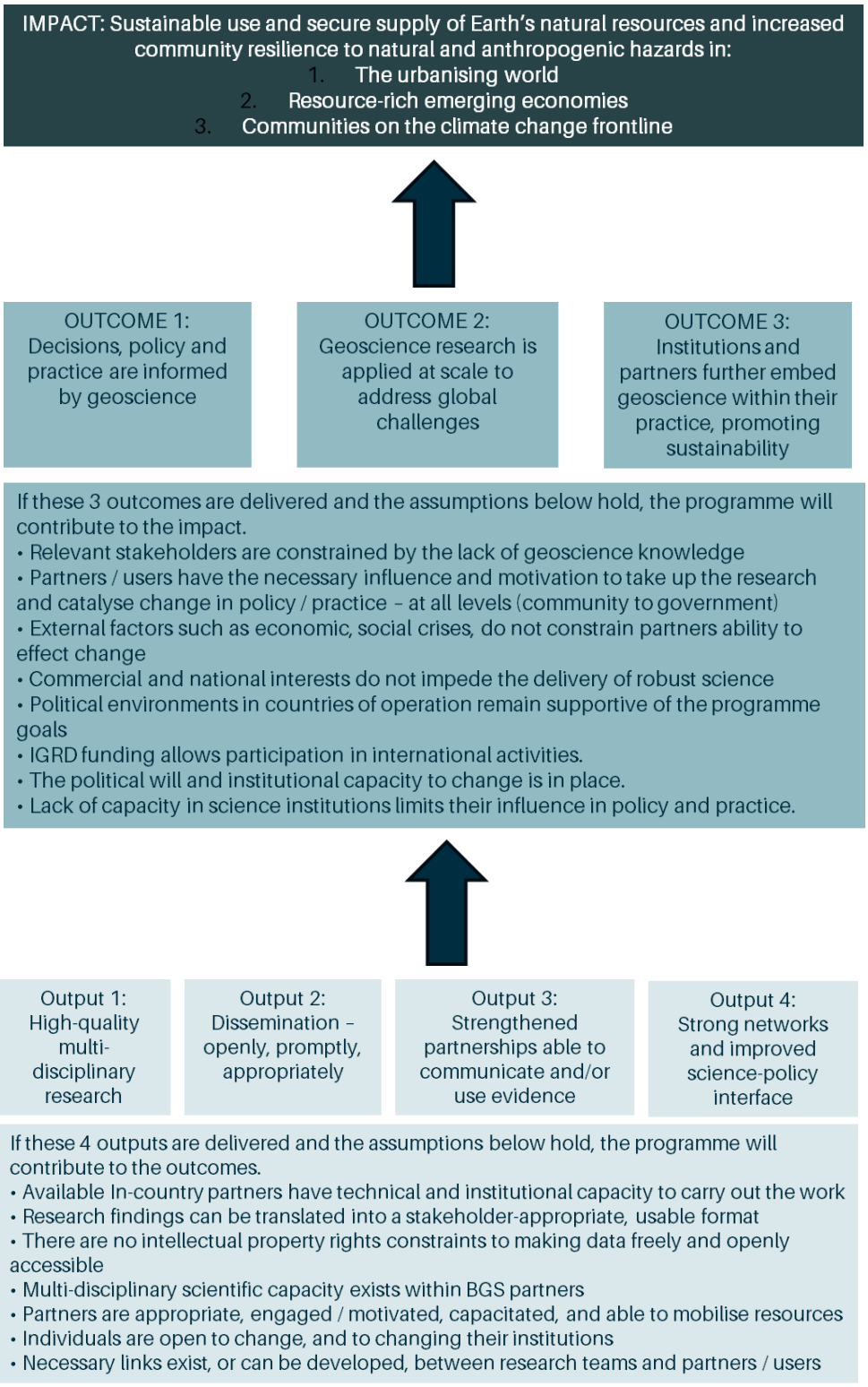


Figure 2. IGRD programme Theory of Change

RIC 3 relates to land and water use and climate change adaptation decisions. The objective is that farmers, local authorities and/or national agencies (in Zambia and India) will adopt working with nature approaches to soil and groundwater conservation. Government agencies (in Canada, and Mexico) will use social and hydrological tools to assess the resilience of

marginalised communities and optimise blue-green infrastructure solutions. Impacts of climate change on future soil and water resource will be quantified and incorporated into national resource plans and planning mechanisms (in Kenya, Philippines).

The second objective at the outcome level is that **geoscience outputs and products are applied at scale to address global challenges.** Providing global leadership and influence, alliances that share environmental and scientific ambitions meet the scientific challenges of the complexity and scale that require an international response.

For RIC 1, DRM and resilience stakeholders with a global presence (e.g., UNDRR, UN Global Shelter and WASH clusters) are informed by RIC 1 outputs. Landslide forecasting in tropical regions is informed by landslide trigger threshold workflow developed for India. Inventory maps for landslide-prone regions produced by the 'landslide tracker' tool are in use. The process for making subsidence forecasts is applied to rapidly expanding cities in different geological settings around the world. For example, the understanding of how multi-hazards interact with policy in the Philippines is applied elsewhere; approaches to integrating geoscience in DRM decisions in the UK Overseas Territories (UKOTs) is transferred to other island settings. RIC1 will provide international leadership and influence through supporting the implementation of the Sendai Framework for Disaster Risk Reduction by developing mechanisms for reporting against its targets.

For RIC 2, the objective is that research outputs inform and influence natural resource stakeholders across the world. RIC2 research enables the application of: Ni-laterite waste monitoring to international mine sites and emerging areas such as landfill mining; the better understanding and best practice for sand mining to other areas of the world where active sedimentary environments are mined; new understanding from the Lithium triangle to other environmentally sensitive mining districts especially in arid areas where mining could exacerbate water scarcity; the knowledge gained through the CO_2 storage research in India to the Indian subcontinent and Southeast Asia; the development of critical mineral occurrences databases, guides and maps to stimulate direct inward investment across southern Africa based on the work in Zambia; and the superhot geothermal research to volcanic settings worldwide.

For RIC 3 this will mean the development of digital platforms for data delivery on soils and geosciences, the African Groundwater Literature Archive and the African Groundwater Atlas. African policy makers in the water sector give increased attention to the groundwater sector influenced by bodies such as the African Ministers' Council on Water (AMCOW) and the APA Groundwater Programme. Geological Surveys in SE Asia prioritise urban geoscience issues, influenced by bodies such as the Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP) and the Research Centre on Urban Geology (RCUG). Tools developed for social and hydrological resilience, climate change impact, predicting future groundwater abstraction and urban typologies are adopted outside partner countries.

The third objective at the outcome level was that **institutions and partners further embed the geoscience within their practice, promoting sustainability**. This will vary across partners and partner types. It will include the ability to undertake research but also to network and connect the supply of evidence with the demand for it. The capacity of researchers and intermediaries will strengthen research uptake approaches.

RIC 1: Partners (in India) have capacity to carry out landslide trigger threshold modelling. Partners have increased 3D visualisation and modelling capacity that supports communication with people exposed to hazards in the Philippines. There is raised awareness among geoscience partners of what information is needed for making DRM

decisions. Decision makers in the UKOTs are aware of geohazards and the need for monitoring in the UKOTs. Humanitarian partners understand the role of water supply in recovery, and how geoscience can support their decision making. They design and implement strategies accordingly.

RIC 2: Partners and stakeholders have the knowledge and capacity to make natural resource decisions based on geoscience data and information. RIC2 research will enable the: multiscale observation of tailings storage facilities to mitigate the risks of failure and enable sustainable mining to recover critical raw materials; the improvement of sand and lithium mining practices; the development of reconnaissance methods for the assessment of critical mineral resources; the development of CO_2 storage in India and beyond; the potential of groundwater in sub-Saharan Africa to be unlocked to help achieve water and food security; the provision of geoscientific data and geoscientific knowledge needed for geothermal resource development.

RIC 3**:** Support to AMCOW and BGS representation on the RCUG board and scientific steering committee will ensure that these partners integrate the latest research on groundwater and urban geoscience into central government planning and action. Partners in academic sectors in Africa and Central America will have the capacity to support and extend the deployment of tools developed by IGRD projects in the long-term and will demonstrate a capacity to win grants and access funding to support fieldwork and studentships.

Feeding into those outcomes are the outputs, the deliverables of the programme. The paragraph below describes these. For these outputs to contribute to the three outcomes listed above several enabling factors are required. These are listed below:

- Available in-country partners have the technical and institutional capacity to carry out the work and there is multidisciplinary scientific capacity in place. The partners are appropriate, engaged, motivated, capacitated, and able to mobilise resources.
- The necessary links exist, or can be developed, between research teams and partners, and users.
- The individuals involved in the programme are open to change and to changing their institutions.
- The research findings can be translated into a stakeholder appropriate, usable format and there are no intellectual property rights constraints to making that data freely and openly accessible.

There are four classes of outputs. The first is that **high quality, multi-disciplinary research is produced**. That is, responsible research that adheres to the ‘fair’ principles, that data should be findable, accessible, interoperable, and reusable. This research will be cross-disciplinary.

The second output is that **evidence, knowledge, and tools are shared and communicated openly, promptly and appropriately**. This will ensure that data, information, and knowledge will be openly available and easily accessible to a global audience, that it will be informed by a range of stakeholders to ensure that it is useful, usable and used.

The third output is **strengthened partnerships able to communicate and or use evidence**. These partnerships will be ethical and equitable, ensuring relevance and informed consent.

The fourth output relates to **strong networks and improved interfaces between scientists and user communities**.

Appendix 2 MEL Strategy

MEL PRIORITIES

Monitoring, Evaluation and Learning (MEL) is a key pillar of programme implementation. The purpose of MEL is to increase the likelihood of the programme achieving its intended outcomes and impact, while maintaining key values of efficiency, integrity, equity, preventing harm (safeguarding), inclusivity and openness. Information gathered via monitoring is primarily for the purpose of enabling reflection and programme adjustments towards increased impact.

Official reporting requirements are through the UKRI ResearchFish platform, on an annual basis, but the programme will also prepare an annual report to highlight key achievements, progress and learning. This will help to inform the next corporate-level evaluation by NERC, which is likely to take place in 2026. The reporting is guided by an IGRD Logframe reporting template. This is used to document the key outcome stories under each of the 3 outcomes. The template also collates aggregated data on the outputs and outcomes.

USERS

The primary users of the data are within BGS. The project leads and partners can share the information and reflect on progress, updating the workplan and budget to improve performance. The RIC leads can look across projects in that portfolio to share good practice and lessons, and to see patterns of change, or identify blockages. The programme lead can use the data and analyses to reprioritise projects or areas of work, to understand where there might be synergies or gaps and to pull together all the work done and benefits gained from the implementation of the whole programme.

DATA COLLECTION

There is data collection from each project at the output level using a 2-strand approach.

Information on the research outputs and engagement activities is uploaded to NORA with corresponding datasets uploaded to the National Geoscience Data Centre (NGDC). Engagement activities (including meetings, conferences, blogs, training, workshops, panel discussion, outreach events, media activity) are recorded on a separate form(s). Projects report on outputs as they happen, throughout the year– with data compiled for input to the Logframe in February/March of each year

The information from these sources can then inform ResearchFish.

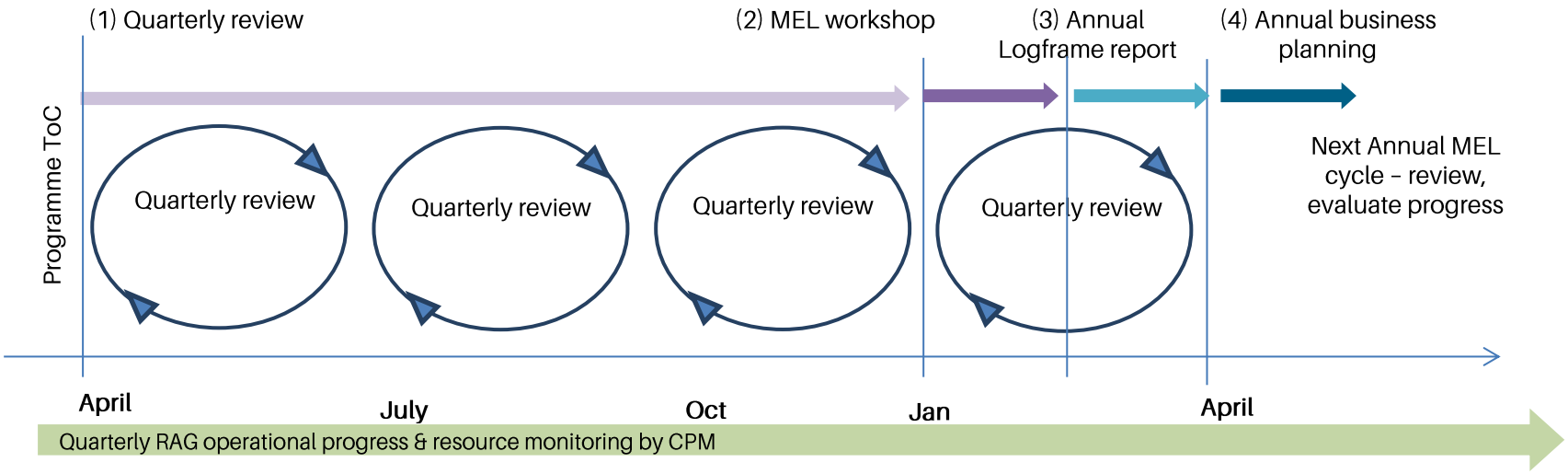
Information at the outcome level is gathered primarily in the regular (quarterly) discussions with the RIC lead. These discussions review outputs that have been reported, linking back through the project impact pathway towards the outcomes. Impact stories collected in this way are recorded in the Logframe. So, for example, if a project reports several engagement events, the RIC lead will probe to elicit further information on the consequences of those engagements, in terms of policies or practices that have been influenced. RIC leads will use a reporting template to guide their discussions and gather relevant information for the Logframe. Outcome data will be compiled for input to the Logframe in February/March.

The annual report will be completed in March/April.

The MEL process is supported by one or more workshops throughout the year. These provide opportunity for cross-project and cross-RIC exchange, allow progress towards outcome and impact to be discussed and evaluated at a programme level, and promote discussion of future priorities.

TIMELINE

IGRD Annual MEL Cycle



(1) Quarterly review cycle:

- RIC leads discuss progress along pathways to impact with project leads
- Logframe reporting template supports discussions
- RIC leads discuss with MEL lead to inform Logframe reporting

Outputs reporting:

- Ongoing by PLs via NORA and engagement activities form
- Annual metrics into Logframe (February)

(2) MEL workshop:

- Involves all Project leads and CoIs
- Review and assimilate progress over the year in emerging outcomes, constraints and opportunities

Focus workshop: MEL lead, RIC leads and CoIs:

- Synthesise key outcomes narrative
- Identify where outcomes / pathways could be amplified – these are followed through into business planning

(3) Logframe report

- Completed by MEL lead with input from RIC leads

(4) Business planning:

- Led by PI, CPM and RIC leads

Figure 3. IGRD Annual MEL cycle

Appendix 3 Logical Framework

Table 3. IGRD programme Logical Framework.

IMPACT							
Sustainable use and secure supply of Earth's natural resources and increased community resilience to natural and anthropogenic hazards in: i) The urbanising world; ii) Resource rich emerging economies; and iii) Communities on the climate change frontline.							
OUTCOMES							
			Year 1		Year 2	Year 3	Year 4
Outcome	Indicator	Number delivered	Milestone	Progress against Milestone	Number delivered	Number delivered	Number delivered
O1. Decisions, policy and practice are informed by geoscience	O1.1. Number of citations of IGRD research (papers / datasets / tools / reports) within policy or practice documents	0	n/a	n/a	1	2	3
	O1.2. Number of media reports (written articles, TV, radio) mentioning IGRD research	7	n/a	n/a	19	77	282
	O1.3. Number of stories of change to stakeholder decisions, policy, practice, or public awareness / understanding of an issue influenced by IGRD research	0	n/a	n/a	2	8	10

	O1.3a. Number of *developing* stories of change to stakeholder decisions, policy, practice, or public awareness / understanding of an issue influenced by IGRD research	5 (*5*)	n/a	n/a	19	10	3
O2. Geoscience research is applied at scale to address global challenges	O2.1. Number of citations of IGRD research (papers / datasets / tools / reports) within policy or practice documents *beyond project localities*	3	n/a	n/a	4	5	9
	O2.2. Number of academic citations	n/a	n/a	n/a	330	1150	2164
	O2.3. Number of stories of change to stakeholder decisions, policy, practice, or public awareness / understanding of an issue *beyond project localities* influenced by IGRD research	0	n/a	n/a	5	12	12
	O2.3a. Number of *developing* stories of change to stakeholder decisions, policy, practice, or public awareness / understanding of an issue *beyond project localities* influenced by IGRD research	9 (4)	n/a	n/a	5	7	1
O3. Institutions and partners further embed the geoscience within their practice, promoting sustainability	O3.1. Number of partners who report a change in their capacity (e.g. stronger networks/additional funding success/position of responsibility/ research outputs)	n/a	n/a	n/a	23 (100% respondents)	n/a	21 (100% respondents)
	O3.2. Number of instances of participation (by partners) in relevant stakeholder meetings / forums	*1*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*

	O3.3. Number of stories of change to the capacity or working practices of institutions and partners as a result of IGRD research	3	n/a	n/a	8	15	12
	O3.3a. Number of *developing* stories of change to the capacity or working practices of institutions and partners as a result of IGRD research	6 (2)	n/a	n/a	15	5	2
OUTPUTS							
			Year 1		Year 2	Year 3	Year 4
Output	Indicator	Number delivered	Milestone	Progress against Milestone	Number delivered	Number delivered	Number delivered
P1. High quality, multi-disciplinary research is produced by the IGRD programme	P1.1. Number of academic publications	9	n/a	n/a	36	55	77
	P1.2. Number of products and tools	2	n/a	n/a	6	16	29
P2. Dissemination of research	P2.1. Number of non-academic outputs (e.g. policy briefs, webpages, blogs)	1	n/a	n/a	14	25	33
	P2.2. Number of presentations at conferences / workshops	25	n/a	n/a	89	130	149
P3. Strengthened partnerships able to communicate and/or use evidence	P3.1. Number of collaborations and partners	tbc	n/a	n/a	59	n/a	52

	P3.2. Number of co-produced outputs and activities (including training and capacity building activities)	34	n/a	n/a	56	57	67
P4. Strong networks and improved interfaces between scientists and user communities	P4.1. Number of external stakeholder workshops and networks engaged with	46	n/a	n/a	126	230	263

Appendix 4 IGRD Thematic Narratives

While the programme was managed as a series of projects and activities within the three RICs, each of which is focussed on specific science questions and distinct geographies, there are several thematic hubs, which address multi-disciplinary global challenges, around which multiple projects coalesce. These hubs provide a useful framework for developing narratives, or stories of change, which describe how the programme is progressing towards outcomes and impact in response to the global challenges described above.

RIC 1: NOVEL DETECTION AND FORECASTING OF HAZARDS

Forecasting of hazards including earthquakes, landslides and urban subsidence is extremely complex but offers the possibility of improving anticipation and planning for such hazards. It often requires huge quantities of data. Artificial Intelligence (AI)/Machine Learning (ML) is opening up the potential of these volumes of data by automating some of the analysis, allowing rapid detection and response to hazards. In 2025-2026, the projects in this hub have pushed forward the state-of-the-art in their respective fields, delivering research that helps to improve how hazards are understood and managed.

'AI in seismology' has been investigating the performance of ML algorithms and recent advances in deep learning (DL) for observational seismology and modelling. It has focused on the performance of DL algorithms for automatic data processing in near-real time conditions to produce rapid, high-resolution earthquake catalogues in regions of high and low seismic hazard. Deep learning in earthquake detection and forecasting is a powerful tool for informing our process-based understanding thus potentially enabling improved warning to populations and civil emergency authorities in future. It is now widely accepted that DL earthquake detection provides 10x more earthquakes than the traditional human analyst approach. This is game changing for seismological research and data assimilation practices.

In 2023/24, the team implemented deep learning workflows for earthquake detection in a scalable, cloud-based environment and applied this to high (Italy) and low (UK) seismicity environments. In 2024/25, the project established systems and processes to enable rapid processing of data on premise and cloud environments such as Amazon Web Services (AWS).

In 2025/26, the project team have submitted several papers on their findings in high impact journals including *Volcanica* and *Nature, Astronomy and Geophysics*. They have continued to engage with scientists from national agencies with statutory responsibility for earthquake forecasting to establish pathways to impact for the future uptake of this new methodology. The power of this approach was demonstrated in collaboration with international partners during the 2025 Santorini seismic crisis. It provided new insights into the physical processes driving the earthquakes that were happening that helped to inform disaster-related decision making. The approach has also been applied to seismicity beneath Napoli associated with Campi Flegrei volcanic field as part of an effort to understand risk in high hazard areas (see below). In addition, an international event at the Royal Astronomical Society in January 2026 organised by the project lead (Margarita Segou) explored the transformative potential of recent machine learning advances for supporting emergency response for earthquakes, tsunami and volcanic eruptions. Discussions are currently underway about other future-focussed workshops and events.

The potential of high-resolution data motivated the submission of a Large Grant (MERLIN; PI Segou) featuring one of the largest transatlantic collaborations for magmatic systems and disaster mitigation together with University of Stanford, University of California, Berkeley, Oxford University and the British Antarctic Survey. Volcanoes in extreme environments from Antarctica to Caribbean and Mediterranean will be locations of interest. The AI in Seismology project has inspired and supported at least 18 projects within BGS. It has also supported components of commercial research including more recently the development of a catalogue of seismicity for the Irish Sea to explore the potential for it to improve earthquake monitoring of Carbon Capture and Storage (CCS) sites.

ML approaches are also being used to process large volumes of Earth Observation data to detect changes on the Earth's surface, providing new methodologies to monitor and quantify rates of subsidence and to automatically identify areas where landslides have taken place. As with the seismic data above, the ability to automatically analyse and interpret large datasets to understand the location and evolution of natural hazards provides a new way to develop disaster risk reduction and response strategies. During the IGRD project, analysis of InSAR data using ML methods has been used to model urban subsidence, providing an improved understanding of the potential causes of subsidence such as from loading due to construction or groundwater abstraction, and a library of characteristic subsidence signals. In 2023/24, libraries of loading-induced subsidence signals were developed for Hanoi (Vietnam), Bandung (Indonesia) and Kuala Lumpur (Malaysia). This was extended to enable automatic recognition of subsidence patterns over larger areas, allowing identification of subsidence hazards in rapidly expanding cities across the world. Ongoing engagement with continental and global stakeholders such as UNESCO and the European Environment Agency, led to BGS being appointed as an observer on the UNESCO Land Subsidence International Initiative (LaSII) in 2024/25. LaSII enhances the scientific understanding and technical knowledge required to identify and characterize hazards related to natural and anthropogenic land-level lowering, thus strengthening potential pathways to impact for this work, which could ultimately inform urban planning decisions and enable urban decision-makers to design appropriate mitigation strategies. The work also underpinned BGS' ability to secure funding for further subsidence projects in the UK (working with the Mining Remediation Authority, formerly known as the Coal Authority), Northern Ireland (working with the NI Executive), and Cyprus.

In 2025/26, the focus has been on consolidating and extending this research. This has included presenting project findings at high level international workshops. For example, LaSII and Geological Surveys of Europe organised an event in Brussels on subsidence and its management (November 2025) to widen knowledge about these topics. As a result of activities like this, two members of the team have also been invited to join the 'Sinking Cities Community of Practice'. This is a UN Economic and Social Commission for Asia and the Pacific (ESCAP) and UN-Habitat initiative under the "Confronting the Silent Crisis of Asia-Pacific's Sinking Cities" initiative. Several papers based on what the project has found are currently in development for high impact journals including *Nature*.

The ML-based tools that have been developed in the project are opening pathways into new research (e.g. analysing subsidence data for the UK in the context of changing sea levels) and there are plans to apply them across Java where subsidence is a particular issue (this links to the Geohazards in Indonesia project discussed below). However, the approach/tools could be applied anywhere the data exist.

ML algorithms have also been used to automatically identify areas where landslides have taken place using satellite imagery. This allows the rapid production of landslide inventories following

earthquakes (e.g. in Morocco and Turkey in 2023) and landslides (e.g. Kenya in 2024-2025) to support disaster response. Work has now commenced for FCDO to extend the landslide mapping portal developed in the IGRD project to include exposure data so multiple risk-relevant information strands can be brought together to support decision makers. Alongside this, the project and team have been generating interest in the work and extending its reach via presentations and networking at high profile meetings. New projects have been developed that take this work and other parts of RIC1 forward. This includes the project mentioned above that is exploring how ML can help us understand risk in high hazard areas focusing on Campi Flegrei volcano near Naples.

Over the last 4 years, RIC1 research has demonstrated how the use of AI is changing how we understand physical processes that impact on society. This progress also depends on a strong process understanding, with fundamental research that explains hazard occurrences and translates that understanding into robust models, particularly in data-scarce environments where evidence can be limited. Our collaborative programme in Kerala in 2025–2026, delivered with the University of Kerala and the Geological Survey of India, has continued to advance understanding of landslide triggering thresholds in tropical residual soils. By developing and integrating advanced hydrological and slope-stability models, the project strengthens the regional-scale assessment of periods and locations of heightened likelihood for rainfall-triggered landslides. Crucially, the work demonstrates that explicitly representing soil moisture and groundwater dynamics can potentially provide actionable insight into landslide initiation even where time-stamped landslide inventories are limited, which often constrains conventional data-driven methods.

During the project, significant landslide events have occurred in Kerala. In parallel with the triggering research, an approach was also applied that enables landslide debris volumes to be estimated more accurately from the difference in pre- and post-event Digital Elevation Models. Major landslides in Idukki and the July 2024 Wayanad disaster, which killed over 400 people, were a particular focus for the project team and partners. Together they documented the landslide characteristics and triggering processes using field investigation and modelling, to develop a methodology for quick assessment of landslide runout features and impact. This combination of crowd-sourced data with numerical modelling accelerates evidence gathering and interpretation when timely authoritative data are hardest to obtain yet most needed.

Taken together, the work provides a replicable workflow that supports risk-informed decision making through improved hazard characterisation and rapid impact appraisal. Discussions are underway with donors to replicate the Kerala approach elsewhere in India.

RIC 1: UNDERSTANDING AND MANAGING MULTI-HAZARD INTERACTIONS

This hub centres on geoscience for disaster risk management and making geoscience useful, useable, and used for decision-making. Following changes to the programme in 2024/25, 2025/26 this hub focused on the work in multi-hazards in Indonesia, and the capture, analysis and reporting of data and information about volcanic activity and its impacts for local to global use, including the UK Overseas Territories (UKOTs). As with the other hubs, emphasis has been not only on delivering research outputs but also maximising the impact of the work and developing new opportunities that will extend the projects' reach.

In Indonesia, high quality, collaborative, multi-hazard science has been contributing to improved understanding of hazards and their management, local capacity development, and influence on local and national policy. In 2023/24, the project carried out research with partners into the seismic hazard from the Lembang Fault, which led to partners adopting an improved approach

to undertaking GNSS (Global Navigation Satellite Systems) campaigns on active faults. It also led to the team being approached for official advice after an earthquake emergency and the project contributing to the new national seismic hazard model for Indonesia, which will be used for setting building design standards. Collaborative research on the 2018 eruptive event at Anak Krakatau led to the development of new hazard models to simulate volcanic flows over water. This understanding is being used to improve hazard communication to those communities most at risk to help improve their preparedness for future events. There have also been efforts to improve the representation of Indonesian experts from the Centre of Volcanology and Geological Hazard Mitigation within international advisory groups, such as the World Meteorological Organisation Advisory Group for Volcanic Sciences, to ensure their knowledge and expertise is represented in global discussions. PhD students have played a vital role in extending the reach of the project and what it has been able to deliver.

The focus in 2025/26 was on planning a major symposium on geohazard solutions for Indonesia hosted by the British Embassy. This event, held in June 2025, led to the publication of an FCDO white paper on UK-Indonesia partnerships for advancing geohazard science for disaster risk assessment in Indonesia (Hussain et al., 2025). Discussions with key stakeholders about how to take the recommendations in the white paper forward are now underway.

What has been particularly notable about this project is the richness of the many partnerships that have grown from it. These have created opportunities to connect to and develop other parts of the IGRD programme and beyond. This includes the AI-focussed project investigating surface deformation described above and other connected work such as a project to develop a drainage master plan for Surabaya city in eastern Java. Alongside this, in 25/26, the Geohazards in Indonesia project has produced at least 1 report and 4 papers for high impact journals , which have been cited in key documents such as the new source model for the planned update of the national seismic hazard map for Indonesia. The project work and case studies are also supporting the national Geospatial Agency to make the case to the Indonesian Ministry of Finance for a multi-million-dollar programme to build a national level ground motion monitoring service Four successful research proposals have also been developed in 25/26 , which will allow various aspects of the project to be taken forward after IGRD ends.

The UKOTs project has focused on Tristan da Cunha and Ascension Island in the South Atlantic and is providing scientific evidence for sustainable development and disaster risk management on the islands. Through multiple field campaigns, recent volcanic deposits on Ascension Island have been characterised, improving understanding of eruption styles, timing and extent of past eruptive events leading to production of a geological map. Research into the regional seismicity at Ascension Island has resulted in the first seismic catalogue of its kind, including new evidence for volcano-tectonic seismicity. From this new understanding of baseline seismicity at Ascension, monthly seismicity summaries have been in preparation for delivery to on-island partners in the Ascension Island Government (AIG) in 2026. Combined with the team’s experience of volcanic unrest and eruptions in Montserrat and worldwide, this research has enabled development of volcano-tectonic scenarios for planning. In 2024/25, the team contributed to the first phase of a scenario planning exercise at the request of FCDO London and the AIG. On Tristan da Cunha, their engagement has led to an FCDO-commissioned project to establish baseline data for landslides that may pose a risk to people and infrastructure. The work is already supporting on-island decision making around land use and hazard mitigation measures.

The work in the UKOTs has complemented the efforts of the wider ‘Global Reporting’ project. Working at global to local scales, the project aims to enhance the capture, analysis and

reporting of data and information about worldwide volcano-tectonic activity and its impacts to support disaster and risk-related decision making at all levels. As in Indonesia, the partnerships and outputs that have arisen from Global Reporting have been instrumental for developing major new projects. Most notably, new methodologies, tools and approaches have led to an MoU with FCDO's Research and Evidence Directorate to deliver scientific evidence and advice to support improved FCDO decision making worldwide, which began in 2025 (£2.3M).

The team were invited to attend the 2025 UN Global Platform to engage with UK representatives, launch the UN Hazards Information Profiles (BGS contributed to the latest version) and join the initiation of GeoRiskNet (a newly launched global network on geohazard risk). They have also provided input to key international information resources and guidance relating to managing the impacts of volcanic ash on aviation (e.g. the International Civil Aviation Organisation *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds* and *Handbook on the International Airways Volcano Watch)*.

The research undertaken in the Global Reporting project has led to improved understanding of hazards and risks at local to national scales and new research projects. For example, the team collaborated with the UK Centre for Observation and Modelling of Earthquakes, Volcanoes and Tectonics (COMET) and scientific partners at Addis Ababa University to support response to an emergency at Fentale-Dofen volcanoes when 75,000 people were evacuated (Lewi et al. 2025; Way et al. 2025). The team won a NERC urgency grant to investigate, with the national agency (INSIVUMEH, Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología / Guatemalan National Institute for Seismology, Volcanology, Meteorology and Hydrology), pyroclastic density currents resulting from the eruption of Volcán de Fuego in Guatemala in 2025. This led to an invitation from INGV to collaborate on related research on Etna in Italy. Collaborating with in-country science partners is crucial to this project's approach. Other research on volcano-tectonic unrest, forecasting (state of the art) and volcanic alert levels and colour code systems has been undertaken with partners from around the world. In addition, the team have worked with partners to initiate the European Volcano Observatories Network and through the Global Reporting project have been able to take a leading role in the North Atlantic Volcanic Hazards Partnership, which supports UK resilience. Alongside this, tools that have been produced during the course of the project are now being developed further by the international community for use by scientific organisations around the world, even providing the basis for climate projections in the next IPCC report (Vol2Clim).

RIC 2: STRATEGIES FOR SUSTAINABLE MINING AND RAW MATERIAL SUPPLY

The first RIC2 hub is focussed on geoscience informed decision making for resource development that aims to help secure the continued supply of raw materials, particularly for the energy transition to net zero, and ensure minimal environmental and social impact.

As part of the drive to ensure responsible sourcing of mineral resources, the critical and technology metals-related research in the Philippines is focused on the whole system understanding of nickel laterite deposits and geophysical imaging of copper mine tailings storage facilities (TSFs) as well as the geochemistry of copper-cobalt mining waste. In the Philippines, we have piloted for the first time BGS geophysical monitoring technology (PRIME) as a means of non-invasively and volumetrically monitoring subsurface changes within the body of a tailings dam – for the purpose of producing a new decision support tool for TSF management. The monitoring station was installed in 2022 and has provided resistivity data that has enabled modelling of subsurface seasonal moisture dynamics and informed the development of a hydrogeological model to provide the basis for monitoring geotechnical

stability. This provides the starting point for an early warning system for tailings dam slope failure. The results from this research have stimulated significant interest from mining companies and consultants in the UK, Philippines, and Australia. On the other hand, the nickel laterite project in the Philippines is providing enhanced geochemical and mineralogical constraints on the spatial distribution, host phases and partitioning behaviour of critical metals, forming a robust basis for geometallurgical modelling. The study has also documented the presence of environmentally significant components, including hexavalent chromium and asbestiform minerals, which require careful management due to their potential environmental and public-health impacts. Integrated field observations and laboratory analyses have been shown to be essential for optimising recovery of both primary and by-product metals, such as cobalt, scandium and platinum-group elements, while reducing the volume and toxicity of mine waste. These findings can inform the development of more sustainable mining and processing operations and support evidence-based mitigation strategies, particularly as nickel production in the Philippines is anticipated to expand in response to rising global demand for critical raw materials.

Global recognition of the environmental pressures created by sand and construction material consumption, now the second largest anthropogenic material flow after water, continues to grow. Against this backdrop, the Sand and Sustainability project has significantly raised the visibility and influence of BGS and IGRD research. The team strengthened its international engagement by presenting at the United Nations Economic Commission for Europe (UNECE) annual conference in Geneva in 2024 and continued collaboration with the UNECE-supported UK International Centre of Excellence on Sustainable Resource Management (UK ICE SRM). This partnership has substantially increased the global profile of our work on sustainable mining practices. Engagement with the UN Environmental Programme's (UNEP) Global Resource Information Database (GRID) Geneva has also advanced, opening pathways for further collaboration and raising recognition of BGS expertise. As a direct result, BGS was invited to contribute to UNEP's forthcoming 2026 global report on international sand governance. This major publication will include good practice illustrations created in earlier phases of the IGRD programme, bringing project outputs to a worldwide audience.

The project also delivered strong scientific progress. New methodologies using Earth Observation to assess sand consumption and quantify material flows were developed, with a paper on the innovative Malaysia case study now submitted to the Journal of Industrial Ecology and available as a preprint. These methods were presented at the annual CCOP conference in Laos (November 2025), reaching a broad international network of stakeholders. UNEP GRID Geneva has since adopted the methodology for their construction materials modelling and produced new case studies for The Gambia in collaboration with BGS, demonstrating real-world uptake and impact. As the project entered its final stages, emphasis shifted to communication and dissemination. A comprehensive ArcGIS StoryMap was produced to present all project outputs in an accessible and engaging format. In addition, an international conference was held in mid-March 2026 at the Geological Society, London, which generated additional outputs and further strengthened global engagement.

The continuing and growing demand to supply the critical and battery raw materials needed for the energy transition to a low-carbon society has led to increasing pressure to find these resources. The BGS support of the Zambian Geological Survey Department (GSD) is one example of BGS' work to support African governments' engagement with the exploration and development of critical raw materials. The geological understanding of resources, reconnaissance exploration, laboratory characterisation and freely accessible publication of

minerals information and maps are ways in which national geological surveys in Africa can play a valuable part in the discovery and development of these critical and battery raw material resources. The Critical Mineral Resources – Zambia research combined the past BGS graphite and mineral waste research in a project that aimed to develop a better understanding of the critical mineral resources of Zambia in support of the Zambian Government. The IGRD research was pivotal to leveraging three phases of FCDO funded (~£800k) research in Zambia since late 2023. This ongoing BGS research activity, including graphite fieldwork, training and critical minerals workshops, informed the development of the Zambian 'National Critical Minerals Strategy' (published in mid-2024) of the Ministry of Mines and Minerals Development (MMMD). The current FCDO-funded project "Supporting resource capability for critical minerals in Zambia" supports this strategy. The focus being on developing the critical raw materials capacity of the Zambian GSD. In June 2025, the BGS in collaboration with the GSD published a guide on the 'Critical minerals potential of Zambia' that covers copper, cobalt, coltan (columbite-tantalite), graphite, lithium, manganese, nickel, rare earth elements, sugilite, tin and uranium in Zambia. The guide will help inform exploration companies, academia, decision makers and the public on the resources of these critical minerals in Zambia. A workshop in Lusaka was held on 25th February 2026 as an official launch of the guide and was supported by the MMMD and the British High Commission to Zambia. At the time of writing this workshop was of interest to the President of Zambia, Hakainde Hichilema. Other BGS teams worked with the GSD to support the laboratory capacity and to enable archived Zambian minerals information to be more accessible. The BGS also continue to support PhD research in collaboration with the Copperbelt University (CBU) into the environment health impact and critical raw material potential of the abundant copper refinery slag/mine tailing across the Copperbelt. In summary, the Critical Mineral Resources – Zambia research delivered an increased understanding of critical raw material resources, reconnaissance programmes by geological surveys, and mineral promotion leading to active exploration for critical and battery raw materials in Africa.

The high Andean resources research project focused on understanding the provenance and determining the responsible sourcing of lithium from brines exploited from salars in Argentina, Bolivia and Chile. The IGRD research built on the outputs from the Lithium for Future Technologies (LiFT) and Science and Innovation Network (SIN) tactical fund project "Responsible sourcing framework to enable up-scaling of lithium production and supply". Environmental, Social and Governance (ESG), Life Cycle Assessment, in particular examining existing frameworks and certification, stakeholder engagement and communication of the issues around salars were key aspects of the research. Lithium extraction from salars forms one of the case studies in the UN Resource Management System (RMS) as part of the Centre of Excellence of which BGS is a part, enabling decisions, policy and practice to be informed by geoscience. Co-operation with the USGS and Rio Tinto (operators of a lithium mine in Argentina) allow new understanding of lithium provenance in salars (e.g. Salar de Uyuni, Bolivia) and process understanding developed through IGRD research to be applied at scale. The project maintained regular communications with stakeholders in all three South American countries and internationally, including geological survey organisations, government officials, operators and NGOs, promoting sustainability and translating geoscience knowledge into practice. BGS hosted visits from lithium institutes in both Chile (National Lithium and Salars Institute – INLiSA) and Argentina (Jujuy) and recently (January 2026) signed an MoU with INLiSA.

RIC 2: ENERGY RESOURCE EVIDENCE FOR TRANSITION TO NET ZERO

The second RIC 2 hub examined the way geoscience is harnessed to help develop the potential of the subsurface, particularly for geothermal energy and Carbon Capture, Utilisation & Storage (CCUS), for the energy transition to net zero.

The superhot geothermal research project demonstrated the use of rock physics modelling techniques to estimate geothermal gradient using passive seismic and magnetotelluric (MT) surveys of Aluto, a stratovolcano in the Central Main Ethiopian Rift, part of the East African Rift. The developed methodology can assist in better identification of zones of high geothermal energy potential that might be economically useful for renewable energy production in the Ethiopian rift and elsewhere. The research project methodology will enable future collaboration with the Institute of Geophysics, Space Science and Astronomy (IGSSA) at the University of Addis Ababa in Ethiopia to promote engagement with energy companies to further develop the geothermal potential of the East African Rift. This is a challenging research space due to a lack of temperature data which is typically only available in boreholes down to a few hundred metres but is required to a depth of several kilometres to validate the modelling. Should the methodology be adopted more widely, the outcome of the geothermal research would be to de-risk geothermal drilling and to provide investors a greater degree of certainty for hitting good geothermal yields.

The Indian CCUS research project has actively collaborated with in-country partners to address some of the fundamental research required to understand the potential to deploy CCUS technologies in India. In March 2024, BGS co-chaired a three-day symposium in Mumbai on the role of geosciences in carbon storage, organised by the Society of Exploration Geophysicists. BGS presented IGRD research on CO_2 trapping by mineralisation in Deccan Trap basalts, CO_2 storage containment risks in the onshore Cambay Basin, and the application of CO_2-storage monitoring in India using seismic reflection methods. The research led to the establishment of new partnerships with commercial companies operating in India, enabling the application of geoscience knowledge at scale and further embedding geoscience research into practice. Through bilateral research visits and exchanges, we have assisted partner institutes in adopting best practice methods in geological site characterisation for CO_2 storage, risk assessment and monitoring feasibility. An outcome of the work is that project partners in India, funding agencies and regulatory bodies consider BGS to be a trusted partner. Consequently, the British High Commission announced their aspiration to launch a UK-India joint innovation centre on CCUS with support from the Govt. of India Department of Science and Technology. Consequently, a network of partners from both the UK and India are actively seeking to deliver an ongoing programme of collaborative CCUS research to extend beyond the IGRD programme. BGS are also actively collaborating on a new research project focussed on CO_2 storage monitoring using surface seismic technologies, building on IGRD research.

RIC 3: UNLOCKING THE POTENTIAL OF GROUNDWATER

This hub provides evidence and partnerships to support sustainable groundwater use, management and protection for improved water security in Africa and South and Southeast Asia.

In sub-Saharan Africa (SSA), this hub is centred around several key areas of research: (1) improving our understanding of basement aquifer typologies across SSA and their potential to support sustainable groundwater abstraction, alongside an understanding of key groundwater quality challenges; (2) identifying the key hydrogeological, social and engineering controls on the functionality of rural water points; (3) working with the solar pumping community to ensure

that groundwater data and knowledge informs the anticipated shift to solar-powered groundwater abstraction in SSA.

The groundwater mapping methodology being developed under IGRD, which has fostered new ways of interdisciplinary working between the geologists, hydrogeologists and environmental modellers in BGS, is building the foundation for a new approach to characterising aquifers in Africa. The approach, which has advanced our thinking about aquifer productivity, is being recognised and taken up by stakeholders at a continental scale and has been key to leveraging further work (>£0.5M) at a sub-national, regional and continental scale. BGS' groundwater mapping capability was a key factor in BGS' success in winning funding from UNICEF (2023-2025), with whom we have a long-standing partnership, to carry out groundwater resource assessments in Southern and Eastern Africa under their More Water More Life programme. This mapping informs UNICEF's water supply infrastructure investment decisions to provide resilient water sources for rural communities. The mapping approach has also been applied in projects across Ethiopia, Kenya, and Somalia under the World Bank's Horn of Africa Groundwater for Resilience programme (2023-2026). At a continental-scale, it is underpinning a new decision-making tool, being funded by BGR (German Federal Institute for Geosciences and Natural Resources, 2024-2026) and working in collaboration with the Kenyan Water Resources Authority, which will inform investment decisions by stakeholders working on water supply projects at different scales in sub-Saharan Africa.

The work on waterpoint functionality concluded in 2025/26 with a major publication in PLOS Water, in collaboration with partners across Ethiopia, Uganda, and Malawi. During 2024-26, BGS leveraged additional funds under Phase 3 of the initiative to undertake further work to identify and quantify determinants of corrosion risk to rural water supply infrastructure and to develop handpump borehole diagnostics that can be implemented at different points in the rural water supply life-cycle, from construction to ongoing maintenance. Through this initiative, BGS' functionality work is informing discussions with other partners within the campaign (e.g. Rural Water Supply Network, World Bank, WaterAid, UNICEF) about the role of handpumps in rural water supply under SDG 6 (Clean Water and Sanitation) and decisions about the future of standardisation for handpumps and handpump components.

BGS' contribution to work on solar pumping in Africa continues to influence the narrative on this important topic, which is receiving increasing attention from donors and investors at a global scale. In 2023, BGS, along with partners, contributed to a World Bank publication on the economics of groundwater in times of climate change, which highlights the opportunities and potential risks of maladaptation associated with the expansion of solar pumping in Africa. During 2024-26, the solar work continued through two PhDs jointly supervised by Paris Saclay University. This allowed BGS to place the issue high on the agenda at the 2024 World Groundwater Congress in Davos, resulting in an Opinion Editorial by Alan MacDonald in the Guardian (September 2024), and was a focus at the IGAD Water Forum in May 2025.

The Africa Groundwater Atlas, which continues to be developed under the IGRD programme, pulls together much of the evidence being generated by IGRD and is a primary source of information on groundwater in Africa. In 2026, downloads of the country-scale hydrogeology maps reached 70,000 with users from academia, government agencies, non-governmental organisations, and the private sector. In 2024, a new version of the Africa Groundwater Literature Archive (AGLA) was launched, allowing the African Ministers' Council on Water (AMCOW) to link their online knowledge hub to AGLA for the first time. This provides a new entry point to AGLA, potentially increasing the number of users, and providing more visibility for groundwater to a wider range of users. AMCOW continues to recognise BGS as a partner to

their continental strategic groundwater programme. At a series of continental consultations on the post-2025 Africa Water Vision (Dec 2024 – April 2025), the Africa Groundwater Atlas was highlighted by AMCOW as an important and strategic resource that should continue to be developed in support of groundwater's contribution to socio-economic transformation on the continent. AMCOW's newly launched Africa Water Vision 2063, strongly highlights groundwater as a strategic climate resilient resource for sustaining lives, economies and peace on the continent.

BGS continue to provide input as co-author on a new global manual on natural water chemistry. This will be a high-impact successor to a well-known book used by many stakeholders: "Study and interpretation of the chemical characteristics of natural water" by John Hem (USGS, 1985).

In South Asia, the Indo-Gangetic Basin (IGB) is one of the world's most important transboundary water resources, and one of the most heavily exploited aquifers in the world (c. 25% of global withdrawals). Under the IGRD programme, BGS worked with key partners in the region, including the World Bank, Indian, Pakistani and Nepali water research organisations and the Australian government, on three objectives with important implications for management of water resources: (1) assessing the accumulation of groundwater salinity across the Indus Basin, quantifying groundwater salt stocks and salt fluxes; (2) quantifying the effects of abstraction, surface water inflows and groundwater capture on groundwater resources in the Upper Indus; (3) investigating groundwater residence times and resilience in the Kathmandu valley, Nepal.

The international dimensions of data access have been key to project success in the Indus basin and, building on the work of identifying data sources carried out during the first year of the project, data was collated on over 20,000 sampling points where salinity information is available. This was used to prepare maps of existing salinity and salt accumulation rates, and a linear model was developed to test the relative effect of groundwater abstraction, canal irrigation, climate change, spatial distribution of rivers, canals and agriculture on salt accumulation. This research transformed our understanding of the dominant controls on groundwater salinity in this region, highlighting the potential for effective management interventions on human timescales. Work is ongoing with our established partner networks to translate this understanding into policy and practice recommendations to address salinity issues in a region heavily dependent on groundwater. Natural tracers have also been used to determine rates of groundwater recharge in the Kathmandu valley to assess the resilience of an aquifer that is an important water resource, yet highly vulnerable to climate change impacts. This work led to further funding from FCDO (2024-2026) to: (1) understand controls on the propagation of floods in the upper parts of the Gangetic basin to inform future flood mitigation; (2) investigate the changing dynamics of natural and artificial groundwater recharge to enhance the adaptive capacity and resilience of agricultural and water supply systems.

Work in **the Philippines** focused on developing national-scale hydrological models able to better prepare society and decision-makers for future change. Calibration of the models was completed in 2023/24, and a series of future scenarios were run in 24/25 and delivered to non-specialists through a newly designed web-platform to help in-country stakeholders understand and quantify the susceptibility of water systems to future hydrometeorological and urbanisation extremes, for instance on islands subject to environmental pressure from tourism. The project provided a strong foundation for ongoing and future work on water scarcity in the Philippines and played a role in raising groundwater up the agenda at a national level. Through close engagement with the National Water Resource Board and Department of Science and Technology, the project has placed a strong emphasis on network development and identifying pathways to extend activities and fund partners. This led to DOST (Philippines science funding

body) adopting the IGRD programme as a basis for a national funding call in 2023/24 and the BGS team, alongside partners securing additional funding from the British Council in 24/25 to continue engagement through development of a Hydro Hub.

RIC 3: GEOSCIENCE SOLUTIONS FOR SUSTAINABLE LAND MANAGEMENT

The impact of land degradation from poor land management has consequences for food security – impacting both food production on land and in lakes, where leached nutrients result in ecological imbalance in downstream aquatic environments. This is a significant issue in the Winam Gulf of Lake Victoria, Kenya, which supports the largest freshwater fishery in the world, providing food security and supporting the livelihoods of ~4 million people across Kenya, Uganda, and Tanzania. Via aligned funding from the Royal Society, initial investigation was undertaken in the Winam Gulf of Lake Victoria, through academic, research institute and community/regulatory partnerships, to encompass agriculture, industry and urban changes that influence land-to-lake dynamics, with global relevance for settings experiencing rapid deforestation for conversion to agricultural use. Modelling at catchment scale for land-to-lake transfers of soil/sediment connect the agricultural and fisheries sectors and their decision makers to develop holistic management practices e.g. working with nature in land and aquatic environments. The resulting model for land-to-lake dynamics in the Winam Gulf of Lake Victoria was used to demonstrate a catchment scale approach to inform sustainable land/aquatic management by prioritising limited resources for mitigation (e.g. afforestation) to specific locations within a catchment. Pathways to inform decision making in Kenya were established through a stakeholder forum, comprised of partners across the land and lake management sectors. Our ambition is to explore the extension of this approach to a diverse range of environments, while continuing the development of tools to make the data and learning widely accessible to regional stakeholders. Initially, this will link through the Lake Victoria Advisory Group to a broader regional study, building on the success of the land and lake management stakeholders in government, private sector and communities in Kenya. To facilitate this translation across the Lake Victoria Basin, the project has contributed to a documentary (produced by NGO Train My Generation), which highlights the importance of the lake's ecological health for sustaining its blue economy. This aims to attract funding for further research on the evolution of Lake Victoria's ecological health to inform future management policy. There is further potential for translation of knowledge and stakeholder linkage to the African Great Lakes in East Africa through a developing partnership with the African Centre for Aquatic Research and Education.

The IGRD programme also builds on previous work from the CEPHaS (Strengthening Capacity in Environmental Physics, Hydrogeology and Statistics for Conservation Agriculture Research) project, which investigated the effectiveness of conservation agriculture (CA) in Malawi, Zambia, and Zimbabwe, while also looking at the impacts of CA approaches on groundwater.

Conservation agriculture is employed to reduce soil erosion and degradation by improving water retention, retaining nutrients, and reducing acidification of soils. Through IGRD, a multi-country, African-led publication was produced, providing insights into the impacts of CA on groundwater recharge in subhumid drylands in sub-Saharan Africa. This led to the development of a new project proposal to look at the role of dambos in collaboration with partners in Zimbabwe and in 2025/26 a PhD studentship was secured, which will integrate hydrology and ecology to guide the conservation and management of dambo systems in SSA. This work also helped to establish a new partnership with Practical Action and supported preliminary groundwater

monitoring in Senegal to understand the role of groundwater in contributing to and mitigating flooding in the city of Thies.

Urban water quality is a multi-dimensional issue, affecting cities and populations in diverse ways depending on geology, climate and the history of infrastructure development and industry. Our projects aim to understand the relative importance of these factors. As an exemplar, working with UNICEF and Practical Action in Zimbabwe on shallow water points that are extensively used by marginalised urban communities, where population growth has outstripped infrastructure development, the project and partners have installed monitoring technology to understand urban groundwater balances. A programme of analysis used eDNA as a tool to identify sources of pollution. This is an emerging technology, and as part of the project new protocols and policies for its use in Zimbabwe were agreed with the Environmental Management Agency (EMA). In 2024/25, the groundwater monitoring network was fully handed over to the EMA, and an expansion of the network is being planned. This is helping to leverage additional funding to continue the work under FCDO's Green Cities Initiative. In Kenya, measurements of organic pollutants in urban soils and sediments identified contaminant transfer through the urban environment. The data and interpretations have been delivered to the National Environment Management Authority and directly contribute to Kenya's Vision 2030 which aims to improve sanitation and waste disposal.

RIC 3: GEOSCIENCE TO INFORM URBAN PLANNING

More than half the global population currently live in urban areas. This is projected to increase to nearly 70% by 2050, requiring effective urban planning to ensure safe and resilient cities. The IGRD programme, building on work under the previous international NC programme, aims to support and increase the use of urban geoscience knowledge by urban planners to optimize the use of the sub-surface and minimize the exposure of urban populations and infrastructure to geohazards. This work is largely focussed on Asian cities, where BGS has long-standing and developing partnerships with geological surveys, universities, and decision-makers. A key pathway to impact for the urban work within IGRD is the strong partnership with CCOP (a multilateral organisation representing Southeast Asian geological surveys), who have a well-established focus on urban geoscience. For example, in Malaysia, co-developed systems and workflows for managing urban geoscience data and urban geological modelling are being implemented by the Malaysian geological survey (JMG) through a £0.5M project, which will develop a 3D geological model of the greater Kuala Lumpur area, supported by BGS. An MoU between BGS and JMG is in process. Through this collaboration, BGS was invited to comment on new Malaysian site investigation standards. In South Korea, an ongoing collaboration with the geological survey (KIGAM), is allowing BGS' stochastic approach for lithofacies modelling to inform 3D geological modelling at a national scale.

The urban work within IGRD is facilitating collaboration across the programme to address urban geohazard risk assessment and mitigation. One example of this is a collaboration with UNITEN (a Malaysian university privately owned by the national electric utility company), which resulted in them purchasing a BGS PRIME system to be installed on a critical slope above one of the largest hydroelectric dams in Malaysia. This will allow UNITEN to assess and mitigate risk to power generation and downstream populations associated with slope / dam failure. The urban project is also facilitating translation of IGRD sand and sustainability work from Hanoi to Malaysia and of the landslide trigger thresholds work from India to Malaysia.

Work under IGRD instigated new engagement between CCOP and the EuroGeoSurveys Urban Geology Expert Group, which aims to promote further uptake and application of urban geoscience tools within Southeast Asia. BGS' prominent role within the CCOP advisory group also provides new potential pathways for the translation of BGS research, beyond urban geoscience, to new geographical contexts. One potential example of this is a new CCOP Research Centre in Urban Geology, established in Nanjing, China, which has proposed a two-year programme of research with a focus on cities where there is a significant legacy of historical mining. This offers the opportunity of collaboration on themes from the UKRI-funded UKGEOS programme (especially mine water heat), and the challenges of mine related subsidence and water quality. In 2025/26, BGS also began a new collaboration with the Department of Mineral Resources in Thailand, who are seeking advice from BGS on establishing an urban geoscience centre and discussions are ongoing with ADB regarding potential funding for this initiative.

Appendix 5 Workshop Reports

MARCH 2026 WORKSHOP

This workshop was a celebration of the research conducted between BGS and its research partners around the world during a 4-year UK National Capability International programme as part of a network of research partnerships and multiple ongoing international projects addressing diverse environmental challenges. The workshop was held online using pre-recorded video testimonials from partners for each project with a discussion between partners and BGS staff in real-time to comment on the testimonials and future pathways for success. We posed two questions to partners to frame their videos:

(1) What were the highlights of the research collaboration with BGS?

(2) How is this research being used?

The agenda for the workshop is shown below.

International collaborative research for global environmental challenges

18th March 2026, 8.30 GMT

08.30 Dr Michael Watts as lead for the BGS International Geoscience R&D programme will open the meeting and explain the objective and format of the meeting.

08.40 First theme based on **Living in Multi-hazard environments (Susanne Sargeant-BGS)**

Subsidence and Geohazard Risks in Indonesia

1. *Institut Teknologi Bandung, Dr Endra Gunawan,*
2. *National Research and Innovation Agency, Dr Rahma Hanifa and*
3. *Resilience Development Initiative, Dr Saut Sagala*

BGS: Ekbal Hussain and Luke Bateson

Landslide Trigger thresholds for tropical residual soils

4. University of Kerala Professor Kumar

BGS: Nikhil Nedumpallile

ALMEO

5. Chengdu University of Technology, Professor Xiachuan Tang

BGS: Alessandro Novellino

09.00 Second theme: **Sustainable land management and climate change adaptation (Kirsty Upton-BGS)**

Groundwater Security in Asia

6. National Institute of Hydrogeology, India, Dr Gopal Krishan

BGS: Dan Lapworth

Water Security in Africa

7. University of NorthWest University, South Africa, Dr Seifu Kebede

BGS: Alan MacDonald

Urban Geoscience

8. Mr Ma Yongzheng, Director of the Technical Secretariat for the Coordinating Committee for Geoscience Programmes in east and Southeast Asia (CCOP).

BGS: Marcus Dobbs

Land Use and Environmental geochemistry

9. University of Eldoret, Professor Odipo Osano and Dr Chris Aura

BGS: Michael Watts

09.20 Panel Discussion

09.50 Third theme: **Resources for the future (John Williams-BGS)**

Strategies for sustainable mining and raw materials

10. University of the Philippines Diliman and Philippine Nuclear Research Institute, Dr Ruth Delina-Agillon

BGS: Alicja Lacinska

Emissions reduction and enabling growth in India through CO_2 storage

11. Indian Institute of Technology Bombay, Professor Vikram Vishal

BGS: John Williams

Critical Resources in Zambia – graphite and mineral resources

12. Copperbelt University, Professor Kakoma Maseka and Geological Survey Department, Director Gerald Mwila

BGS: Clive Mitchell

Improving Social and Environmental Assessment (SEA) of Li-brine mining from the Lithium Triangle, South America

13a. Lithium research centre in Jujuy, Argentina, Dr Victoria Flexer

13b. Melisa Olivelli, a microbiologist from University of San Martin, Buenos Aires

13c. Hernan Caceres, Director of the Chile Lithium Institute (INLiSA), Antofagasta, Chile

BGS: Andrew Hughes

10.10 Panel Discussion

10.30 Broader comments from the audience across all themes

Do partners think that international collaboration facilitates impactful research?

11.00 Closing thoughts from:

Maggy Heintz - Director of BGS International and

Karen Hanhoj - Director of BGS

Appendix 6 Thematic Synergies

Table 4. IGRD programme thematic synergies.

	Multihazard Detection & Forecasting	Multihazard Management	Water Security	Urban Resilience	Sustainable Resources	Decarbonisation	Sustainable Land Management	Useful, useable, used
RIC1								
Philippines multi-hazards		x						x
Earthquake forecasting using AI	x							x
Self-recovery after disasters		x	x				x	x
Geohazards and risk in Indonesia		x						x
Landslide trigger thresholds	x							x
Landslide mapping using Earth Observation	x							x
Subsidence in developing urban centres	x			x				x
Global reporting of multi-hazards and impact		x						x
Geoscience for sustainable living in the UK Overseas Territories		x	x					x
RIC2								
Mineral mine waste: whole system approach (multiple tasks)	x				x			x
Sand and sustainability					x			x
Improving SEA of Li-brine mining from Lithium Triangle of South America					x			x

Food and water security Africa (multiple tasks)			x					x
Enabling clean growth India through CO2 storage						x		x
African geoscience data for improved geothermal assessment						x		x
Identifying superhot geothermal zones using geophysical methods						x		x
RIC3								
Land use and environmental geochemistry (multiple tasks)							x	x
Blue green infrastructure (multiple tasks)	x		x	x			x	x
Groundwater Futures (multiple tasks)			x				x	x
Groundwater in SE Asia (multiple tasks)			x					x
Urban Geosciences (multiple tasks)			x	x				x

Appendix 7 Partnership Survey

BGS International Geoscience Re and Development (IGRD) Partnership Survey

20 Apr 2026

* Required

8 Participant Information

The International Geoscience Research and Development (IGRD) Programme is a BGS-led initiative, funded by the Natural Environment Research Council (NERC) from 2022-2026. It aims to facilitate the sustainable use and secure supply of Earth's natural resources and increased community resilience to natural and anthropogenic hazards through the provision of geoscience data, information, and knowledge. Partnerships are a key foundation of IGRD and are critical for delivering solutions to the global environmental challenges being addressed by the programme.

As we approach the end of the programme, we are inviting partners to provide their perspectives and experiences of the programme, and of working with BGS, by completing a short online questionnaire. This is largely a repeat of the questionnaire carried out in 2023/24, which will allow us to monitor changes over the last two years and reflect on the successes and challenges of the programme.

The questionnaire comprises 17 questions and will take approximately 15-30 minutes of your time. Your involvement is voluntary and you can choose not to answer particular questions. You can withdraw at any time and request that your data is extracted from the study, up until the publication of outputs, expected by March 2026. Consent can be withdrawn by emailing Dr Kirsty Upton, IGRD Monitoring, Evaluation and Learning lead (see contact details below). Data collected during this survey will be anonymised. No information will be shared from the survey that would identify you or your organisation. Declining to participate will have no negative consequences for you or your organisation.

The results from the survey will be used to evaluate the programme and inform any future international research programmes being led by BGS. The results will also be used for reporting purposes, both internally within BGS and externally with our funders. The anonymised and aggregated results may be published in openly available reports, which will be shared with project partners.

The survey has been reviewed and approved by the BGS Research Ethics Committee (reference code: BGSREC-2023-005). If you are worried about this survey, or if you are

concerned about how it is being conducted, you can contact Dr Louise Ander, Chair of the BGS Research Ethics Committee (see contact details below).

Contact Information: Dr Kirsty Upton, Monitoring Evaluation and Learning Lead, IGRD kirlto@bgs.ac.uk; Dr Michael Watts, Principal Investigator, IGRD mwatts@bgs.ac.uk; Dr Maggy Heintz, Director, International Geoscience mheintz2@bgs.ac.uk;
Dr Louise Ander, Chair, BGS Research Ethics Committee BGSEthics@bgs.ac.uk

9 Participant Consent

Before taking part in this survey, please review the statements below. If you wish to participate, please tick the box to confirm your consent.

In giving my consent to participate in this study, I confirm that:

- I understand the purpose of this survey and that all procedures adhere to the BGS Ethics process.
- I understand that I can ask questions about this survey before participating, using any of the email addresses above. I understand that I am under no obligation to take part in the survey, have the right to stop my participation at any point for any reason, or decide not to answer a particular question, and will not be required to explain my reasons for any of these actions.
- I understand that I can withdraw my consent to participation (by emailing Dr Kirsty Upton) at any point up until the publication of outputs (March 2026), and request my data is extracted from the study and destroyed. I agree to any personal information I choose to provide being processed in accordance with the UK General Data Protection Regulations (further information can be found here: https://www.ukri.org/about-us/privacy-notice/). I understand that my personal information will be stored in a secure location, and only accessible to the project team named above, unless (under the statutory obligations of the agencies which the researchers are working with) it is judged that confidentiality will have to be breached for the safety of the participant.
- I understand that anonymised data may be used in outputs (e.g. publications, reports, web pages).

1. I agree to take part in this study with the above in mind *

◯ Yes, I consent to taking part in this survey

◯ No, I do not consent to taking part in this survey

10 Partnership with BGS

2. Partnering with BGS is delivering value to my research

☆ ☆ ☆ ☆ ☆

Strongly disagreeStrongly agree

3. There was a clear plan for the partnership (including vision, objectives and defined responsibilities of each partner)

☆ ☆ ☆ ☆ ☆

Strongly disagreeStrongly agree

4. The necessary resources (e.g. personnel or finance) are available for the partnership to function effectively

☆ ☆ ☆ ☆ ☆

Strongly disagreeStrongly agree

5. Information/knowledge sharing between BGS and my organisation is effective

☆ ☆ ☆ ☆ ☆

Strongly disagreeStrongly agree

6. It is easy to openly discuss problems, and any issues are dealt with respectfully and constructively

☆ ☆ ☆ ☆ ☆

Strongly disagreeStrongly agree

7. Cultural differences between BGS and my organisation are handled sensitively and effectively

☆ ☆ ☆ ☆ ☆

Strongly disagreeStrongly agree

11 Partner's role in the project

8. What is the nature of your role within the project? (Please select all that apply)

*** If providing information in the text box, please do not include any personal data in your response that could identify you or a project partner***

- ◯ Actively involved in research, e.g. undertaking fieldwork, analysis, producing outputs, dissemination of knowledge/outputs
- ◯ Advisory
- ◯ Engaged due to interest / aligned areas of work
- ◯ Other

9. What type of outputs is the work you are involved in producing? (Please select all that apply)

*** If providing information in the text box, please do not include any personal data in your response that could identify you or a project partner***

- ◯ Publications (e.g. peer reviewed papers, workshop reports etc)
- ◯ Software and technical products
- ◯ Artistic and creative products
- ◯ Further funding applications
- ◯ Datasets, databases, and models
- ◯ Conference presentations
- ◯ Workshops, outreach, or training/educational activities
- ◯ Stakeholder meetings / engagement activities
- ◯ Other
- ◯

◯ 10. My effort is being fairly reflected in the ownership/authorship of the deliverable(s)

☆ ☆ ☆ ☆ ☆

◯ Strongly disagreeStrongly agree

12 Impact of project on partner and partner organisation

11.Has involvement in the project resulted in any positive or negative changes for you, or your organisation?

- ◯ Yes - positive change
- ◯ Yes - negative change
- ◯ No change
- ◯

12.What is the nature of this change for you as an individual? (Please select all that apply)

*** If providing information in the text box, please do not include any personal data in your response that could identify you or a project partner***

- ◯ Co-authored outputs
- ◯ Increased capacity due to training, skills development, new knowledge
- ◯ Career progression
- ◯ New or expanded networks / partnerships
- ◯ Increased invitation to regional / country stakeholder meetings
- ◯ Other
- ◯

◯ 13. What is the nature of this change for your organisation? (Please select all that apply)

- ◯ New working practices / processes
- ◯ Additional funding secured
- ◯ New networks / partnerships
- ◯ Increased ability to advise / inform stakeholders (e.g. government, communities)
- ◯ Other
- ◯

13 Impact of work external to partner organisation

14. To your knowledge, has involvement in the project resulted in any positive or negative changes for external stakeholders (i.e. those not directly involved in the project)?

- ◯ Yes - positive change
- ◯ Yes - negative change
- ◯ No change
- ◯

15. What type of stakeholder(s) has the project had influence on? (Please select all that apply)

*** If providing information in the text box, please do not include any personal data in your response that could identify you or a project partner***

- ◯ Government department (local or national)
- ◯ Non-governmental organisation (national or international)
- ◯ Private sector / commercial
- ◯ Geological survey or equivalent
- ◯ University or research centre
- ◯ Communities
- ◯ Other
- ◯

- ◯ 16. What is the nature of the change that has occurred as a result of the project? (Please select all that apply)

*** If providing information in the text box, please do not include any personal data in your response that could identify you or a project partner***

- ◯ Change or influence on narrative / way of thinking
- Increased awareness
- ◯ Change or influence on policy
- Change or influence on practice, process, or ways of working
- ◯ Change or influence on behaviour
- Funding decisions
- ◯ Training to strengthen research uptake
- New networks or partnerships
- ◯ Other
- ◯
- ◯ 17. Please provide details and, if possible, evidence for the change(s) that has/have occurred as a result of this project
- ◯ *** If providing information in the text box, please do not include any personal data in your response that could identify you or a project partner***

Enter your answer

18. If relevant, how did you become aware of this evidence?

*** If providing information in the text box, please do not include any personal data in your response that could identify you or a project partner***

Enter your answer

14 Additional Information

Please note that, as above, the following questions do not have to be answered, any data provided can be extracted from the study upon request, all personal information provided will be processed in accordance with UK General Data Protection Regulations and only accessible to the project team named above, and all results will be anonymised.

19. What type of organisation do you work for?

- ◯ Academic / research
- Government / public sector
- ◯ Non-governmental organisation
- Commercial / business
- ◯
- ◯

20. What career stage would you identify as?

- ◯ Early career
- Mid career
- ◯ Late career
- ◯

21. If you would be happy to be contacted by BGS as a follow-up to this survey, please provide your contact details below

Enter your answer

Thank you!

Thank you for taking the time to complete this survey.

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