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NATURAL ENVIRONMENT RESEARCH COUNCIL

Workshop Report: Earth and Environmental Science for Sustainable Development (Nairobi, March 2017)

BGS Global - Eastern Africa ODA Platform

Open Report OR/17/039



BRITISH GEOLOGICAL SURVEY

BGS GLOBAL - EASTERN AFRICA ODA PLATFORM

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Participants discussing the UN Sustainable Development Goals in Nairobi, Kenya.

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Foreword

This report describes the outcomes of a two-day interactive workshop in Nairobi (Kenya), in March 2017. The British Geological Survey (BGS) gathered 32 delegates from 22 organisations in Kenya to explore sustainable development priorities in eastern Africa and consider the role of Earth and environmental science. This workshop was an activity of the BGS Eastern Africa *Official Development Assistance* (ODA) Research Platform. We used a collaborative approach to foster dialogue and gather information to inform future planning of BGS ODA activities.

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Contents

Foreword	ii
Acknowledgements	ii
Contents	ii
Summary	iv
1 Introduction	1
1.1 Background.....	1
1.2 BGS Engagement in Eastern Africa	1
1.3 Workshop Objectives	2
1.4 Report Structure.....	2
2 Workshop Participants	3
2.1 Overview	3
3 Prioritising the UN Sustainable Development Goals	6
3.1 Individual Perspectives on Priority SDGs	7
3.2 Group Perspectives on Priority SDGs	10
3.3 Characterising Specific Challenges	12
3.4 Earth and Environmental Science.....	14
3.5 Discussion and Limitations	15

4	Thematic Working Groups	16
4.1	Food-Water-Energy Nexus.....	17
4.2	Clean Water and Sanitation	18
4.3	Natural Resources (Minerals).....	20
5	Science-for-Development Partnerships.....	21
6	Conclusions	23
6.1	Summary.....	23
6.2	Next Steps.....	23
Appendix 1	Workshop Programme.....	25
	Day 1 (28 March 2017)	25
	Day 2 (29 March 2017)	26
Appendix 2	Workshop Feedback.....	27
References		28

FIGURES

Figure 1. Workshop Matrix. A blank workshop matrix, used by participants to express their perspectives on high priority SDGs in Eastern Africa and Kenya.

Figure 2. Sum of Individual Perspectives on Priority SDGs. A synthesis of 24 perspectives on the SDGs (Figure 1), with the ‘Weighted Total’ determined as expressed in Equation 1. Shading is used to visualise priority SDGs.

Figure 3. Discussing the UN Sustainable Development Goals. Following dynamic discussions, groups selected the four SDGs they believed to be of highest priority in eastern Africa.

Figure 4. Specific challenges in eastern Africa associated with SDG 6 (Clean Water and Sanitation). Individuals and groups added notes on specific challenges to SDG posters.

Figure 5. ‘Food-Energy-Water Nexus’ thematic group. Exploring the science, innovation and technologies relating to this nexus, and the delivery of multiple SDGs.

Figure 6. ‘Clean Water and Sanitation’ thematic group. Exploring the science, innovation and technologies required to tackle specific challenges relating to clean water and sanitation (SDG 6).

Figure 7. ‘Natural Resources (Minerals)’ thematic group. Exploring the science, innovation and technologies relating to sustainable management of minerals, and the delivery of multiple SDGs.

TABLES

Table 1. Participating organisations.

Table 2. Group prioritisation of the UN Sustainable Development Goals.

Table 3. Summary of comments justifying selection of priority SDGs.

Table 4. Specific challenges in eastern Africa associated with UN Sustainable Development Goals.

Table 5. Earth and environmental science and the SDGs in eastern Africa.

Table 6. Specific challenges in Kenya associated with the minerals sector.

Summary

This report describes the outcomes of a two-day interactive workshop in Nairobi (Kenya), conducted in March 2017. We gathered 32 delegates from 22 organisations in Kenya to determine sustainable development priorities and consider the role of Earth and environmental science in addressing these. Delegates came from diverse disciplines (e.g., geology, agriculture, geography, hydrology, ecology) and sectors (e.g., academia, commercial, civil society, government). Using the UN Sustainable Development Goals (SDGs) as a reference tool, participants identified primary development challenges and their research and data needs to help address these. Key themes included the food-water-energy nexus, clean water, and natural resources (minerals). Participants co-designed a set of draft science-for-development projects relating to these themes.

BGS are using this information, together with the results of additional workshop activities, to inform the development of collaborative *science-for-development* activities in eastern Africa as part of our commitment to Official Development Assistance (ODA) in the region. We will further develop specific project ideas, using information gathered at this workshop, with appropriate regional and international partners. Information from this workshop provides supporting evidence of expressed development need and stakeholder expertise in eastern Africa. This information will guide future project applications to the *Global Challenges Research Fund*, and other appropriate research and innovation funding sources.

Key Results and Conclusions

Small group discussions and group voting generated a collective ranking of SDG priorities. Participants also reflected on where they believe Earth and environmental science can make the greatest contribution to development impact. These rankings were:

Overall SDG ranking (Eastern Africa) based on summing of small groups votes:

1. **Clean Water and Sanitation** (SDG 6)
2. **No Poverty** (SDG 1)
3. **Zero Hunger** (SDG 2)
4. **Good Health and Wellbeing** (SDG 3)
5. **Quality Education** (SDG 4)

Role for Earth and environmental science rankings:

1. **Clean Water and Sanitation** (SDG 6)
2. **Climate Action** (SDG 13)
3. **Life on Land** (SDG 15)
4. **Affordable and Clean Energy** (SDG 7)
5. **Zero Hunger** (SDG 2)

Group discussions suggested that interconnectedness of SDGs and basic (immediate) development needs were likely to influence the prioritisation process. For example, participants noted that ending poverty (SDG 1), ending hunger (SDG 2) and ensuring access to clean water and sanitation (SDG 6) would underpin progress in many of the other SDGs.

We used these rankings to establish three thematic working groups, with each tasked to identify specific challenges, research priorities, information needs and potential projects. Groups were:

- **Food-water-energy nexus.** This group identified geographic areas of interest, and considered crosscutting issues (data, cultural and political barriers, partnerships, lessons learned, and capacity building).
- **Clean water and sanitation.** This group discussed water availability mapping, enhanced water policy/governance/management, improved catchment management, data gaps, and applied research and training activities.
- **Natural resources (minerals).** This group identified activities relating to a Mombasa to Kisumu resource corridor, and artisanal and small-scale mining activities.

Developing these activities will require effective science-for-development partnerships. Partnership characteristics of greatest importance to Kenyan participants were (i) sharing of project outputs, (ii) sharing of data, (iii) being treated as equals by other members of the partnership, and (iv) access to training and capacity building.

1 Introduction

1.1 BACKGROUND

The UN Sustainable Development Goals (SDGs) and the UK Aid Strategy (UK Government, 2015) emphasise the need to invest in strengthening resilience and response to crises, promote global prosperity, and help to tackle extreme poverty in the world's most vulnerable communities.

As part of the UK Government's commitment to the SDGs and its Aid Strategy, the British Geological Survey (BGS) is increasing the proportion of its budget spent on Official Development Assistance (ODA). BGS will deliver this via three research platforms, each of which will seek to develop new partnerships with a wide range of expertise to co-design and deliver a 3-year programme up to 2020.

In Eastern Africa, exponential population growth, rapid urbanisation and economic development, confounded by the effects of climate change, are having an increasing impact on health and well-being, national security and the ability of governments and aid agencies to cope. Such changes present challenges and new opportunities for science to support delivery solutions in respect to the sustainable use of natural resources (e.g., soils, minerals, water), infrastructure and services, training and skills enhancement.

Our long-term ambition therefore is to develop a platform of research and capacity building that enables our partners in ODA-recipient countries to use their natural resources to maximum benefit in an environmentally acceptable manner. Here we report on an introductory workshop organised in Nairobi that aimed to explore development priorities and understand how geological research can help support sustainable development.

1.2 BGS ENGAGEMENT IN EASTERN AFRICA

BGS has worked extensively across Eastern Africa for over 70 years on a variety of projects in support of the country geological surveys focused on mineral resources, water supply, natural hazards, infrastructure and energy. Currently we have active projects in a range of countries, including Ethiopia, Kenya, Malawi and Uganda. Examples include:

- **Kenya.** Funded by the UK Department for International Development, BGS are providing technical assistance to the Government of Kenya as they establish a National Geodata Centre.
- **Uganda.** BGS are working with the African Union, International Geoscience Services, GeoSoft, and the Uganda Chamber of Mines to facilitate access to geological, environmental and social data to enhance inward investment.
- **Malawi/Zambia/Zimbabwe.** Funded by the Royal Society and UK Department for International Development, BGS is working with project partners in Malawi, the UK, Zambia and Zimbabwe to enhance spatial predictions of soil type and chemistry to help combat low agricultural productivity and micronutrient deficiencies (so called "hidden hunger") in vulnerable communities.
- **Ethiopia.** Since 2014, BGS has been participating in RiftVolc, a NERC-funded project to investigate past and current volcanism and volcanic hazards in the Main Ethiopian Rift. International project partners include Addis Ababa University, and the Geological Survey of Ethiopia.

This report synthesises the perspectives and input from 32 delegates from 22 organisations who attended a workshop in Kenya, including representatives from government, academia, industry and civil society. Using interactive group exercises enabled BGS to listen and collate the views, thoughts, and ideas of the workshop participants that lead to a better understanding of the sustainable development priorities.

The workshop represents an activity of the BGS Eastern Africa ODA Research Platform, informing the planning of a programme of *science-for-development*. Our work aims to build scientific collaborations, foster networks of scientists across the Global South, and support capacity building through focused training, research interactions, and applying for additional research funding (e.g., Global Challenges Research Funds).

1.3 WORKSHOP OBJECTIVES

Primary workshop objectives are noted below, with the sections of this report that provide evidence that these objectives were met:

<i>Stakeholder Mapping</i>	Better understand existing stakeholder networks, responsibilities, and research interests and capabilities.	Achieved by mapping out participating organisations and their activities (see Section 2).
<i>Needs Assessment</i>	Determine development priorities in eastern Africa at a range of scales (i.e., from broad overview development goals to specific challenges), and consider the Earth and environmental science research required to inform solutions.	Achieved by a set of activities aiming to prioritise and discuss development objectives (see Section 3), and potential solutions (see Section 4).
<i>Partnership Building</i>	Facilitate respectful dialogue between and across BGS and potential in-country partners.	Relationships enhanced during the workshop (see feedback in Appendix B), with information on participant-priorities helping to facilitate future strong partnerships (see Section 4).
<i>Consolidate Positive BGS Reputation</i>	Build trust and respect through delivering a workshop centred on meaningful engagement and listening.	Workshop feedback provides evidence that participants felt their perspectives were valued (see Appendix B).
<i>Multi-Disciplinary and Multi-Sectoral Perspectives</i>	Include diverse science and sectoral perspectives (e.g., academia, think tanks, NGOs, government).	Workshop participant list indicates diverse sectors and disciplines (see Section 2).

1.4 REPORT STRUCTURE

In this report, we first characterise workshop participants ([Section 2](#)), before proceeding to present the results of workshop activities exploring the UN Sustainable Development Goals ([Section 3](#)) and potential activities to support their delivery ([Section 4](#)). We finish by documenting the initial results of an exercise aiming to understand participants' perspectives on what makes a positive science-for-development partnership ([Section 5](#)). We outline next steps in [Section 6](#).

The Official Development Assistance (ODA) programme of the BGS will use this workshop information to inform future project planning and research development in eastern Africa. All workshop participants will receive a copy of this report.

2 Workshop Participants

2.1 OVERVIEW

Over the course of the two-day workshop, BGS engaged with 32 participants from 22 different organisations. Participants were recruited via emails to existing contacts, a search of relevant organisations in Nairobi, and through word-of-mouth. All of the workshop participants were based in Kenya. Some organisations or individual academics were also engaged in research and/or activities in the wider eastern Africa region and beyond. **Table 1** gives a summary of organisations participating in the workshop. This table includes relevant information about each organisation's purpose and activities, with information taken from organisational websites and an initial workshop activity where participants mapped their work.

Table 1. Participating Organisations

Sector	Organisation	Groups	Description of Work
Academia	Strathmore University	Extractives Baraza	An advocacy-neutral online platform that promotes knowledge, transparency and evidence-based stakeholder dialogue on the extractives sector in Kenya. Its ultimate goal is to enhance citizen participation and engagement in the governance of Kenya's extractives sector. www.extractives-baraza.com/about-us
		Energy Research Centre	Established in 2012 with the aim of carrying out high-quality research, technical training, and project development services in the energy sector. www.serc.strathmore.edu/
	Kenyatta University	Department of Geography	Specialises in Integrated Water Resource Management (IWM), hydrology and water resources, geomorphology, climatology, biogeography, population and settlement and geospatial techniques and remote sensing. www.ku.ac.ke/schools/humanities/departments/geography
	University of Nairobi	Department of Geology	Core areas of specialisation include mineralogy and petrology, economic geology and mineral resources, environmental geology and management, engineering geology, hydrogeology and groundwater resources management, petroleum geology, marine geology and resources, applied geochemistry, applied geophysics, seismology, palynology and micropalaeontology, and mineral exploration. The Department is strong in seismic studies and hosts a National Seismological Network, which monitors earthquakes in the region. geology.uonbi.ac.ke/
Department of Geography and Environmental Studies		Their vision is to provide dynamic leadership in the teaching, research, consultancy and outreach services in geography and environmental studies for the benefit of humanity and sustainable development. Postgraduate courses include agricultural geography, biodiversity and natural resources management, climatology, economic geography, environmental planning and management, geomorphology, population geography, transport geography, urban geography, water resources management, hydrology, sustainable urban development. geography.uonbi.ac.ke/node	

Sector	Organisation	Groups	Description of Work
		Institute for Climate Change and Adaptation	The Institute's academic staff consists of a diversified team of experts and researchers. They are dedicated to building human capacity necessary to address the unique climate change adaptation needs of vulnerable communities through teaching, action-oriented research, development of innovative technologies and community participation. It provides expert advice for national and regional policy formulation and implementation. icca.uonbi.ac.ke/
	University of Eldoret	Department of Fisheries and Aquatic Sciences	The university's mission is to provide high quality education and training in science, agriculture and technology that promotes networking, partnership and linkages with other institutions and industry. uoeld.ac.ke/uoepro module/school-of-natural-resource-management
	Technical University of Kenya	School of Business and Management Studies	Imparts creative and innovative training in business and management that develops knowledge, skills, competence, and attitudes that enable students to achieve competitive edge in the national, regional and global markets. business.tukenya.ac.ke/
	Maseno University	School of Environment and Earth Science	Speciality topics include global environmental issues such as climate change, natural resources management, water and sanitation, energy, human settlements and waste management. maseno.ac.ke/
	Jaramogi Oginga Odinga University of Science and Technology		Offers relevant and quality market driven academic programmes for steering socio-economic development. The University focuses on the development of Kenya's cultural heritage through the utilization of the vast natural resources for academic advancement and research purposes premised on improving the socio-economic status of communities. www.jooust.ac.ke/
Civil Society	World Vision Kenya		The national office of an international NGO, focusing on education and child protection; health and nutrition; water, sanitation and hygiene; livelihoods and resilience; and humanitarian and emergency relief. www.wvi.org/kenya
	Africa Wildlife Foundation		Their mission is to ensure wildlife and wild lands thrive in modern Africa. www.awf.org/
	African Association of Women in Geosciences		The AAWG objectives include promoting the advancement of scientific and technological knowledge in the field of geosciences; disseminating information on scientific and technical research and discoveries and promote public understanding of the role of geosciences in Africa's development; and establishing and maintaining relations between African scientists and the international scientific community. www.aawg.org/

Sector	Organisation	Groups	Description of Work
	Geological Society of Kenya		The Geological Society of Kenya (GSK) is a non-profit making, non-political organization established in 1974 as an umbrella organization representing the professional interests of all geologists in Kenya. GSK has been instrumental in championing the rights, welfare and needs of its members and the geology fraternity at large. www.gsk.or.ke/
	African Collaborative Centre for Earth Systems Science (ACCESS)		Primary functions are to (i) foster global change research on a regional scale, including climate change impacts on water resources, food security, ecosystem, health and sustainable development in Africa; (ii) develop human resources and enhance regional scientific capacity; and (iii) provide support for policy formulation and institutional development in Africa. www.access-uon.co.ke/
	Sustainable Ecological Models in Africa		An NGO focusing on livelihood improvement, environmental conservation and commercialisation of agriculture through research and technology transfer. SEMA provide objective and authoritative agro-technologies, information and knowledge to help society to mitigate and adapt to environmental change, use its natural resources (water, land, and food) responsibly, and be resilient to environmental hazards. www.semafrica.org
Government	Ministry of Mining	Directorate of Geological Surveys	Undertakes various functions aimed at enhancing growth of the mining sector in the country. The Kenyan Directorate of Geological Surveys (DGS) aims to generate, manage and disseminate geological and mineral information and promote sustainable mineral resources development. www.mining.go.ke
	Ministry of Water and Irrigation		Contributes to national development by promoting and supporting integrated water resource management to enhance water availability and accessibility. www.water.go.ke
	Ministry of Lands and Physical Planning	Department of Lands	Administers both public and community land on behalf of the county governments. www.ardhi.go.ke/
		Department of Survey	Implements the Government's policy of sustainable exploitation of land and its natural resources. It is composed of five divisions: Geodetic and Geographical Information System (GIS), Mapping, Administration, Cadastral, Land Adjudication, and Hydrographic. www.ardhi.go.ke/
	Kenya Wildlife Service		Conserves and manages Kenya's wildlife for the Kenyan people and the world. Their mission is to sustainably conserve, manage, and enhance Kenya's wildlife, its habitats, and provide a wide range of public uses in collaboration with stakeholders for posterity. kws.go.ke/

Sector	Organisation Groups	Description of Work
	Ministry of Agriculture, Livestock and Fisheries	Improves the livelihood of Kenyans and ensures food security through creation of an enabling environment and ensuring sustainable natural resource management. www.kilimo.go.ke/
Private Sector	Afri-Project Management	<i>No information provided.</i>
	Risk Africa Ltd	Delivers training, advisory and software solutions that intensify the risk management focus and discipline of government institutions and private sector institutions around Africa. www.riskafrica.co.ke
	Westerveld Agriculture and Livestock Development (WALD)	Develops projects with the aim to turn them profitable after 3–5 years. Use a unique approach to transform semi-arid land that is under pressure from erosion and water shortage, into improved land that is suitable for people, wildlife and agricultural activities. www.4elementsinvest.nl/
Other Research Institutes	International Centre of Insect Physiology and Ecology (ICIPE)	Helps to alleviate poverty, ensure food security and improve the overall health status of peoples of the tropics, by developing and extending management tools and strategies for harmful and useful arthropods, while preserving the natural resource base through research and capacity building. www.icipe.org/
	Sustainable Development Research Institute	Founded in 2016 in order to champion the attainment of the UN Sustainable Development Goals in Kenya and sub-Saharan Africa.

3 Prioritising the UN Sustainable Development Goals

The Sustainable Development Goals (SDGs) are an ambitious set of 17 goals and 169 targets, agreed by members of the United Nations in September 2015. Over a 15-year timeframe (2015–2030), the SDGs aim to: (i) eradicate global poverty, (ii) end unsustainable consumption patterns, and (iii) facilitate sustained and inclusive economic growth, social development, and environmental protection (United Nations, 2017).

This workshop used activities to determine stakeholder perspectives on development priorities in eastern Africa, using the SDGs as a reference tool. Participants first shared their individual perspectives on high priority SDGs using a matrix worksheet ([Section 3.1](#)). Small groups then discussed the SDGs, coming to a consensus on their relative importance and the highest priority SDGs in an eastern African context ([Section 3.2](#)). Participants also documented specific challenges associated with priority SDGs ([Section 3.3](#)) and identified SDGs that they believe Earth and environmental science could make the biggest contribution to delivering ([Section 3.4](#)). These results are discussed in the context of development needs assessment ([Section 3.5](#)).

3.1 INDIVIDUAL PERSPECTIVES ON PRIORITY SDGS

3.1.1 Overview and Method

Using a blank matrix (**Figure 1**), participants were asked to identify (i) four SDGs that they consider to be of highest importance in an eastern African context, and (ii) four SDGs that they consider to be of highest importance in a Kenyan context. Participants were encouraged to do this individually, ensuring that every workshop participant had their perspectives recorded.

3.1.2 Results

Twenty-eight participants submitted completed worksheets for this exercise, with four (14%) of these invalid due to multiple boxes being ticked per column. Of the remaining 24 (86%) of submissions, 22 included information relating to both eastern Africa and Kenya, and 2 included information only relating to Kenya. **Figure 2** shows the results of this exercise for eastern Africa and Kenya. Numbers in the columns labelled 1st, 2nd, 3rd and 4th relate to the number of participants selecting the SDG as a priority. The column labelled ‘*Weighted Total*’ sums the number of participants in each column, applying a weighting depending on whether participants selected it as their 1st, 2nd... choice. The formula expressed in **Equation 1** outlines this weighting. Orange shading is used in **Figure 2** to help visualise the relative *Weighted Total* values.

$$\textit{Weighted Total} = 4[n_{1st}] + 3[n_{2nd}] + 2[n_{3rd}] + 1[n_{4th}] \quad \textbf{Equation 1}$$

Using **Figure 2**, we can identify the SDGs with the highest *Weighted Total* (WT) values. This is indicative of the group collectively considering the SDG to be a high development priority.

Eastern Africa. **Zero Hunger** (SDG 2, WT=30) emerges as being the highest development priority, followed by **Quality Education** (SDG 4, WT=26), **No Poverty** (SDG 1, WT=23), **Clean Water and Sanitation** (SDG 6, WT=23), and **Good Health and Wellbeing** (SDG 3, WT=21). Together these five SDGs represent the first choice (highest priority) SDG of 73% of participants, and 58% of all possible selections.

A second cluster of SDGs with lower *Weighted Totals* (12–16) includes work and economic growth (SDG 8), peace, justice and strong institutions (SDG 16), and partnerships for the SDGs (SDG 17).

Kenya. **Zero Hunger** (SDG 2, WT=47) again emerges as the highest development priority, followed by **Clean Water and Sanitation** (SDG 6, WT=35), **No Poverty** (SDG 1, WT=34), **Quality Education** (SDG 4, WT=26), and **Good Health and Wellbeing** (SDG 3, WT=21). Together these five SDGs represent the first choice (highest priority) SDG of 75% of participants, and 63% of all possible selections.

A second cluster of SDGs with lower *Weighted Totals* (9–12) includes gender equality (SDG 5), energy (SDG 7), work and economic growth (SDG 8), and life on land (SDG 15).

These results are a reflection of the expertise and experience of those attending the workshop, with perspectives from at least 16 diverse organisations included. There is stronger consensus on the development priorities for Kenya (national scale) than eastern Africa (regional scale). This is expected given the Kenyan focus of participants. We discuss these results in **Section 3.5**.

		Eastern Africa [Choose one SDG per column]				Kenya [Choose one SDG per column]			
		1 st	2 nd	3 rd	4 th	1 st	2 nd	3 rd	4 th
1	No Poverty	End poverty in all its forms everywhere.							
2	No Hunger	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.							
3	Good Health	Ensure healthy lives and promote well-being for all at all ages.							
4	Quality Education	Ensure inclusive and equitable quality education and promote life-long learning opportunities for all.							
5	Gender Equality	Achieve gender equality and empower all women and girls.							
6	Clean Water & Sanitation	Ensure availability and sustainable management of water and sanitation for all.							
7	Clean Energy	Ensure access to affordable, reliable, sustainable, and modern energy for all.							
8	Good Jobs & Economic Growth	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.							
9	Innovation & Infrastructure	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.							
10	Reduced Inequalities	Reduce inequality within and among countries.							
11	Sustainable Cities & Communities	Make cities and human settlements inclusive, safe, resilient and sustainable.							
12	Responsible Consumption	Ensure sustainable consumption and production patterns.							
13	Protect the Planet	Take urgent action to combat climate change and its impacts.							
14	Life Below Water	Conserve and sustainably use the oceans, seas and marine resources for sustainable development.							
15	Life on Land	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.							
16	Peace & Justice	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.							
17	Partnerships for the Goals	Strengthen the means of implementation and revitalize the global partnership for sustainable development.							

Figure 1. Workshop Matrix. A blank workshop matrix, used by participants to express their perspectives on high priority SDGs in Eastern Africa and Kenya.

UN Sustainable Development Goal	(i) Eastern Africa					(ii) Kenya				
	1st	2nd	3rd	4th	Weighted Total*	1st	2nd	3rd	4th	Weighted Total*
1. No Poverty	4		1	5	23	6	1	2	3	34
2. Zero Hunger	5	2	1	2	30	7	5	1	2	47
3. Good Health and Well-Being	2	3	2		21		3	5	2	21
4. Quality Education	1	5	2	3	26		6	4		26
5. Gender Equality		3	1		11	1	1	1		9
6. Clean Water and Sanitation	4		2	3	23	5	2	3	3	35
7. Affordable and Clean Energy	1	1			7	2			3	11
8. Decent Work and Economic Growth	1	1	2	1	12	1	2	1	0	12
9. Industry, Innovation and Infrastructure		2	1	1	9		1	1	2	7
10. Reduced Inequalities		1	2	1	8				2	2
11. Sustainable Cities and Communities			1	1	3					
12. Responsible Consumption and Production				1	1		1	1		5
13. Climate Action		1	1		5			3		6
14. Life Below Water			1		2					
15. Life on Land		1	2	2	9		1	2	4	11
16. Peace, Justice, and Strong Institutions	1	2	1	1	13		1		2	5
17. Partnerships for the Goals	3		2		16	2			1	9

* Weighted Total = $4[n_{1st}] + 3[n_{2nd}] + 2[n_{3rd}] + 1[n_{4th}]$

Figure 2. Sum of Individual Perspectives on Priority SDGs. A synthesis of 24 perspectives on the SDGs (Figure 1), with the 'Weighted Total' determined as expressed in Equation 1. Shading is used to visualise priority SDGs.

3.2 GROUP PERSPECTIVES ON PRIORITY SDGS

3.2.1 Overview and Method

Another insight into development objectives in eastern Africa was documented by asking small groups of participants to come up with a consensus on SDG priorities. Mixed-sector groups determined the four SDGs that they believed to be of greatest importance in an eastern African context. Group discussions were prolonged and dynamic, with groups developing arguments as to why they considered key SDGs to be relevant and important (**Figure 3**).



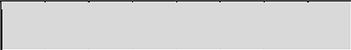
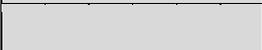
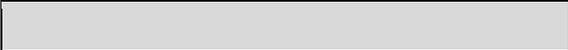
Figure 3. Discussing the UN Sustainable Development Goals. Following dynamic discussions, groups selected the four SDGs they believed to be of highest priority in eastern Africa.

3.2.2 Results

Following participant discussion, each group had 10 voting stickers to allocate to their four priority SDGs. Voting was undertaken by placing stickers on appropriate SDG posters, with the 10 stickers being allocated in the proportion best suited to the group conclusion (e.g., 4-3-2-1, 3-3-2-2, or 4-2-2-2 were all allowed). The distribution of group votes can be seen in **Table 2**,

From **Table 2**, we note that the SDGs ranked highest are **Clean Water and Sanitation** (SDG 6, 13 votes), **No Poverty** (SDG 1, 8 votes), **Zero Hunger** (SDG 2, 6 votes), **Good Health and Wellbeing** (SDG 3, 6 votes), and **Quality Education** (SDG 4, 6 votes). Together these five SDGs represent 78% of all possible votes. These results suggest that after opportunity for detailed group discussion, including the sharing of personal experiences and perspectives, groups converged on many of the same SDGs as indicated by summing individual perspectives (**Section 3.1**).

Table 2. Group Prioritisation of the UN Sustainable Development Goals.

SDG	Summary	Votes	
1	No Poverty	8	
2	Zero Hunger	6	
3	Good Health and Well-Being	6	
4	Quality Education	6	
5	Gender Equality	0	
6	Clean Water and Sanitation	13	
7	Affordable and Clean Energy	0	
8	Decent Work and Economic Growth	0	
9	Industry, Innovation and Infrastructure	2	
10	Reduced Inequalities	0	
11	Sustainable Cities and Communities	0	
12	Responsible Consumption and Production	0	
13	Climate Action	2	
14	Life Below Water	0	
15	Life on Land	3	
16	Peace, Justice, and Strong Institutions	3	
17	Partnerships for the Goals	1	

This second exercise allowed the capture of narrative on why certain SDGs were prioritised over others. A summary of comments justifying the selection of priority SDGs is provided in **Table 3**.

Table 3. Summary of comments justifying selection of priority SDGs.

SDG	Summary	Votes	Justification for Selection
6	Clean Water and Sanitation	13	Basic need for survival; a potential source of conflict (international and national); significant role in hunger, health, poverty.
1	No Poverty	8	
2	Zero Hunger	6	Motivation for everything; basic need for survival.
3	Good Health and Well-Being	6	Fundamental to everything.
4	Quality Education	6	Will help to address other priority goals.
15	Life on Land	3	Strong affinity to climate change; necessary for food security.
16	Peace, Justice, and Strong Institutions	3	Provides framework conditions/foundation for all other activities.
9	Industry, Innovation and Infrastructure	2	Need innovation for smart agriculture and an improved economy; breaks down social barriers; helps produce more than consume.
13	Climate Action	2	Controls other activities (e.g., food production, clean water, sanitation).
17	Partnerships for the Goals	1	

Emerging themes are the interconnectedness of the SDGs, and differences between resources needed immediately for survival (i.e., short-term development) and activities relating to long-term sustainable development. These results are further discussed in [Section 3.5](#).

3.3 CHARACTERISING SPECIFIC CHALLENGES

This exercise asked individuals and groups to add notes to SDG posters on specific challenges in eastern Africa associated with priority UN Sustainable Development Goals. For example, **Figure 4** shows a range of specific challenges associated with SDG 6 (Clean Water and Sanitation).



Figure 4. Specific challenges in eastern Africa associated with SDG 6 (Clean Water and Sanitation). Individuals and groups added notes on specific challenges to SDG posters. The information in the post-it notes is included in [Table 4](#).

Table 4 outlines the challenges identified for each SDG. While groups were encouraged to focus on priority SDGs (see [Section 3.2](#)), they were free to add comments on specific challenges to any of the SDG posters.

Table 4. Specific challenges and needs in eastern Africa associated with UN Sustainable Development Goals.

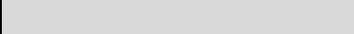
SDG	Summary	Specific Challenges and Needs
1	No Poverty	Uncoordinated aid; ineffective and poor governance; corruption; resilience to climate; lack on income and property; equal pay for equal work; gender inequality; illiteracy; cultural barriers; local attitudes and perceptions.
2	Zero Hunger	Crop productivity; poor farming practices; implementation of technology and mechanisation; land degradation; poor production and preservation methods; lack of dietary diversity; cultural barriers to food; lack of access due to cost; lack of good infrastructure; climate change, environmental and seasonal variability; shifts in planting and harvesting seasons.
3	Good Health and Well-Being	Lack of funding and capacity; cheap and clean energy; hunger; governance; remoteness; corruption; ignorance; lack of clean water; inadequate infrastructure; conflict; witchcraft; cultural barriers; poor waste management in urban areas; air/water/soil pollution; affordability of lifestyles; environmental factors; cultural and lifestyle habits.
4	Quality Education	Cost; poor governance; poverty; education system not valued; unemployment.
5	Gender Equality	Empowerment of women.
6	Clean Water and Sanitation	Corruption in the water sector, illegal connections; poor management and degradation of catchment areas; resources put into maintenance; pollution and water quality; resource mapping; loss of water mobility; inability to close water budget (e.g., leakage, over-abstraction, water waste); lack of data on water availability; poor water conservation; lack of awareness raising in communities; deforestation; climate change; depletion of groundwater; management of water sources; life cycle of water-supply solutions; maintenance of systems; lack of skills in water conservation and harvesting; low water availability; inadequate harvesting and storage; bad water management; management of infrastructure; inadequate and expensive technology for extraction and distribution; environmental degradation; exposure to sewage and contaminated, dirty water.
7	Affordable and Clean Energy	<i>None stated.</i>
8	Decent Work and Economic Growth	<i>None stated.</i>
9	Industry, Innovation and Infrastructure	Harness science and technology in our development.
10	Reduced Inequalities	<i>None stated.</i>
11	Sustainable Cities and Communities	<i>None stated.</i>
12	Responsible Consumption and Production	<i>None stated.</i>
13	Climate Action	<i>None stated.</i>
14	Life Below Water	<i>None stated.</i>
15	Life on Land	Integrated program of assessment and mitigation (science and solutions).
16	Peace, Justice, and Strong Institutions	<i>None stated.</i>
17	Partnerships for the Goals	Integration of serious, meaningful and responsible (with decision-making powers) partnerships at all levels and among sectors.

These challenges and needs were a starting point for designing Earth and environmental science activities to support the delivery of the SDGs ([Section 4](#)). Further discussion of these challenges, in the context of other results in this section, is included in [Section 3.5](#).

3.4 EARTH AND ENVIRONMENTAL SCIENCE

In addition to identifying priority SDGs in eastern Africa ([Sections 3.1–3.2](#)) and specific challenges associated with these ([Section 3.3](#)), participants were then asked to reflect on where Earth and environmental science can make the greatest contribution to development impact. Many of the SDGs require geological research and practice. Each workshop participant was given four voting stickers to place on the SDG posters they considered had a high requirement for Earth and environmental science research. The distribution of votes can be seen in [Table 5](#).

Table 5. Earth and environmental science and the SDGs in eastern Africa. Sum of individual perspectives on where Earth and environmental science can have the biggest development impact in eastern Africa.

SDG	Summary	Votes	
1	No Poverty	8	
2	Zero Hunger	12	
3	Good Health and Well-Being	3	
4	Quality Education	2	
5	Gender Equality	3	
6	Clean Water and Sanitation	25	
7	Affordable and Clean Energy	13	
8	Decent Work and Economic Growth	1	
9	Industry, Innovation and Infrastructure	5	
10	Reduced Inequalities	0	
11	Sustainable Cities and Communities	6	
12	Responsible Consumption and Production	2	
13	Climate Action	19	
14	Life Below Water	4	
15	Life on Land	14	
16	Peace, Justice, and Strong Institutions	5	
17	Partnerships for the Goals	3	

From [Table 5](#), we note that the SDGs ranked highest in terms of a role for Earth and environmental science are **Clean Water and Sanitation** (SDG 6, 25 votes), **Climate Action** (SDG 13, 19 votes), **Life on Land** (SDG 15, 14 votes), **Affordable and Clean Energy** (SDG 7, 13 votes), and **Zero Hunger** (SDG 2, 12 votes). Together these five SDGs represent 66% of all possible votes. Further discussion of these results is included in [Section 3.5](#).

3.5 DISCUSSION AND LIMITATIONS

3.5.1 Summary of Key Observations

From [Sections 3.1–3.4](#), we can make the following observations and conclusions:

- **Priority SDGs**

Across both prioritisation exercises ([Sections 3.1](#) and [3.2](#)), SDGs consistently selected as being of high importance in eastern African were **Clean Water and Sanitation** (SDG 6), **No Poverty** (SDG 1), **Zero Hunger** (SDG 2), **Good Health and Wellbeing** (SDG 3), and **Quality Education** (SDG 4). These were the same when asked to consider Kenya only. The highest priority SDG using the method in [Section 3.1](#) was **Zero Hunger** (SDG 2), with the highest priority SDG using the method in [Section 3.2](#) being **Clean Water and Sanitation** (SDG 6).

- **Consistency of Results**

There was a high level of consistency between the results of the sum of individual perspectives ([Section 3.1](#)) and the group discussion exercise ([Section 3.2](#)). If differences were highlighted, this could have been indicative of (i) a small number of strong personalities dominating group discussions, or (ii) significant numbers of people changing their mind after reflecting on the group discussion.

- **Interconnectedness of SDGs**

During the group discussions, an emerging theme was the interconnectedness of the SDGs ([Section 3.2](#)). For example, actions to support one SDG could help reinforce or support another SDG. Inherent to tackling issues of water, health, food and/or poverty, are the need to build resilience to **Climate Change** (SDG 13), ensure access to **Affordable and Clean Energy** (SDG 7), and reduce environmental degradation by protecting **Life on Land** (SDG 15). A development intervention or research project could also feasibly support multiple SDGs. For example, projects related to the food-water-energy nexus could relate to SDGs on poverty, food, water, energy, infrastructure, and climate. In their discussions, many groups were considering which SDGs were focal points, and would support the implementation of other SDGs.

- **Immediate vs. Long-Term Development**

Many of the SDGs identified in [Sections 3.1](#) and [3.2](#) as being high-priority SDGs are ‘basic needs’ and critical for survival (e.g., food, water, and health). These are likely to be of immediate importance to participants; especially given the recent contexts of drought and food insecurity (e.g., see ReliefWeb, 2017). Both immediate (humanitarian) and long-term (development) solutions are required to address these ‘basic needs’. Additional exercises could be developed for future workshops that ask participants to consider priority challenges in 10, 20 and 50-years from now. This would encourage participants to think beyond the current development landscape, and reflect on long-term development.

- **Earth and Environmental Science**

In the context of eastern Africa, SDGs ranking highest in terms of a role for Earth and environmental science ([Section 3.4](#)) were **Clean Water and Sanitation** (SDG 6), **Climate Action** (SDG 13), **Life on Land** (SDG 15), **Affordable and Clean Energy** (SDG 7), and **Zero Hunger** (SDG 2).

- **Overlap of Priority and Science Needs**

SDGs identified as being both a high priority and having a significant role for Earth and environmental science ([Sections 3.1](#), [3.2](#) and [3.4](#)) are therefore **Clean Water and Sanitation** (SDG 6) and **Zero Hunger** (SDG 2).

The information gathered during this two-day workshop provides additional context to the implementation of the UN Sustainable Development Goals, and other records of development priorities. For example, at a regional scale the [East African Community Vision 2050](#) and [Kenya Vision 2030](#) offer regional and national scale visions for sustainable development. The latter includes an economic, social and political pillar, together with enablers and macro factors such as infrastructure, energy, science-technology-innovation, and human resources development.

3.5.2 Uncertainties and Limitations

The perspectives discussed through [Section 3](#) are a function of the sectors and disciplines attending the workshop, and the personal expertise and experience of individuals attending the workshop. While a high diversity of sectors and disciplines were present, some key groups were under-represented. For example, the workshop was skewed towards Earth scientists, with few from political economy, social and economic sciences present. There was also limited diversity in terms of nationality, with most of the participants being from Kenya. Results relating to eastern Africa, therefore, should be considered to be the Kenyan perspective on regional development. This perspective can be confronted with other perspectives gathered beyond Kenya to explore if there is a regional consensus on development priorities, challenges and solutions.

4 Thematic Working Groups

The information collected in [Section 3](#) was used to establish three thematic working groups on the second day of the workshop. These groups, and the reasons for their inclusion, were:

Food-Water-Energy Nexus

Focus on SDGs 2, 6, 7. Food and water ranked highly in terms of development priorities, and food, water and energy were all noted to be areas where Earth and environmental science can help deliver sustainable development. This group reflected the recognition of interconnections between the SDGs.

Clean Water and Sanitation

Focus on SDG 6. This SDG was repeatedly emphasised to be of high importance with a significant role for Earth science. This group reflected the importance that participants placed on this SDG.

Natural Resources (Minerals)

Focus on SDGs 8, 9, 12. Access to, and sustainable management of, natural resources underpins many of the SDGs, including those ranked as high priority (e.g., Zero Hunger) and medium priority (e.g., Economic Growth). This group reflected the expertise of participants, and their desire to explore how resource management can support the SDGs.

Each group also considered how their theme interacted with SDGs relating to poverty (SDG 1), health (SDG 3) and climate (SDG 13). Groups initially considered specific challenges relating to the theme of their working group, including drawing on those initially set out in [Section 3.3](#). These challenges were discussed to identify those of greater and lesser priority. Groups then proceeded to explore possible solutions to these challenges, reflecting on the science/innovation/technologies needed to have development impact.

We present a summary of the discussions in each working group in [Sections 4.1–4.3](#). These summaries are based on notes taken by members of each group and the feedback presented during summary sessions. The notes below, therefore, offer a record of the conversations had by groups but these conversations have not been edited or checked to remove errors.

4.1 FOOD-WATER-ENERGY NEXUS

This group included contributions from: Jaramogi Oginga Odinga University of Science and Technology, Strathmore University, African Collaborative Centre for Earth Systems Science, International Centre of Insect Physiology and Ecology, and the British Geological Survey.

Recognising the integrated approaches needed to tackle development objectives, this group focused on the food-water-energy nexus. This considered challenges relating to SDG 2 (zero hunger), SDG 6 (clean water and sanitation), and SDG 7 (affordable and clean energy), and interactions between them.

Initial challenges related to competing interests of the three nexus components, recognising that these are often managed separately. Coordination is required, however, to help mitigate against cascading consequences. Coordination will likely depend on goal-orientated systems analysis, developing information networks to support modelling future scenarios (prediction). Principal goals are (i) access to clean water, (ii) access to cheap and clean energy, and (iii) crop productivity, lake/river management (fish) and animal husbandry. Additional challenges include data (discussed in more detail below), waste management, dietary diversity and sustainability.



Figure 5. 'Food-Energy-Water Nexus' thematic group. Exploring the science, innovation and technologies relating to this nexus, and the delivery of multiple SDGs.

Some preliminary examples were discussed which explored interactions between water, energy and food, with potential for changes due to climate change.

- i. **Tana River Catchment.** This is used for power and irrigation. It runs through 16 counties, each of which has a devolved governance structure.
- ii. **West Kenya Lakes.** The site of the Dondo hydropower scheme. There is also an important fish economy.
- iii. **Urbanisation.** The Nile Basin Initiative are exploring the impact of urbanisation on Lake Victoria (e.g., at Kisumu). There are issues of greywater, urban agriculture and waste. Urbanisation is also important in both (i) and (ii).

The group also discussed the following broader issues in depth:

- **Data**

Understanding data availability, quality, and baselines are important. There may be no digital (soft) copies of data, and/or significant information gaps. Monitoring and automated systems would help to improve data collection. Digital data capture systems are likely not used, but will be important. Data will still need to be screened for quality before processing.

Example: There exists ~50 years of meteorological data for Kenya, but some of this is only in hard copy. This data needs to be digitised, and a consistent data collection approach.

To understand data availability and gain access, trust is needed between stakeholders. Project details and benefits must be communicated effectively. When trust is established, doors will open. Some data is considered ‘top secret’ and requires an oath to be sworn to access it. Middle facilitators (e.g., NACOSTI) can help to engage ministries and ensure personal contacts are made, ideally with Permanent Secretaries in key ministries. It is key to involve senior figures within ministries. NACOSTI must be involved to get permits for research.

Research is needed into other data repositories and the mechanisms to assemble archived data. This may include the development of new technologies/sensors for new data. Possible holders of data include: Bureau of Statistics (a portal exists, with payment required to access it), Government Ministries, NGOs, and the Remote Sensing Center. There is also valuable information in the scientific literature and grey literature produced by key organisations (e.g., World Bank, DANIDA)

- **Barriers and Partnerships**

These include cultural (local attitudes, beliefs and lifestyles) and local governance issues. To help avoid resentment from local communities, it is important to stop rumours about the work being done. Involving local religious and community leaders can help this process, and help integrate the project with the community. Kenya has high levels of regional devolution, and therefore understanding and engaging with local government is critical. Identifying social scientists and cultural extension services operating in the regions of interest will be necessary in the context of any project. Groups involved in climate, political economy, social and economic sciences should be identified. Kenya has many multi-disciplinary research institutes (e.g., Strathmore University, International Centre of Insect Physiology and Ecology). Local buy-in will also be necessary in the development of projects. Partnerships will need to be inter/trans/cross-disciplinary, sustained and involve active learning. For example, the Kenya Climate Information Center (KCIC, <https://kenyacic.org/>) have experience of unlocking cultural barriers relating to dietary habits. A culture is needed that enables people to work together.

- **Lessons Learned**

There are many success and failure stories that can help us to learn. For example, the Kisumu port has community chillers to improve fish preservation, with the community actively providing this solution. Another lesson is the value of using science communicators to translate technical solutions to stakeholders.

- **Capacity Building**

This should be in academia and local communities at all levels. Strengthening capacity beyond Nairobi was requested.

4.2 CLEAN WATER AND SANITATION

This group included contributions from: Westerveld Agriculture and Livestock Development, Maseno University, African Association of Women Geoscientists, Kenyatta University, University of Nairobi, Ministry of Water and Irrigation, University of Eldoret, World Vision Kenya, Centre for Ecology and Hydrology, and the British Geological Survey.

Clean Water and Sanitation (SDG 6) ranked highly in terms of priority and requiring Earth and environmental science (**Section 3**). A working group was established to discuss this SDG, and explore what activities could help to address the range of challenges previously noted in **Table 4**.



Figure 6. ‘Clean Water and Sanitation’ thematic group. Exploring the science, innovation and technologies required to tackle specific challenges relating to clean water and sanitation (SDG 6).

After an initial discussion, the group decided to focus on clean water, reflecting the stakeholders’ areas of expertise, the workshop remit of ‘Earth and Environmental Science’ and time limitations. However, it was recognised that there are many important links between water and sanitation. Potential collaborative activities discussed by this group are noted below:

1. Water Availability Mapping

There is a range of information available on water quantity and quality issues, but this data is stored and disseminated by multiple organisations. For example, the Water Resources Management Authority, National Environment Management Authority, Survey of Kenya (part of the Ministry of Lands and Physical Planning), Department of Resource Survey and Remote Sensing, Met Office, and the Geology Department. Bringing these agencies, and their data, together is a challenge, but is very important to understanding what data is available and where the gaps are. A **data portal** could be developed that would enable information to be collated and disseminated to multiple users. It would enable the gaps in data to be identified, with these gaps ranked in terms of priority to gather data. NGOs (e.g., Oxfam) hold some data in Kenya (e.g., access to clean water).

2. Water Policy, Governance and Management

a. There is currently no **groundwater-monitoring network** in some countries in eastern Africa. For example, Kenya has no formal network while Uganda has a well-established network. It is difficult to understand and manage challenges of over-abstraction and unsustainable utilisation of groundwater without some baseline monitoring. One area of collaboration could be in the design and installation of a monitoring network, with the development of in-country protocols for reporting and summarising monitoring results. This information could feed in to a cross hydro-meteorological agency process to develop a national hydrological outlook or similar. This could form, for example, the basis for improved monitoring during the onset of droughts and managing and coordinating responses to them more effectively. It is difficult to understand and manage challenges of over-abstraction and unsustainable utilisation of groundwater. The design and installation of a monitoring network, with protocols for reporting and summarising monitoring results would help to address this challenge.

b. Catchment and/or Land Use Management was also highlighted as an important topic relevant to this SDG, and draws upon various environmental and Earth science agencies. It is necessary for effective hazard mapping of water resources (i.e., impacts on quality and quantity of water from industry, agriculture and urbanisation). A good entry point for exploring potential research in this field is the Kenya Water Towers Agency (KWTA, www.kwta.go.ke/). Research could help to use

state of the art technology and methods (including new observations and modelling) to close the gap in knowledge of current and future availability of clean water, giving good guidance for decision-making.

3. Key Data Gaps and Applied Research and Training Activities

The group recognised that while some very good data sets are available across eastern Africa, there are many barriers to accessing and using the data for research and other purposes. The group also recognised that data sets to inform water resource planning are not available for many areas in Kenya and elsewhere in eastern Africa, and this has a major constraint on the science that is possible and the development of evidence in this region. In terms of skilled professionals, Kenya is in a better situation than many countries in the region. The local resource base with which to undertake water resource activities, however, was recognised to be a major constraint in delivering improved water and sanitation in the region. Partnerships and joint knowledge exchange, training and applied research activities, drawing on the expertise available across eastern Africa, could help to address this specific challenge.

4.3 NATURAL RESOURCES (MINERALS)

This group included contributions from: Ministry of Agriculture, Livestock and Fisheries, Ministry of Mining, Geological Society of Kenya, University of Nairobi, and the British Geological Survey.

The workshop included participants with expertise in natural resource management, and therefore a group was established to explore how this expertise can support sustainable development. Natural resources are necessary for the delivery of many SDGs, including SDG 2 (Zero Hunger), SDG 7 (Clean Energy), SDG 8 (Good Jobs and Economic Growth), and SDG 12 (Responsible Consumption). This group started by identifying specific challenges associated with the development of Kenya's minerals sector (**Table 6**).

Table 6. Specific challenges in Kenya associated with the minerals sector.

Theme	Specific Challenges
Natural Resources (Minerals)	<ul style="list-style-type: none"> Technology. Artisanal and small-scale mining (financial management, health, mercury and environmental impact, and security). Human resources and skills development (dialogue, skills and number of staff, understanding of modern processing techniques, need to make our science understandable at all levels). Links with other natural resources (minerals and renewable energy such as solar, nuclear, batteries, wind, hydropower, and geothermal). Best use of land (e.g., minerals vs other uses). Water needs. Ensuring value addition to Kenya. Location of resources. Resource corridors. People displacement and environmental impacts. Data. Resource substitution.



Figure 7. ‘Natural Resources (Minerals)’ thematic group. Exploring the science, innovation and technologies relating to sustainable management of minerals, and the delivery of multiple SDGs.

Potential collaborative activities discussed by this group are noted below:

1. Mombasa to Nakuru/Kisumu Corridor.

Running for 600 km from Mombasa in eastern Kenya to Nakuru (Menengai/Kisumu) in western Kenya, with a width of approximately 20 km. This follows existing infrastructure development (e.g., railway), and is likely to be one corridor where future development in eastern Africa is concentrated. This project would seek to integrate data from multiple ministries and agencies to support surface and sub-surface land-use planning. For example, data would be required on geohazards, geology, mineral locations, geophysics, socio-economic factors, environment, land-use, and geotechnical parameters. The portal hosting this data would be dynamic, allowing real-time monitoring of ground conditions and ultimately 3D modelling of the sub-surface.

2. Artisanal and Small-Scale Mining (ASM).

This project would consider key factors associated with ASM in Kenya, including exploring what, where and how ASM is being done and could be done. ASM can provide alternative livelihoods in poor areas. For it to be utilised effectively, a range of data, capacity building exercises and research programmes are needed. Examples identified by the working group include existing baseline data, supply chain analysis, health and safety training and awareness, possible rehabilitation tools, co-location of minerals, cost-benefit analyses, the roles of women and children in ASM, and geoeconomic initiatives. The group also proposed comparing and contrasting ASM in terms of base metals and construction materials.

5 Science-for-Development Partnerships

The final session of the workshop invited participants to characterise good *science-for-development* partnerships, using a questionnaire methodology. Here we note a summary of initial results. Data will be analysed further in the context of the published literature, and drafted into a separate future report.

In this context, we consider ‘*science-for-development*’ to be research, application and/or communication of science directed towards efforts to tackle poverty, improve economic and human development, manage the natural environment, and reduce risk and increase resilience. Science and research that supports sustainable development may require collaborations that are

- i. **International** (i.e., people and organizations from multiple countries),
- ii. **Multi-sectoral** (i.e., people from diverse sectors, such as the public and private sectors),
- iii. **Multi-disciplinary** (i.e., people from diverse disciplinary backgrounds).

Questionnaires were completed independently by participants, and they were anonymous.

Participants were initially asked to comment on previous experience of *science-for-development* partnerships. They then proceeded to explore what characteristics they think are most important in developing positive and effective partnerships. Fourteen characteristics were presented, with participants asked to rate on a 7-point Likert scale (from *Strongly Agree* to *Strongly Disagree*) how important they believe each factor to be in the formation of positive ‘science-for-development’ partnerships. One test characteristic (*members of the partnership are all the same nationality*) was also added to check that participants were evaluating each statement carefully and not simply giving the highest ranking to each statement.

Based on 21 responses, the characteristics of *science-for-development* partnerships ranked as being of most importance are listed below.

1. Sharing of project outputs across the partnership (e.g., reports, journal articles).
2. Sharing of data across the partnership.
3. Being treated as an equal by other members of the partnership.
3. Access to training and capacity building.
5. Respectful dialogue between members of the partnership.
5. Access to funding/financial resources.
7. Co-authorship of research outputs (e.g., journal articles, reports).
8. Frequent e-mail communication between members of the partnership.
9. Opportunity for all members of the partnership to contribute to project design.
9. Regular face-to-face meetings between members of the partnership.
11. Access to expertise of other organizations.
11. Understanding of cultural differences across the partnership.
13. Access to facilities of other organizations.
14. Frequent telephone communication between members of the partnership.
15. Members of the partnership are all the same nationality [*test characteristic*].

The rankings presented above suggest that characteristics associated with **equality** are of greatest importance to participants. Three of the top four ranked characteristics relate to the affirmation of partners as equals in any science-for-development collaboration. Ensuring equal access to project outputs (e.g., reports, journal articles) (#1) and data generated as part of the partnership (#2) are the factors valued most by those questioned. This is closely followed by the partnership treating all members as equals (#3). Other characteristics associated with this ‘equality’ theme are ensuring opportunities for co-authorship of research outputs (#7), and opportunity for all members of the partnership to contribute to project design (#9).

Secondary to these ‘equality’ values are a set of values relating to **resources** and the resourcing of partners. Access to training and capacity building (#3) was prioritised more than access to funding and financial resources (#5), expertise (#11), or facilities (#13). Finally a set of values can be identified which relate to the partnership **process**. Respectful dialogue (#5) and frequent email communications between partnership members ranked relatively highly (#8).

This data synthesis can help to inform partnership development in a Kenyan context. It provides BGS with an understanding of key values to embed within research partnerships, supporting ongoing monitoring and evaluation of whether partnerships remain mutually beneficial. Replication of this research in other countries can help to develop a multi-national perspective on characteristics for effective science-for-development partnerships.

6 Conclusions

6.1 SUMMARY

Through this workshop, and subsequent analysis, we have undertaken and understood the following:

- **Section 2.** Characterised the organisations involved in this workshop, identifying key stakeholders from academia, government, civil society and the private sector. The workshop adopted a bottom-up approach, with those attending demonstrating a high level of enthusiasm, engaging positively, with a willingness to share their expertise and experiences.
- **Section 3.** Explored development priorities in eastern Africa and Kenya, and the role of Earth and environmental science in addressing these, identifying clean water and sanitation, ending poverty, ensuring food security, and improving health and education as recurring priorities. This report allows all workshop participants (including the BGS) to understand development priorities in eastern Africa and Kenya, using the SDGs as a reference tool.
- **Section 4.** Summarised the discussions of three working groups, exploring potential ideas relating to the food-water-energy nexus, water and sanitation, and natural resources (minerals) development. From these groups we identified crosscutting project priorities (data collection, management and organisation), and thematic projects that could support sustainable development. For example, emerging from the natural resources (minerals) working groups was the idea of characterising a ‘*resource corridor*’ running from Mombasa to Kisumu. The resource corridor approach allows the integration of Earth, environmental, and socio-economic data for a region to underpin effective and innovative planning and governance and aligns with international encouragement of ‘*coherent economic-social-environmental policies*’ (UNDESA, 2013).
- **Section 5.** Documented the characteristics that workshop participants considered to be of greatest importance in *science-for-development* partnerships, identifying those characteristics associated with equality. For example, equal access to project outputs (e.g., reports, journal articles) and data generated as part of the partnership, and treating all members as equals. All of the activities identified will require multi-sectoral and multi-disciplinary partnerships.

In the following section, we outline the next steps, to be explored with project partners, which will advance these ideas.

6.2 NEXT STEPS

This workshop report discusses development challenges in eastern Africa (particularly Kenya), and presents several ideas where Earth and environmental science will support sustainable development. *We will send this report to all workshop participants, and encourage their active engagement in reflecting on the conclusions and refining the proposed next steps.* BGS staff will shortly return to Kenya to discuss the following actions to advance and enhance the outputs from this workshop:

- i. ***Progress the ‘resource corridor’ concept discussed by the natural resource (minerals) working group.*** Full characterisation of a resource corridor requires the integration of diverse environmental, social and economic data. This project, therefore, would include aspects of water availability mapping, land management, and understanding the food-water-energy nexus raised by other working groups (see **Section 4**). The Geological Survey of Kenya is tasked with updating the geological mapping along the Mombasa to Nairobi railway line (to be extended to Kisumu). Bringing together this geological mapping with other data could help to improve planning in multiple contexts (e.g., economic, wildlife, urban development). *Led by Bath University, BGS are contributing to a workshop on this*

theme in Kenya, scheduled for October 2017, with engagement from Kenyan partners. This will form the basis for an application for support from the UK Global Challenges Research Fund (GCRF).

- ii. ***Co-produce project proposals (aims, objectives, background context, pathways to development impact) for ideas generated in this workshop.*** Workshop participants identified a set of potential projects that could be developed through Newton or GCRF funding. For example, water availability mapping, capacity building in water policy/governance/management, artisanal and small scale mining, and geodata management. Through meetings with stakeholders in Kenya, *we will co-produce with Kenyan colleagues outline proposals for these projects in preparation for relevant Newton and GCRF funding opportunities.*
- iii. ***Bring in stakeholders from additional disciplines.*** While the workshop attracted 22 organisations, there were key groups missing, particularly those from socio-economic sectors and other environmental themes. For example, research on the food-water-energy nexus will need greater input from agriculture and public health researchers to strengthen pathways to impact. Such groups can help to overcome barriers and create diverse partnerships through their extension services. *We will pro-actively work with the socio-economic scientists that attended the workshop to better understand the nature of this discipline in Kenya, map out stakeholders, and ensure enhanced engagement at future workshops. We will also engage with the climate science community in Kenya and the UK (e.g., the Met Office).*
- iv. ***Connect stakeholders in Kenya with BGS (and external) expertise relevant to emerging projects.*** Having identified relevant expertise and research/project interests in Kenya, *we will use the extensive BGS network of researcher links from across eastern Africa and the UK to catalyse new interactions.*
- v. ***Explore eastern African priorities by replicating this workshop in other countries.*** Kenya is a hub for business and development in eastern Africa, with many of the participants working in other countries in the region. Building on the regional scope from this workshop, we will enhance our understanding of sustainable development priorities by engaging with stakeholders in further countries using participatory workshops. *We will plan to deliver workshops in two further locations, likely Zambia and Tanzania.*
- vi. ***Improve our understanding of effective international partnerships to support science-for-development.*** During this workshop, we collected data to understand partnership priorities in a Kenyan context. *We will supplement this data with semi-structured interviews, and aim to publish a peer-reviewed journal article on science-for-development partnerships. We will also understand and explore NGO engagement across eastern Africa, including their focus and priorities.*

Appendix 1 Workshop Programme

The two-day workshop programme is included below, with detail of the sessions planned.

DAY 1 (28 MARCH 2017)

	Session	Activities	Purpose
09.00-09.30	Registration & Coffee		
09.30-10.00	Welcome/ Introduction	<ul style="list-style-type: none"> Formal welcome Welcome from Kenyan Representative Context and objectives of the workshop Overview of the workshop structure/activities Participants' expectations 	
10.00-10.50	Participant Introductions and Mapping	<p>10.00-10.15 Icebreaker</p> <p>10.15-10.50 Group Activity (Mapping Participants' Activities)</p> <ul style="list-style-type: none"> Introductions: Each person introduces them self (name, where from, where they work, type of activities included in their work, where these activities take place). Map: Simultaneously, use the A3 map to represent information about the group. We will show you an example before starting. Determine Spokesperson: Identify a group representative to introduce (briefly) the expertise on their table. <i>We will photograph and project these maps on the screen to help you and allow the audience to see what each group has done.</i> 	This exercise acts as an icebreaker, catalyses dialogue between participants, and generates data to support effective stakeholder mapping. It helps all participants know what groups are represented at the workshop, and what work they are doing in Kenya, eastern Africa, and globally.
10.50-11.10	Coffee Break		
11.10-11.45	Participant Introductions and Mapping (Continued)	Feedback. Each group is given 5 minutes to briefly introduce the expertise on their table	(See above)
11.45-12.30	Plenary Talks (10 minutes each, with 5 minutes for questions):	<ul style="list-style-type: none"> Eastern Africa and the SDGs (Professor Eric Odada, African Collaboration Centre on Earth Science Systems); Kenya and the SDGs (Dr Melba Wasunna, Extractives Baraza, Strathmore University); British Geological Survey and the SDGs (Professor John Ludden, BGS). 	The plenary talks set the scene, giving useful context to the SDGs in Eastern Africa and Kenya, as well as the work of the British Geological Survey.
12.30-14.00	Buffet Lunch		
14.00-15.30	Regional Development Needs (Big picture, high-level problems)	<p>14.00-14.10 Session Introduction</p> <p>14.10-15.30 Sustainable Development Goals</p> <ul style="list-style-type: none"> Individual Exercise. Populate a matrix with information about priority SDGs in Kenya and eastern Africa. Group Exercise. Rank the SDGs in terms of their relative importance. All together. Feed information back, and explore specific challenges and the role of Earth and environmental science. 	This session explores stakeholder perspectives on development priorities in eastern Africa, using the Sustainable Development Goals (SDGs) as a reference tool.
15.30-16.00	Coffee Break		
16.00-16.30		Open discussion: Walking tour of the posters, with discussion about the key challenges.	(See above)
16.30-17.00	Questions and Answer	Participants can ask questions to the BGS team about their intentions, experiences and work.	To promote transparency and honest discussion.

	Session	Activities	Purpose
	Session with BGS Team		
17.00-17.15	Summary	<ul style="list-style-type: none"> • Reflection • Summary of Day 1 • Plan for Day 2 	
17.15-18.15	Drinks Reception		

DAY 2 (29 MARCH 2017)

	Session	Activities	Purpose
08.45-09.00	Arrival & Coffee		
09.00-09.15	Welcome/ Recap	<ul style="list-style-type: none"> • Recap Objectives • Recap key outputs from Day 1 • Structure Day 2 	
09.15-12.30	Regional Development Needs <i>(Earth and Environmental Science Research Questions for Specific Development Needs)</i>	09.15-09.30 Session Introduction 09.30-10.30 Discussion Groups (<i>themes to be determined at the end of Day 1</i>) <ul style="list-style-type: none"> • Specific Challenges. What are the specific challenges associated with the theme of your group? • Ranking. Rank these challenges in different ways (e.g., priority, ease of finding solutions, need for Earth science, need for new research). • Evidence. What is the evidence that helps us to know that these are high-priority development challenges in eastern Africa? 	To explore priority development challenges (from Day 1) in more depth, and identify the role of Earth and environmental science in addressing these. This information enables participants to evaluate specific development needs, where these are a problem, evidence, and people working on the problems.
10.30-11.00		Coffee Break	
11.00-12.30		Continue exploring key themes in discussion groups <ul style="list-style-type: none"> • Science Requirements and Gaps. What science information is required to address specific challenges? What are the gaps in Earth science research that would help to tackle key challenges? • Mapping Stakeholders. Who do you know that is working on these problems (include researchers, civil society, government agencies, private sector groups)? • Prepare to feedback information. Review the key information from this session to feedback to all participants after lunch. 	(See above)
12.30-14.00		Buffet Lunch	
14.00-15.00		Presentation of information from discussion groups to all participants, with time for questions and answers.	(See above)
15.00-15.20	Coffee Break		
15.20-16.20	Research-for-Development Partnerships	What are the characteristics of good international partnerships? We will explore this theme through: <ul style="list-style-type: none"> • Questionnaire. • Group Discussion Exercise 	This session characterises good research-for-development partnerships, from the perspective of workshop participants.
16.20-17.00	Concluding Remarks	<ul style="list-style-type: none"> • Review • Reflections on ways forward Formal close/thank you	

Appendix 2 Workshop Feedback

How would you rate your overall experience as a participant at this workshop?

<i>Very Negative</i>	<i>Fairly Negative</i>	<i>Slightly Negative</i>	<i>Neither</i>	<i>Slightly Positive</i>	<i>Fairly Positive</i>	<i>Very Positive</i>
0	0	0	0	0	3	13

How would you rate each of the following aspects of this workshop?

Communication before the Workshop:

<i>Very Negative</i>	<i>Fairly Negative</i>	<i>Slightly Negative</i>	<i>Neither</i>	<i>Slightly Positive</i>	<i>Fairly Positive</i>	<i>Very Positive</i>
			1		5	8

Workshop Programme:

<i>Very Negative</i>	<i>Fairly Negative</i>	<i>Slightly Negative</i>	<i>Neither</i>	<i>Slightly Positive</i>	<i>Fairly Positive</i>	<i>Very Positive</i>
					4	10

Venue:

<i>Very Negative</i>	<i>Fairly Negative</i>	<i>Slightly Negative</i>	<i>Neither</i>	<i>Slightly Positive</i>	<i>Fairly Positive</i>	<i>Very Positive</i>
						14

Catering/Refreshments:

<i>Very Negative</i>	<i>Fairly Negative</i>	<i>Slightly Negative</i>	<i>Neither</i>	<i>Slightly Positive</i>	<i>Fairly Positive</i>	<i>Very Positive</i>
					2	12

Quality of Discussion:

<i>Very Negative</i>	<i>Fairly Negative</i>	<i>Slightly Negative</i>	<i>Neither</i>	<i>Slightly Positive</i>	<i>Fairly Positive</i>	<i>Very Positive</i>
						14

Opportunity to Contribute to Activities:

<i>Very Negative</i>	<i>Fairly Negative</i>	<i>Slightly Negative</i>	<i>Neither</i>	<i>Slightly Positive</i>	<i>Fairly Positive</i>	<i>Very Positive</i>
						14

Consider your overall experience at this workshop. Please indicate the extent to which you agree/disagree with the following statements (n =14, 2 did not complete):

I received the communication I needed to play an effective part in the workshop.

<i>Strongly Disagree</i>	<i>Disagree</i>	<i>Slightly Disagree</i>	<i>Neither Agree nor Disagree</i>	<i>Slightly Agree</i>	<i>Agree</i>	<i>Strongly Agree</i>
	1				7	6

I felt comfortable getting involved in the table discussions.

<i>Strongly Disagree</i>	<i>Disagree</i>	<i>Slightly Disagree</i>	<i>Neither Agree nor Disagree</i>	<i>Slightly Agree</i>	<i>Agree</i>	<i>Strongly Agree</i>
					2	12

I felt comfortable getting involved in the larger (whole-workshop) discussions.

<i>Strongly Disagree</i>	<i>Disagree</i>	<i>Slightly Disagree</i>	<i>Neither Agree nor Disagree</i>	<i>Slightly Agree</i>	<i>Agree</i>	<i>Strongly Agree</i>
					2	12

The workshop proceeded at a pace I felt comfortable with.

<i>Strongly Disagree</i>	<i>Disagree</i>	<i>Slightly Disagree</i>	<i>Neither Agree nor Disagree</i>	<i>Slightly Agree</i>	<i>Agree</i>	<i>Strongly Agree</i>
					5	9

I understood how each session linked to the objectives of the workshop.

<i>Strongly Disagree</i>	<i>Disagree</i>	<i>Slightly Disagree</i>	<i>Neither Agree nor Disagree</i>	<i>Slightly Agree</i>	<i>Agree</i>	<i>Strongly Agree</i>
					7	7

I felt my opinions were valued by other workshop participants.

<i>Strongly Disagree</i>	<i>Disagree</i>	<i>Slightly Disagree</i>	<i>Neither Agree nor Disagree</i>	<i>Slightly Agree</i>	<i>Agree</i>	<i>Strongly Agree</i>
					4	10

I felt my opinions were valued by the workshop facilitators.

<i>Strongly Disagree</i>	<i>Disagree</i>	<i>Slightly Disagree</i>	<i>Neither Agree nor Disagree</i>	<i>Slightly Agree</i>	<i>Agree</i>	<i>Strongly Agree</i>
					3	11

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