Geoscience and Sustainable Development

Learning resources to help integrate sustainability concepts and skills into geoscience teaching in Higher Education

GEOLOGY FOR GLOBAL DEVELOPMENT (GfGD) is a not-for-profit organisation, established to champion the role of geology in sustainable development, mobilising and equipping the geology community to support the UN Sustainable Development Goals. Registered Charity Number: 1165663.

Supported by the:

International Union of Geological Sciences

UNESCO / IUGS International Geoscience Programme Project 685: Geoscience for Sustainable Development (GeoSD)

v.1.1 (10 September 2020)

GEOSCIENCE AND SUSTAINABLE DEVELOPMENT

Module Background and Aims. We recognise the increasing demand for the inclusion of sustainability concepts into geoscience teaching within higher education, as well as the impact of Covid-19 on the means of delivering learning resources. This open-access module on 'Geoscience and Sustainable Development' is our response. Specifically, we aim to help learners:

- Explore key global development frameworks, and the national and local sustainability challenges they seek to address.
- Understand how geoscience knowledge can contribute to understanding and tackling these challenges.
- Develop skills to strengthen engagement in sustainable development activities.
- Understand that '*how we work*' is as important as *'what we do*' – and therefore the need to build equitable partnerships, and address inequalities in the geosciences.

What does this module include? This module includes eight classes: the United Nations Sustainable Development Goals, Working in the Global South, Decarbonisation, Disaster Risk Reduction, Water Security, Health and Land Degradation, Sustainable Urban Development, and Reducing Inequalities. Each class contains:

Learning Objectives: Brief statements of what learners will be able to do after engaging with learning resources and activities.

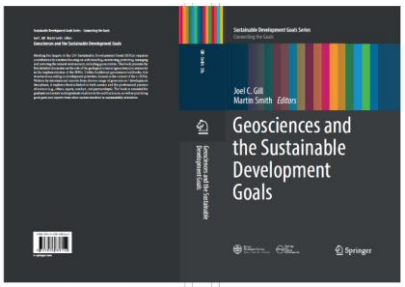
Core Reading: An open-access journal article (including research, policy-focused and perspective papers) to set the scene.

Supplementary Resources: A collection of 4–6 diverse resources, including videos, blogs, data portals, websites, reports, and journal articles. Collectively, these provide learners with an opportunity to explore the theme in more depth, consider case studies and explore how geoscience connects with other disciplines to address global challenges.

Suggested Discussion Questions and Activities: These help learners to explore the themes individually, in small groups, or in whole-class contexts. Activities vary from those intended to provoke discussion, to those that will help to build key skills to improve geoscientists contributions to sustainable development, whether working in research, industry, government, or civil society. Examples (with classes in parentheses) include science diplomacy (1, 5), context mapping (2), survey design (2), policy engagement (3, 4), and diverse communications skills (1–8).

This document, and any updated versions and additional resources, can be downloaded from our website: www.gfgd.org/education.

How to use this module? We have structured this module so that it can be used in different ways, to meet different needs, while supporting the overall learning objectives we set out. We have included activities to suit a range of levels, but you may wish to adapt these to suit the audience that you know best. You can (i) use the whole module (selecting 1 or 2 activities from each class), to give groups an introductory course to geosciences and sustainable development, (ii) select individual classes and integrate these into your existing modules, (iii) use specific resources or activities (or adaptations of these) from one of the classes to support or enrich an existing class, or (iv) be inspired by the content we present, and develop your own questions and activities that are context and institution specific. We have deliberately left some activities open in terms of requested output so that you can suggest learners address them through presentations, blogs, essays, on in a class discussion. While designed for higher education, we hope materials may be of benefit in other contexts including 11–18 education and continued professional development courses.



Further Resources. At the end of this module you will find in *Annex A*, a list of additional relevant resources that may be on interest and use to teaching, and in *Annex B* full URL links to supplementary resources in classes 1–8. In *Annex C*, we list examples of organisations (international, national, and local) working to help deliver the Sustainable Development Goals. This may help learners to identify further reading and training, get involved in relevant networks, or contribute to outreach activities. These lists are not exhaustive, and we recognise there are many other organisations contributing to sustainability objectives. This set of resources precedes a dedicated book, including further learning resources, on '*Geosciences and the Sustainable Development Goals*' to be released soon by Springer-Nature. This book was co-produced by GfGD and the British Geological Survey, involving 42 authors from 6 continents.

Reporting. We ask all those using these resources in their teaching (in whatever form) to tell us about your experiences – how and where are you using them, what do learners enjoy, what impact do they have on learners' understanding of geology for development? Your stories and feedback will help us to improve future resources, better serving the global geoscience community.

Support Our Work. We encourage those who can, to participate in the #GfGDPayItForward initiative, where use of our module is acknowledged by supporting our work in another way. Ideas include: (i) fundraise for us in your Department, (ii) make a direct donation to support our work, (iii) collect and donate surplus textbooks for us to rehome in institutions in the Global South, (iv) contribute to our blog, (v) provide a small grant to students in your Department to help them engage in our work, and (vi) help us spread the word about the educational resources. Contact us for more information.

DELIVERED BY:

GEOLOGY FOR GLOBAL DEVELOPMENT (GfGD) is a registered charity championing the role of geology in sustainable development, and mobilising and reshaping the geology community to help deliver the UN Sustainable Development Goals. Find out more about our work online (www.gfgd.org), follow us on Facebook (www.facebook.com/gfgd.org) and Twitter (@Geo_Dev). Contact us for information about services we can offer to help you use or adapt this resource for your organisation (www.gfgd.org/contact-gfgd).

Project Team

Kit Baker recently graduated with an MSci in Earth Sciences from the University of Cambridge, with a particular interest in palaeontology and climate, and is returning in October 2020 for an MPhil in Holocene Climates. For the last two years, Kit has been involved with GfGD, as an ambassador for the University Group at Cambridge, helping to organise events such as mapathons, and attending the GfGD conference. Kit is excited to help to educate geoscientists on sustainability concepts, and particularly to address inequalities within the geosciences.

Rachael Sims is in her third year of a BSc Geology degree at the University of Southampton, with an interest in joining the mining industry post-graduation. For the past year Rachael led the university group at Southampton as Vice President and will be responsible for events and communications for the upcoming year. Rachael was part of a team at the 2019 GfGD Conference giving a prize-winning talk titled 'The role of copper in IUDs'. Rachael is keen to integrate sustainability concepts into geoscience education and her future career.

Dr Joel C. Gill is Founder and Executive Director of GfGD. For the last decade, Joel has worked at the interface of Earth science and international development and plays a leading role internationally in championing the role of geoscience in delivering the SDGs. Joel is co-leader of IGCP 685 (Geoscience and Sustainable Development), and lead editor of the upcoming *'Geosciences and the Sustainable Development Goals*' book. He has received two prizes from the London School of Economics and Political Science for interdisciplinary teaching.

Dr Emily White is GfGD Deputy Director and has responsibility for the management and development of our University Group network. Emily has a particular interest in climate change policy and the disproportionate effects of climate change in the Global South. She has recently completed a PhD focussed on modelling regional greenhouse gas emissions and now works as a civil servant in the Department for Business, Energy and Industrial Strategy on policy to decarbonise heating in the UK.

We are grateful to Nic Bilham, Florence Bullough, Kirsty Dawkes, Dr Natasha Dowey and Dr Sarah Gordon (GfGD Trustees) and Laura Hunt (GfGD Administration Lead) and Dr Laura Roberts (GfGD Communications Lead) for project support and reviews.

SUPPORTED BY:

INTERNATIONAL UNION OF GEOLOGICAL SCIENCES (IUGS). GfGD is an affiliated organisation of the International Union of Geological Sciences (IUGS), founded in 1961. The IUGS has 121 national members, representing over a million geoscientists, and is one of the World's largest scientific organizations. It encourages international co-operation and participation in the Earth sciences in relation to human welfare and is a member of the International Science Council.

UNESCO is the United Nations Educational, Scientific and Cultural Organisation, building peace through international cooperation in Education, Science and Culture.

IUGS / UNESCO INTERNATIONAL GEOSCIENCE PROGRAMME (IGCP). UNESCO is the only United Nations organisation with a mandate to support research and capacity-building in geology and geophysics, and the International Geoscience Programme (IGCP) is its flagship international engagement platform, in collaboration with the IUGS. The IGCP mission includes promoting sustainable use of natural resources, advancing new initiatives related to geo-diversity and geo-heritage and geohazards risk mitigation. The IGCP promotes collaborative projects with a special emphasis on the benefit to society, capacity-building, and the advancement and sharing of knowledge between scientists with an emphasis on North-South and South-South cooperation.

IGCP PROJECT 685 (Geology for Sustainable Development, GeoSD). With few geoscientists directly engaged in decision-making around what a sustainable future for humanity will look like, the GeoSD project confronts this apparent disconnect between the geoscientific and policy arenas. Integrating the experience of Earth science practitioners across a range of fields, we explore how geoscience and geoscientists are addressing societal challenges at the local, regional and global scales. The work brings together an international interdisciplinary network of academic researchers, industry professionals and geoscience educators to establish a common framework by which geoscientists can more effectively inform wise decision-making about our planet and society's future.

DISCLAIMER

Links to third-party material are provided as a convenience and for informational purposes only; they do not constitute an endorsement or an approval by Geology for Global Development or our supporters of any of their products, services, or opinions. We accept no responsibility for the accuracy, legality or content of the external site or for that of subsequent links. We encourage all those using this material to engage critically and thoughtfully with the resources included.

CLASS 1: THE UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS

LEARNING OUTCOMES

This class will help you to:

1. Understand the aims and content of Agenda 2030 (the United Nations Sustainable Development Goals).
2. Describe different types of contribution that geoscientists can make to help deliver these ambitions.
3. Set out the skills required to be an effective (geo)science diplomat throughout your career.

CORE READING

Title: Geoscience Engagement in Global Development Frameworks *[published in 2017]*

Authors: Joel C. Gill and Florence Bullough **Open Access Link:** www.annalsofgeophysics.eu/index.php/annals/article/view/7460

Abstract: During 2015, the international community agreed three socio-environmental global development frameworks, the: (i) Sustainable Development Goals, (ii) Sendai Framework for Disaster Risk Reduction, and (iii) Paris Agreement on Climate Change. Each corresponds to important interactions between environmental processes and society. Here we synthesise the role of geoscientists in the delivery of each framework, and explore the meaning of and justification for increased geoscience engagement (active participation). We first demonstrate that geoscience is fundamental to successfully achieving the objectives of each framework. We proceed to characterise four types of geoscience engagement (framework design, promotion, implementation, and monitoring and evaluation), and present examples of engagement within the scope of the geoscience community. In the context of this characterisation, we discuss: (i) our ethical responsibility to engage with these frameworks, noting the emphasis on societal cooperation within the Cape Town Statement on Geoethics; and (ii) the need for increased and higher quality engagement, including an improved understanding of the science-policy-practice interface. Facilitating increased engagement is necessary if we are to maximise geoscience's positive impact on global development.

Why read this paper? This paper introduces the Sustainable Development Goals, and other development frameworks included in Agenda 2030, and outlines how geoscientists can contribute. It profiles a range of examples of research, monitoring, and industry projects aligned with sustainable development, and will encourage reflection on how geoscientists can be part of this global movement to deliver a sustainable future.

SUPPLEMENTARY RESOURCES

Geologists and Sustainable Development – A Brief Introduction (access here)

United Nations Website – Explore the Sustainable Development Goals (access here)

Schrodt *et al.* (2019). To advance sustainable stewardship, we must document not only biodiversity but geodiversity. *PNAS* (access here)

AAAS Introduction to Science Diplomacy - Short Course (1 hour) (access here, or in 10 short videos here)

DISCUSSION QUESTIONS AND ACTIVITIES

- Using the United Nations website, review the SDGs and their targets. Create a matrix – such as the one in Gill and Bullough (2017, the core reading) - which maps *your* geoscience activities (e.g., modules in your curriculum, research topics, outreach) to the 17 SDGs. Draft a letter to your local Member of Parliament (or equivalent representative) outlining 'why geoscience matters', using this matrix to illustrate your argument (it is up to you whether you send the letter or not!).
- Promoting global frameworks, such as the SDGs or Sendai Framework, can encourage people to help deliver them and demonstrate the positive role of geoscience to other disciplines and the broader policy-making community. What steps can you take to raise awareness of the SDGs at your university? Make a short video, create a poster, or write a blog article highlighting some of the ways that geoscience and understanding geodiversity can help deliver the SDGs, and a better future for all.
- Science diplomacy can take many forms, meaning it can be integrated into diverse careers. The American Association for the Advancement of Science has prepared a 1-hour short course introducing science diplomacy. Complete this course and write a list of the skills you think are required to be a geoscience diplomat.

CLASS 2: LEAVING NO ONE BEHIND – WORKING IN GLOBAL SOUTH CONTEXTS

LEARNING OUTCOMES

This class will help you to:

1. Understand the importance of social, political, and economic context when designing and implementing geoscience projects, and explore methods for context mapping.
2. Reflect on the values that should guide how geoscientists contribute to international development.
3. Describe characteristics of ethical and equitable science partnerships, particularly when those in the Global North are working in the Global South (so called 'developing countries').

CORE READING

Title: Interconnected Geoscience for International Development *[published in 2019]*

Authors: Michael G. Petterson **Open Access Link:** http://www.episodes.org/journal/view.html?uid=2064&vmd=Full

Abstract: Spending in international aid programmes from governments and other agencies represents a >> $100Bn US investment annually. International development and global environmental management greatly benefit from the application of high quality/ appropriate geoscience and related expertise. Barriers exist, particularly between research-intensive geoscience organisations and development agencies, that inhibit the greater application of geoscience within development. Key barriers include differing world-views, performance rewards, and values. This paper argues that geoscience can rapidly evolve in its importance and application to complex regional/global, development and environmental challenges. Changes in ethos, performance rewards, attitudes, and culture, will drive an increase in relevance. Case studies are presented, from Afghanistan, and Solomon Islands, to illustrate how geoscience approaches can be applied, within complex multi-faceted development contexts, with consequent outcomes and challenges. Lessons can be learned from such case studies that inform interconnected approaches. A conceptual model is presented of 'interconnected geoscience', defined as: 'a philosophy that combines geoscience expertise with an equivalent expertise/consciousness in the understanding of developmental situations, conditions, and context, including the integration of diverse world views/ wisdom and values, placing development-goals at the heart of the interconnected-approach'.

Why read this paper? While the SDGs are relevant to all national contexts, they include an emphasis on 'leaving no one behind'. Extra support may be needed by the world's least developed countries, landlocked developing nations, small island developing states, and regions affected by conflict. This paper introduces some of the skills and approaches required by geoscientists if they are to support sustainable development initiatives in these regions, working in an effective and sensitive manner.

SUPPLEMENTARY RESOURCES

Overseas Development Institute - Leave no one behind (access here)

Global Code Of Conduct For Research In Resource-Poor Settings (access here)

The Partnering Initiative - Partnership Health Check (access here)

Widya Yudha, S. and Tjahjono, B. (2019) Stakeholder Mapping and Analysis of the Renewable Energy Industry in Indonesia. *Energies*, 12, 602 (access here)

Cape Town Statement on Geoethics (access here)

DISCUSSION QUESTIONS AND ACTIVITIES

- The way in which geoscientists work in the Global South can either help or hinder development progress. Which SDGs do you think geoscientists can contribute to by putting into practice the values described in the Global Code of Conduct and Cape Town Statement on Geoethics? To what extent do you think these values are currently embedded into your geoscience training? What attitudes and behaviours may hinder development progress?
- Understanding context is essential to the design and successful application of geoscience projects. Widya Yudha and Tjahjono (2019) use a PESTLE (political, economic, social, technological, legal, environmental) analysis to complete context mapping for renewable energy development. Use a PESTLE approach to help understand the socio-political context of a country in the Global South affected by volcanic hazards. This does not need to capture all relevant information but try to identify some information for each of the PESTLE terms. Reflect on how this contextual understanding may improve natural hazards research.
- You are tasked with ensuring a positive and healthy relationship between partners from Zambia, Malawi, and the United Kingdom working together on a research project. Review the resource from *The Partnering Initiative,* designed to monitor the health of partnerships during a project. Think about the questions that you could ask each project partner before a project commences to understand their perspectives on what a positive partnership looks like (i.e., how you will work together). Use this information to design a simple survey, thinking carefully about the style of questions you ask (see here for tips). Trial your survey with others on your course.

CLASS 3: GEOSCIENCE AND DECARBONISATION

LEARNING OUTCOMES

This class will help you to:

1. Understand the role of geoscience in decarbonisation.
2. Describe the importance of mining and mineral extraction to decarbonisation technologies, and the importance of ethical and sustainable extraction.
3. Explain the challenges associated with the scale of mineral extraction required for renewable technologies, both in terms of speed required and environmental impact.

CORE READING

Title: Geoscience and decarbonization: current status and future directions *[published in 2019]*

Authors: Michael H. Stephenson, Philip Ringrose, Sebastian Geiger, Michael Bridden and David Schofield

Open Access Link: https://pg.lyellcollection.org/content/25/4/501?cct=2317

Abstract: At the 2015 United Nations International Climate Change Conference in Paris (COP21), 197 national parties committed to limit global warming to well below 2°C. But current plans and pace of progress are still far from sufficient to achieve this objective. Here we review the role that geoscience and the subsurface could play in decarbonising electricity production, industry, transport and heating to meet UK and international climate change targets, based on contributions to the 2019 Bryan Lovell meeting held at the Geological Society of London. Technologies discussed at the meeting involved decarbonisation of electricity production via renewable sources of power generation, substitution of domestic heating using geothermal energy, use of carbon capture and storage (CCS), and more ambitious technologies such as bioenergy and carbon capture and storage (BECCS) that target negative emissions. It was noted also that growth in renewable energy supply will lead to increased demand for geological materials to sustain the electrification of the vehicle fleet and other low-carbon technologies. The overall conclusion reached at the 2019 Bryan Lovell meeting was that geoscience is critical to decarbonisation, but that the geoscience community must influence decision-makers so that the value of the subsurface to decarbonisation is understood.

Why read this paper? This paper, published following the 2015 COP21 conference, 2018 IPCC report, the 2018 IEA World Energy Outlook report, and the 2019 Bryan Lovell meeting, provides a good overview and update on current progress towards decarbonisation. This paper assesses current progress against the models and projections from these key climate reports and conferences and explains how geoscientists can aid decarbonisation.

SUPPLEMENTARY RESOURCES

Our World in Data – Energy Access (access here)

US Geological Survey - Critical mineral commodities in renewable energy (access here)

Mining rare earths for a renewable future, Bloomberg (access here)

Mining Our Way to a Low Carbon Future. TED talk by Lucy Crane (access here)

Resource challenge of meeting net-zero emissions in the UK by 2050, Natural History Museum, London, UK (access here)

The mining sector searches for sustainability, a summary of an IIED report, The Guardian (access here)

DISCUSSION QUESTIONS AND ACTIVITIES

- Sustainable development will require meeting growing demands for energy, tackling energy poverty, and simultaneously reducing carbon emissions. Explore global access to reliable energy supplies using data on the 'Our World in Data' website. What societal challenges may a lack of energy contribute to, and therefore which SDGs are connected to SDG 7?
- Watch the TED talk on 'Mining our way to a sustainable future' and read the Natural History Museum article on the resource challenge of reaching net zero emissions, and explore the US Geological Survey infographic. Explain the importance of mining to decarbonisation, and the social, ethical, and environmental challenges the mining industry will experience in the next 30 years.
- Using the diverse resources above, prepare a two-page briefing note for policy-makers (see here for tips from the UK Parliamentary Office of Science and Technology) that sets out how geoscientists can help deliver the energy transition. Using this information, discuss the themes/skills that are missing in your degree that may help you to support decarbonisation as a geoscientist? Where could you access information to address these gaps?
- Create a list of what you could do to support or help raise public and policy-maker awareness of the role of geoscientists in decarbonisation. From this list, choose something you will do in the next six months, year, and five years.

CLASS 4: GEOSCIENCE AND DISASTER RISK REDUCTION

LEARNING OUTCOMES

This class will help you to:

1. Understand the relationship between hazard, exposure, vulnerability, risk, and disaster.
2. Reflect on the key priorities of the United Nations Sendai Framework for Disaster Risk Reduction and describe ways geoscientists can help to reduce disaster risk and impacts.
3. Consider what it means for science to be 'useful, useable and used' in the context of disaster risk reduction.

CORE READING

Title: Global risks: Pool knowledge to stem losses from disasters *[published in 2015]*

Authors: Susan L. Cutter, Alik Ismail-Zadeh, Irasema Alcántara-Ayala, Orhan Altan, Daniel N. Baker, Salvano Briceño, Harsh Gupta, Ailsa Holloway, David Johnston, Gordon A. McBean, Yujiro Ogawa, Douglas Paton, Emma Porio, Rainer K. Silbereisen, Kuniyoshi Takeuchi, Giovanni B. Valsecchi, Coleen Vogel & Guoxiong Wu.

Open Access Link: www.nature.com/news/global-risks-pool-knowledge-to-stem-losses-from-disasters-1.17751

Why read this paper? Disasters threaten development progress, and disproportionately affect the poor. Resilience to natural (and other types of) hazard is embedded into the SDGs, recognising that there can be no sustainable development without disaster risk reduction. This paper recognises the importance of disaster risk reduction to sustainable development, and the role of scientists in understanding natural hazards, but argues that the science of natural hazards is too fragmented to influence policy effectively. It makes several recommendations about how natural hazard scientists should operate and the international mechanisms required to support a more integrated approach to disaster risk reduction. It emphasises the need to make science useful, usable, and used. The supplementary resources, discussion questions and activities in this class explore these themes in more depth.

SUPPLEMENTARY RESOURCES

PreventionWeb – Disaster Risk, Hazard, Exposure and Vulnerability (access here, and click the links in the equation figure to explore each term)

Overview Chart, United Nations Sendai Framework for Disaster Risk Reduction (access here)

Humanitarian Practice Group – 10 Things you should know about Disaster Risk Reduction (access here)

Aitsi-Selmi *et al.* (2016) Ensuring science is useful, usable and used in global disaster risk reduction and sustainable development. *Palgrave Communications* (access here)

DISCUSSION QUESTIONS AND ACTIVITIES

- Explore the PreventionWeb site and watch the video introducing disaster risk reduction. For each of hazard, exposure, and vulnerability, consider what you can see (out of a window, in an image provided to you by a teacher) and what may be there but not visible. How many of the things you list are 'natural' and how many are shaped by humans and human processes? To what extent do you agree with the statement '*there is no such thing as a natural disaster*'.
- Have a go at the UNDRR Stop Disasters Game (www.stopdisastersgame.org/), where you are tasked with reducing the impacts of hazards such as earthquakes and tsunamis. As you complete one or more of these games – consider how your actions are changing exposure and/or vulnerability to reduce (or increase) disaster impacts.
- The Sendai Framework for DRR Overview includes four priorities for action. Imagine you have an opportunity to meet (i) a senior United Nations official (ii) a national government minister, or (iii) a city planner to discuss how geologists can help achieve the four priorities of the Sendai Framework for Disaster Risk Reduction. Considering your audience, the information they would find useful, and what you hope to achieve, prepare a poster that illustrates your key points.
- *This exercise will require careful coordination, and more time than others. It provides a good way to strengthen the skills required for multi- and inter-disciplinary activities.*

  DRR requires natural hazard scientists (including geologists) to work with multiple disciplines. Examine which departments at your university/institute include modules linked to disaster risk, or a component of disaster risk (i.e., hazard, exposure, vulnerability). Coordinate a round table with other disciplines and choose representatives from each to share (i) how their subject contributes to the understanding of disasters, (ii) the types of data and methods they use to do this, and (iii) examples of where the risk associated with a disaster has been reduced by their field of work.

  Complete the round table by asking each group to list 2 ways in which their work could be improved by collaborating with others around the table. How may this roundtable experience inform your work to make geoscience useful, usable, and used?

CLASS 5: GEOSCIENCE AND WATER SECURITY

LEARNING OUTCOMES

This class will help you to:

1. Recognise the challenges involved in providing clean water for all and in assessing completion of SDG 6.
2. Describe the intersection between providing clean water for all and other SDGs (e.g., climate action, reducing inequalities, and sustainable consumption and production).
3. Describe how geoscientists help achieve key targets of SDG 6, with a focus on groundwater.

CORE READING

Title: Assessing regional groundwater stress for nations using multiple data sources with the groundwater footprint *[published in 2013].*

Authors: Tom Gleeson and Yoshihide Wada

Open Access Link: https://iopscience.iop.org/article/10.1088/1748-9326/8/4/044010/meta

Abstract: Groundwater is a critical resource for agricultural production, ecosystems, drinking water and industry, yet groundwater depletion is accelerating, especially in a number of agriculturally important regions. Assessing the stress of groundwater resources is crucial for science-based policy and management, yet water stress assessments have often neglected groundwater and used single data sources, which may underestimate the uncertainty of the assessment. We consistently analyse and interpret groundwater stress across whole nations using multiple data sources for the first time. We focus on two nations with the highest national groundwater abstraction rates in the world, the United States and India, and use the recently developed groundwater footprint and multiple datasets of groundwater recharge and withdrawal derived from hydrologic models and data synthesis. A minority of aquifers, mostly with known groundwater depletion, show groundwater stress regardless of the input dataset. The majority of aquifers are not stressed with any input data while less than a third are stressed for some input data. In both countries groundwater stress affects agriculturally important regions. In the United States, groundwater stress impacts a lower proportion of the national area and population, and is focused in regions with lower population and water well density compared to India. Importantly, the results indicate that the uncertainty is generally greater between datasets than within datasets and that much of the uncertainty is due to recharge estimates. Assessment of groundwater stress consistently across a nation and assessment of uncertainty using multiple datasets are critical for the development of a science-based rationale for policy and management, especially with regard to where and to what extent to focus limited research and management resources.

Why read this paper? Water stress is likely to greatly increase in many regions in the future due to climate change. Water is vital for life, industry and agriculture, and careful water management is essential. This paper outlines techniques used to assess and monitor groundwater levels in the USA and India and compares the effects of groundwater depletion in these countries. It concludes with suggestions for groundwater management in the future, based on these monitoring techniques.

SUPPLEMENTARY RESOURCES

United Nations Water Data Portal (access here)

International Association of Hydrogeologists - The UN-SDGs for 2030 - Essential indicators for groundwater (access here)

Taylor *et al.* (2012) - Groundwater and Climate Change (access here)

UPGro – Unlocking Africa's Groundwater Potential (access here)

Eleanor Allen Ted Talk - Water is a women's issue (access here)

International Groundwater Resources Assessment Centre Case Study - Transboundary Stampriet Aquifer (access here)

DISCUSSION QUESTIONS AND ACTIVITIES

- Explore the UN Water Data Portal, which tracks progress against SDG 6 indicators. Individually or in small groups, use this portal to characterise progress towards the water-related targets of SDG 6 in a country of your choice in the Global South. Present your results and then collectively discuss how any differences may relate to geology, climate, social, and economic factors.
- Using the resources above, create an annotated poster showing the interactions between SDG 6 and other SDGs. Remember to think about both groundwater and surface water.
- Gleeson and Wada (2013) discuss uncertainties with groundwater estimation, and potential groundwater management strategies. They note that assessment of groundwater stress using multiple datasets is critical for the development of a science-based rationale for policy and management. Through your own research (i.e., resources beyond those listed above), assess the availability of relevant datasets (e.g., groundwater recharge). How may a lack of available data affect groundwater management, and what implications could this have on people, industry, and agriculture?
- Consider the political issues surrounding transboundary aquifers, and how these were resolved in Namibia, Botswana, and South Africa at the Stampriet aquifer. Explain what geological information and data is useful in aiding governance of transboundary aquifers? *This is a good example of where (geo)science diplomacy skills may be required. See Class 1 (The SDGs).*

CLASS 6: GEOSCIENCE, HEALTH AND LAND DEGRADATION

LEARNING OUTCOMES

This class will help you to:

1. Describe ways in which geochemistry can influence human health, with a focus on soils.
2. Outline different sources of and actions to help reduce soil contamination.
3. Understand and communicate to diverse audiences the role of geoscientists in understanding, reducing and remediating soil contamination.

CORE READING

Title: An Apple a day? Assessing gardeners' lead exposure in urban agriculture sites to improve derivation of soil assessment criteria *[published in 2019]*

Authors: Jane A. Entwistle, Patrick M. Amaibi, John R. Dean, Michael E. Deary, Daniel Medock, Jackie Morton, Ilia Rodushkine, Lindsay Bramwell

Open Access Link: https://doi.org/10.1016/j.envint.2018.10.054

Abstract Summary: Globally, many of our urban agriculture sites (UAS) contain high levels of lead (Pb), a contaminant of toxicological concern to humans. In 98% of the sampled soils, Pb concentrations were above the current UK soil guideline for UAS (80 mg/kg). Indeed, there was no statistically significant difference between the BLL (blood Pb levels) of the UAS gardeners and those of non-gardening neighbours. Pb uptake, however, varied with crop type and our study highlights the suitability of certain crops for growing at UAS with elevated Pb, whilst limiting the consumption of others. Our preferred models predict site specific assessment criteria (SSAC) of 722 – 1634 mg/kg. We found fruit/vegetable consumption rates by all participants, and not just UAS gardeners, to be considerably higher than those currently used to derive the UK's category 4 screening levels (C4SLs). Furthermore, the soil to plant concentration factors (SPCFs) used to derive the UAS C4SL significantly over predict Pb uptake. Our study indicates it may be appropriate to develop a distinct exposure dataset for UAS. In particular, we recommend the derivation of SPCFs that are reflective of urban soils, both in terms of the range of soil Pb concentrations typically observed, but also the sources of this Pb.

Why read this paper? Medical geology is an emerging interdisciplinary scientific field which reflects the key role geoscientists play in public health, for example the important contributions regarding exposure pathways and causes of a wide range of environmental health problems. This paper focuses on lead levels in the soil of UK urban allotments and the impacts this has on human health. The findings from this study helped to improve UK soil screening levels and emphasise the need for site specific frameworks.

SUPPLEMENTARY RESOURCES

Finkelman *et al.* (2005) The emerging medical and geological association (access here). We suggest focusing on pages 1–6.

Thompson and Darwish (2019) Environmental chemical contaminants in food: A review of a global problem (access here)

Soil pollution: effects, causes, and solutions (access here)

Improving soil health in Mozambique (access here)

DISCUSSION QUESTIONS AND ACTIVITIES

- Create a poster showing how environmental geochemistry can influence human health. Use the core reading, pages 1–6 of Finkelman *et al.* (2005), and the Thompson and Darwish (2019) review (as well as any other resources you find during your own research).
- 2020 is the start of the United Nations 'Decade of Action' towards delivering the SDGs, stating the need for individual actions. What changes could you make to your lifestyle to reduce soil contamination (i) in your immediate vicinity and (ii) in more distant soils, considering your global impact, for example, through agriculture and extraction of raw materials?
- Prepare a social media campaign to raise awareness of geoscientists' role in understanding and reducing soil contamination, and the links to SDG 3 (health and wellbeing). This could be an illustrated blog, series of tweets, or a collection of captioned images. *[Use this activity to reflect on (i) ethical use of images in international development, and (ii) identifying/crediting third party material*].
- You are tasked with conducting soil screening tests in Mozambique and find that the soil is degraded and nutrient deficient. Create a 1-page leaflet for local farmers (but in English) explaining the situation and possible remediation methods. Consider your audience, the information they would find useful, and any cultural barriers that could exist.

  Explore the concept of 'agrogeology' and investigate whether the geology of Mozambique provides any opportunities for the development of locally sourced agrominerals to improve agricultural productivity.

CLASS 7: GEOSCIENCE FOR SUSTAINABLE URBAN DEVELOPMENT

LEARNING OUTCOMES

This class will help you to:

1. Describe some characteristics of a sustainable urban environment.
2. Explain how the geology of an area influences sustainable urban development.
3. Reflect on the role geoscientists play in achieving sustainable urban development, through different careers.

CORE READING

Title: The smart city develops on geology: Comparing Rome and Naples *[published in 2015]*

Authors: Donatella de Rita, Chrystina Häuber

Open Access Link: https://www.geosociety.org/gsatoday/archive/25/5/article/i1052-5173-25-5-4.htm

Abstract: A smart city is one that harmonises with the geology of its territory and uses technology to develop sustainably. Until the Republican Times, Rome was a smart city. The ancient settlement of Rome benefitted from abundant natural resources. City expansion took place in such a way as to not substantially alter the morphological and geological features of the area; natural resources were managed so as to minimise the risks. The geology, together with prudent management, ensured Rome's fortune. Naples, which developed in a similar geological context and at almost the same time, was exposed to more geological hazards and had access to fewer natural resources. This was fatal for the city that, while remaining one of the most important of the Mediterranean, did not become the capital of an empire as Rome did. The histories of Rome and Naples highlight the important role of geology in the development of a city and the making of its fortune. Over time, fast urban expansion, rapid population growth, and the overuse of resources led to increased hazards for both cities. As a result, the cities became unstable and fragile, and several natural processes resulted in disasters.

Why read this paper? Globally, urbanisation is occurring at a rapid rate, particularly in many Global South contexts. Failing to consider the geology of a region, and incorporate this into urban planning, can result in serious problems. Understanding the subsurface helps inform urban planners on both how to develop an area and protect natural resources, such as water. This paper explains how two cities with similar origins developed differently over time, and the geological influences on this development.

SUPPLEMENTARY RESOURCES

Where are the most sustainable cities in the world? (access here)

United Nations New Urban Agenda - summary video (access here)

Geoscience and sustainable cities in Eastern Africa (access here)

British Geological Survey - The ground beneath cities: Where should future development occur? (access here)

DISCUSSION QUESTIONS AND ACTIVITIES

- Using the supplementary resources, create an image or write a narrative which characterises an idealised sustainable city, in a context of your choosing (e.g., coastal, inland). Consider: (i) the resources it may use, (ii) the infrastructure it may require, (iii) the interaction between people and the natural environment, and (iv) the use of the subsurface. You can integrate good ideas from the reading, as well as your own creative ideas to solve problems associated with urban development.
- Research the geology of a nearby urban region (e.g., using the BGS Geology of Britain viewer, or an equivalent for other national contexts), and contrast this with the places mentioned in the core reading (Rome and Naples). How may geology influence urban development, and what impacts may it have in the future? You may want to consider the availability of natural resources, geological hazards, and ease of engineering. How could your city of choice become more sustainable?
- Prepare a diagram which illustrates the relationships between SDG 11 (sustainable cities and communities) and the other SDGs (i.e., what SDGs contribute to ensuring a sustainable city, and how can sustainable cities help achieve other SDGs?). Annotate this diagram with different geoscience careers to understand the diversity of ways geoscientists can contribute to sustainable urban development. Reflect on how this differs for a coastal city compared to an inland city in a mountainous region.

CLASS 8: GEOSCIENCE AND REDUCING INEQUALITIES

LEARNING OUTCOMES

This class will help you to:

1. Understand the presence of systemic inequality within geosciences and academia as a whole, and its effects on marginalised groups and participation in geosciences.
2. Describe ways in which the geoscience community can work to reduce inequalities.
3. Reflect on how actions can be taken in university departments and other institutions to reduce inequality, and the benefits of this.

CORE READING

Title: No progress on diversity in 40 years *[published in 2018]*

Authors: Rachel E. Bernard & Emily H. G. Cooperdock

Open Access Link: https://www.nature.com/articles/s41561-018-0116-6/

Abstract: Ethnic and racial diversity are extremely low among United States citizens and permanent residents who earned doctorates in earth, atmospheric and ocean sciences. Worse, there has been little to no improvement over the past four decades.

Why read this paper? Geoscience is a subject with a history of inequality. A better understanding of these issues is vital to addressing them in the future. This paper summarises the lack of progress on racial diversity within the geosciences in the last 40 years in the USA, as well as improvements in gender equality in the same period. It also offers some initial suggestions for the reduction of inequalities in the future.

SUPPLEMENTARY RESOURCES

Dutt (2019) Race and Racism in Geosciences (access here)

Giles *et al.* (2020) Barriers to fieldwork in undergraduate geoscience degrees (access here)

Earth Sciences has a Whiteness Problem – NY Times (access here)

AlShebli *et al.* (2018) The pre-eminence of ethnic diversity in scientific collaboration (access here)

Fernando and Antell (2020) Recommendations for improving racial equality, diversity, and inclusion in the Department of Earth Sciences, University of Oxford. Report (access here); Press Release (access here); Video with Ben Fernando explaining the report (~8:00-26:00 mins) and Gwen Antell discussing intersectionality and allyship (~26:00-33:00 mins).

DISCUSSION QUESTIONS AND ACTIVITIES

- Create a visual or digital resource (e.g. a poster) for your department, outlining some of the key barriers to diversity in geoscience, and how these can be addressed. What are the benefits to sustainable development of ensuring diversity in the geosciences?
- Explain (i) the different barriers to equality within geoscience, including race, disability, and gender, and (ii) how these factors can interact to disadvantage further those members of more than one minority group.
- In small groups, discuss some of the issues and activities that lead to inequalities in the geosciences (e.g., fieldwork, a culture of alcohol consumption) and how these issues affect marginalised groups, taking particular care to listen sensitively to others.
- Discuss ways in which the suggestions outlined in the Oxford University race equality report are applicable to your own geoscience department, and ways in which you could promote their implementation. If this report inspires any changes in your department, write this into a short case study and send it to the report authors so they are aware of its impact.

ANNEX A. FURTHER RESOURCES

A non-exhaustive list of further resources to support learning.

Class 1: The United Nations Sustainable Development Goals

Gill (2017) Geology and the SDGs. *Episodes*
This paper presents an overview of the role of geology in the SDGs.
https://doi.org/10.18814/epiiugs/2017/v40i1/017010

United Nations Decade of Action – Interview
An EGU blog interview with GfGD Executive Director, exploring United Nations Decade of Action
https://blogs.egu.eu/geolog/2020/02/21/geotalk-joel-gill-discusses-the-uns-sustainable-development-goals-and-the-decade-of-action/

Geology and the Sustainable Development Goals
A joint Geological Society, British Geological Survey and Geology for Global Development Briefing Note on the role of geoscience in achieving the SDGs
www.geolsoc.org.uk/~/media/shared/documents/policy/SDGs%20Note_FINAL.pdf?la=en

Geoscience for the Future Poster
A Geological Society of London poster showing how geoscience maps to the SDGs
www.geolsoc.org.uk/Posters

Event Report: GfGD at the United Nations 2019
Reporting on GfGD engagement at the UN Forum on Science, Technology and Innovation for the SDGs, leading an international delegation of early-career geoscientists as part of work to strengthen science diplomacy skills.
https://drive.google.com/file/d/1rpEx8PtRWS38KoznPGlGt7k911X1WrmS/view

Class 2: Leaving No One Behind – Working in Global South Contexts

Geoethics Outcomes and Awareness Learning
A geoethics syllabus educational resources for Higher Education to promote awareness of ethical and social implications of geoscience knowledge.
https://goal-erasmus.eu/educational-resources/

Ethical practice on Content Gathering and Use
Responsibilities for and commitments to ethical practice when gathering and using images and stories in development settings
www.bond.org.uk/sites/default/files/bond-statement-ethical-practice-ngo-content-gathering.pdf

Blog - Careers in Geoscience and Development
Guidance and tips for those interested in working in the international development sector.
https://blogs.egu.eu/network/gfgd/2019/07/12/careers/

Class 3: Geoscience and Decarbonisation

The Role of Geoscience in Decarbonisation
Information from the Geological Society of London, including a policy briefing note.
www.geolsoc.org.uk/Policy-and-Media/Policy-Briefing-Notes-and-Position-Statements/decarbonisation

Responsible Mining and Sourcing of Materials
An oversight of ESG (Environment, Social, Governance) within the sourcing of raw materials, and how this works 'on the ground'.
www.responsiblerawmaterials.com/post/satarla-wim-uk-responsible-mining-and-sourcing-of-materials

Rio Tinto blasts Aboriginal site to expand mine
Article exploring a recent case study of a mining company destroying an Aboriginal site.
www.theguardian.com/australia-news/2020/may/26/rio-tinto-blasts-46000-year-old-aboriginal-site-to-expand-iron-ore-mine

Mapping Mining to the SDGs
White paper exploring how the future of mining can align with the SDGs
www.undp.org/content/dam/undp/library/Sustainable%20Development/Extractives/Mapping_Mining_SDGs_An_Atlas_Executive_Summary_FINAL.pdf

Responsible Raw Materials
An archive of talks from the Responsible Raw Materials conference
www.responsiblerawmaterials.com/talks

Black Mesa mines: Native Americans demand return of their ancestors' bones
Article exploring some negative impacts of mining
www.theguardian.com/environment/2014/dec/10/black-mesa-mines-native-americans-demand-ancestral-bones-navajo

Class 4: Geoscience and Disaster Risk Reduction

Disaster Risk Reduction in Action
This Oxfam video presents a case study of disaster risk reduction work in Bangladesh
www.youtube.com/watch?v=48G8vix0RWc

Disaster Risk Reduction Terminology
A helpful glossary of key terms, provided by the United Nations Office for Disaster Risk Reduction
https://www.undrr.org/terminology

Gill *et al.* (2020) Sustainable and Resilient Communities. *NHESS Discussions*
This paper sets out seven recommendations for enhancing the integration of natural hazard science into disaster risk reduction.
www.doi.org/10.5194/nhess-2020-163

Hicks *et al.* (2019) Global Mapping of Citizen Science Projects for Disaster Risk Reduction. *Frontiers in Earth Science*
Citizen science for DRR can help to improve understanding of hazards and impacts.
https://doi.org/10.3389/feart.2019.00226

Class 5: Geoscience and Water Security

Dunning *et al.* (2018) Later Wet Seasons with More Intense Rainfall under Future Climate Change. *Journal of Climate*
This paper uses climate modelling to describe the potential effects of climate change on water security
https://journals.ametsoc.org/jcli/article/31/23/9719/91110/Later-Wet-Seasons-with-More-Intense-Rainfall-over

Case study Transboundary Stampriet Aquifer
Additional information from UNESCO on the Stampriet Aquifer
https://groundwaterportal.net/stampriet-aquifer

Water and Sustainable Development
A report from the 6th GfGD Annual Conference, with links to further reading and resources.
www.gfgd.org/s/GfGDConference2018_Report.pdf

UN Water Facts Homepage
UN-Water website exploring complex factors affecting, and effects of water security
www.unwater.org/water-facts/

UNESCO water vision for 2050
Short video exploring the future of water
www.youtube.com/watch?v=NhdRfQYJl4o

Groundwater and Sustainable Development Goals: Analysis of Interlinkages
An analysis of how groundwater can contribute or conflict with SDG targets.
https://inweh.unu.edu/wp-content/uploads/2018/12/Groundwater-and-Sustainable-Development-Goals-Analysis-of-Interlinkages.pdf

Class 6: Geoscience, Health and Land Degradation

Lead poisoning in Kenya
A news article about a Kenyan activist who won a court case surrounding a community being poisoned by lead pollution in a nearby factory.
www.bbc.co.uk/news/world-africa-53520416

Kihara *et al.* (2020) Micronutrient deficiencies in African soils and the human nutritional nexus: opportunities with staple crops. *Environmental Geochemistry and Health*
A review paper exploring micronutrient deficiencies in African soils.
https://link.springer.com/article/10.1007/s10653-019-00499-w

Combatting soil pollution in Mozambique
News article from the Food and Agricultural Organisation of the United Nations
www.fao.org/mozambique/news/detail-events/en/c/1173887/

Strengthening African capacity in soil geochemistry to inform agriculture and health policies
This project page includes links to several interesting blogs.
https://www.bgs.ac.uk/sciencefacilities/laboratories/geochemistry/igf/sgah.html

Class 7: Geoscience for Sustainable Urban Development

Titz and Chiotha (2019) Urban green infrastructure in Southern and Eastern Africa. *Sustainability*
This paper looks at the potential for sustainable and inclusive cities by utilising green infrastructure. It also discusses the colonial and post-colonial urban planning in such places.
www.mdpi.com/2071-1050/11/10/2729/htm

Gill *et al.* (2019) Sustainable development priorities in Eastern Africa. *Environment and Development*
This paper looks at the opinions of different stakeholders regarding sustainable development and assesses the role of Earth and environmental sciences
www.sciencedirect.com/science/article/pii/S2211464518302641

Wilson and Jackson (2016) Urban geology: An emerging discipline in an increasingly urbanized world. *Earth Magazine*
This article describes urban geology, the challenges, Geoheritage, and the history within North America.
www.earthmagazine.org/article/urban-geology-emerging-discipline-increasingly-urbanized-world

Class 8: Geoscience and Reducing Inequalities

EOS Anti-Racism Collection
EOS special topic with a variety of resources and articles for making geosciences antiracist
https://eos.org/special-topics#antiracism

Núñez *et al.* (2020) Intersectionality in Geosciences. *Journal of Geoscience Education*
Paper exploring how intersectionality can expand equity in geosciences
www.tandfonline.com/doi/pdf/10.1080/10899995.2019.1675131?needAccess=true

Dowey *et al.* (2020) Diversity Crisis in UK Geoscience Research Training
A pre-print of an article describing the diversity crisis in UK geoscience research training
https://eartharxiv.org/z4cju/

Olcott, A.N. and Downen M.R. (2020), The challenges of fieldwork for LGBTQ+ geoscientists, *Eos.*
This article looks at the unique issues that traveling for research poses for LGBTQ+ scientists, and discussions how new data should help us create solutions that foster safety and inclusion.
https://eos.org/features/the-challenges-of-fieldwork-for-lgbtq-geoscientists

ANNEX B. FULL LINKS TO SUPPLEMENTARY RESOURCES IN CLASSES 1–8

Here we provide full URL links to the Supplementary Resources in each of the eight classes.

Class 1: The United Nations Sustainable Development Goals

Geologists and Sustainable Development – A Brief Introduction
http://www.youtube.com/watch?v=velvpIP2coM

Schrodt *et al.* (2019). To advance sustainable stewardship, we must document not only biodiversity but geodiversity. *PNAS*
www.pnas.org/content/116/33/16155.short

United Nations Website – Explore the Sustainable Development Goals
https://sdgs.un.org/goals

AAAS Introduction to Science Diplomacy - Short Course (1 hour)
https://vimeo.com/228223748,
or view in 10 short videos:
www.youtube.com/playlist?list=PLC70NEE733FNUBmfkYbYTHH-nt1Zd3_-S

Class 2: Leaving No One Behind – Working in Global South Contexts

Overseas Development Institute - Leave no one behind
http://www.youtube.com/watch?v=AdkFcypnnt8

Global Code Of Conduct For Research In Resource-Poor Settings
https://ec.europa.eu/research/participants/data/ref/h2020/other/hi/coc_research-resource-poor-settings_en.pdf

Cape Town Statement on Geoethics
www.geoethics.org/ctsg

Widya Yudha, S. and Tjahjono, B. (2019) Stakeholder Mapping and Analysis of the Renewable Energy Industry in Indonesia. *Energies*, 12, 602
www.mdpi.com/1996-1073/12/4/602/htm

The Partnering Initiative - Partnership Health Check
www.thepartneringinitiative.org/wp-content/uploads/2018/12/Partnership-health-check.pdf

Class 3: Geoscience and Decarbonisation

Our World in Data – Energy Access
https://ourworldindata.org/energy-access

US Geological Survey - Critical mineral commodities in renewable energy
www.usgs.gov/media/images/critical-mineral-commodities-renewable-energy

Mining rare earths for a renewable future, Bloomberg
www.bloomberg.com/news/articles/2020-07-29/mining-rare-earths-for-a-renewable-future-green-insight

Mining Our Way to a Low Carbon Future. TED talk by Lucy Crane
www.youtube.com/watch?v=aWTkiQ64u_U

Resource challenge of meeting net-zero emissions in the UK by 2050, Natural History Museum, London, UK
www.nhm.ac.uk/press-office/press-releases/leading-scientists-set-out-resource-challenge-of-meeting-net-zer.html

The mining sector searches for sustainability, a summary of an IIED report, The Guardian
www.theguardian.com/sustainable-business/blog/iied-report-mining-sector-sustainability

Class 4: Geoscience and Disaster Risk Reduction

PreventionWeb – Disaster Risk, Hazard, Exposure and Vulnerability (click the links in the equation figure to explore each term)
www.preventionweb.net/risk/disaster-risk

Overview Chart, United Nations Sendai Framework for Disaster Risk Reduction
www.preventionweb.net/publications/view/44983

Humanitarian Practice Group – 10 Things you should know about Disaster Risk Reduction
www.youtube.com/watch?v=y16aMLeh91Q

Aitsi-Selmi *et al.* (2016) Ensuring science is useful, usable and used in global disaster risk reduction and sustainable development. *Palgrave Communications*
www.nature.com/articles/palcomms201616

Class 5: Geoscience and Water Security

UPGro – Unlocking Africa's Groundwater Potential
www.youtube.com/watch?v=hLJxw6hkjYM&feature=youtu.be

United Nations Water Data Portal
www.sdg6data.org/

Taylor *et al.* (2012) - Groundwater and Climate Change
https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20140006609.pdf

Eleanor Allen Ted Talk -
Water is a women's issue
www.youtube.com/watch?v=--uWCAOehOo

International Association of Hydrogeologists - The UN-SDGs for 2030 - Essential indicators for groundwater
https://iah.org/wp-content/uploads/2017/04/IAH-Groundwater-SDG-6-Mar-2017.pdf

International Groundwater Resources Assessment Centre Case Study - Transboundary Stampriet Aquifer
www.un-igrac.org/case-study/stampriet-aquifer

Class 6: Geoscience and Global Health

Finkelman *et al.* (2005) The emerging medical and geological association.
www.ncbi.nlm.nih.gov/pmc/articles/PMC1473139/pdf/tacca116000155.pdf

Soil pollution: effects, causes, and solutions
www.iberdrola.com/environment/soil-pollution-causes-effects-solutions

Thompson and Darwish (2019) Environmental chemical contaminants in food: A review of a global problem
www.ncbi.nlm.nih.gov/pmc/articles/PMC6332928/

Improving soil health in Mozambique
www.youtube.com/watch?v=6rSrR4EKG7Y

Class 7: Geoscience for Sustainable Urban Development

Where are the most sustainable cities in the world?
www.iberdrola.com/environment/sustainable-cities

United Nations New Urban Agenda - summary video
https://youtu.be/umZedR_8XH8

Geoscience and sustainable cities in Eastern Africa
https://blogs.egu.eu/network/gfgd/2017/09/23/geoscience-and-sustainable-cities-sdg-11-in-eastern-africa/

British Geological Survey - The ground beneath cities: Where should future development occur?
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/461947/future-cities-ground-beneath.pdf

Class 8: Geoscience and Reducing Inequalities

Dutt (2019) Race and Racism in Geosciences
www.nature.com/articles/s41561-019-0519-z

Giles *et al.* (2020) Barriers to fieldwork in undergraduate geoscience degrees
www.nature.com/articles/s43017-020-0022-5

Earth Sciences has a Whiteness Problem – NY Times
https://www.nytimes.com/2019/12/23/science/earth-science-diversity-education.html

AlShebli *et al.* (2018) The pre-eminence of ethnic diversity in scientific collaboration
www.nature.com/articles/s41467-018-07634-8

Fernando and Antell (2020) Recommendations for improving racial equality, diversity, and inclusion in the Department of Earth Sciences, University of Oxford.

- Report: www.earth.ox.ac.uk/wp-content/uploads/2020/06/BAME-EDI-Report.pdf
- Press Release: www.earth.ox.ac.uk/2020/06/department-of-earth-sciences-releases-report-of-ad-hoc-working-group-on-bame-issues/
- Video with Ben Fernando explaining the report (~8:00-26:00 mins): www.youtube.com/watch?v=78z4qniQ8sI
- Video with Gwen Antell discussing intersectionality and allyship (~26:00-33:00 mins). www.youtube.com/watch?v=78z4qniQ8sI

ANNEX C. ORGANISATIONS GROUPS AND CAMPAIGNS OF INTEREST

This is a non-exhaustive list of organisations, groups and campaigns that learners may want to investigate to access further resources, training, and engagement opportunities. SDG icons are illustrative of our understanding of core areas of work, but organisations may be contributing to many more of the goals.

UNESCO Earth Sciences and Risk Reduction
The United Nations agency with a mandate for Earth science, and responsible for providing the secretariat service for the International Geoscience and Geoparks Programme (IGGP).
www.unesco.org/new/en/natural-sciences/environment/earth-sciences/

International Union of Geological Sciences
IUGS encourages international co-operation and participation in the Earth sciences in relation to human welfare and is a member of the International Science Council (ISC).
www.iugs.org/

British Geological Survey (Global Geoscience)
A leading provider of applied geoscience services, with an extensive international programme of research, survey and monitoring, data management and dissemination, including in the Global South.
www.bgs.ac.uk/research/international/home.html

International Association for Promoting Geoethics
A multidisciplinary, scientific platform for widening the discussion and creating awareness about problems of Geoethics and Ethics applied to the Geosciences.
www.geoethics.org/

iCRAG - Irish Centre for Research in Applied Geoscience
Researchers across eight universities/institutions, creating solutions for a sustainable society.
www.icrag-centre.org/

Overseas Development Institute (ODI)
An independent, global think tank. Their vision is a sustainable and peaceful world in which every person thrives.
www.odi.org/

International Institute for Environment and Development (IIED)
A research organisation aiming to deliver positive change on a global scale. IIED deliver original, rigorous research to drive progress, support sustainable development and protect the environment.
www.iied.org/

International Association of Hydrogeologists
A scientific and educational charitable organisation for scientists, engineers, water managers and other professionals working in the fields of groundwater resource planning, management and protection.
https://iah.org/

The Partnering Initiative (TPI)
Working to ensure systematic collaboration across sectors, from international down to community level, that can deliver the Sustainable Development Goals.
https://thepartneringinitiative.org/

UN Climate Change
The United Nations entity tasked with supporting the global response to the threat of climate change.
https://unfccc.int/about-us/about-the-secretariat

International Council on Mining and Metals (ICMM)
International organisation dedicated to a safe, fair, and sustainable mining and metals industry.
www.icmm.com/sdgs

No Natural Disasters.
A campaign group that aims to change the terminology to show that whilst some hazards are natural and unavoidable, the resulting disasters almost always have been made by human actions and decisions.
www.nonaturaldisasters.com/

UK Alliance for Disaster Research
An alliance bringing together the UK's disaster research community to facilitate collaboration and partnership, and, where appropriate, help with the implementation of the Sendai Framework.
www.ukadr.org/

EGU Natural Hazards Division
A community of researchers and scientists within the European Geosciences Union, interested in all aspects of natural hazards, and risk reduction.
www.egu.eu/nh/home/

Parsquake
Delivering earthquake education in the global Persian community
http://parsquake.org/index.php

Groundwater Relief
Group of technical experts who support organisations engaged in supplying water to the world's poorest and most vulnerable people.
https://groundwater-relief.org/about

Rural Water Supply Network
A global network of rural water supply professionals and organisations committed to improving their knowledge, competence and professionalism, to fulfil a vision of sustainable rural water services for all.
https://rural-water-supply.net/en/

Society for Environmental Geochemistry and Health
A forum for scientists to work together in understanding the interaction between the geochemical environment and the health of plants, animals, and humans.
https://segh.net/

International Medical Geology Association
A group of earth scientists, toxicologists, epidemiologists, and medical specialists, characterising the properties of geological processes and agents, the dispersal of geological material and their effects on human populations.
www.medicalgeology.org/

Food and Agricultural Organisation of the United Nations
A specialised agency of the UN that leads international efforts to defeat hunger. Their goal is to achieve food security for all and make sure that people have enough high-quality food to lead active, healthy lives.
www.fao.org/home/en/

C40 Cities
C40 cities are taking bold climate action, leading the way towards a healthier and more sustainable future.
www.c40.org/

African Association of Women in Geosciences
Working to advance scientific knowledge and dissemination, deliver training, and highlight and seek solutions to problems faced specifically by women and grassroots communities in Africa in geoscience.
www.aawg.org/

Association for Women Geoscientists
Foundation dedicated to attaining equality of opportunity for women in the geosciences and training new leaders by funding high impact programs for women in the geosciences.
www.awg.org

Girls into Geoscience
Outreach initiative based at the University of Plymouth, focussing on female Geoscientists.
www.plymouth.ac.uk/research/earth-sciences/girls-into-geoscience

Diversity in Geoscience UK
A chapter of the International Association for Geoscience Diversity, aiming to improve diversity in the geosciences, in terms of disability, gender, race and ethnicity, sexuality and social class.
https://theiagd.org/dig-uk/

ADVANCEGeo
Group taking a research-based focus to identifying and addressing negative workplace experiences, in the Geosciences and beyond.
https://serc.carleton.edu/advancegeo/index.html

National Association of Black Geoscientists (USA)
Non-profit organisation for the advancement of minorities in geoscience.
www.nabg-us.org/purpose.html

Anti-Racism in Science
A call for change within the geosciences and the broader scientific community, recommending changes that will help create an anti-racist scientific community.
https://notimeforsilence.org

