



# The role of Earth and environmental science in addressing sustainable development priorities in Eastern Africa

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## ABSTRACT

Here we synthesise the results of three participatory workshops to explore sustainable development priorities in eastern Africa, and discuss these in the context of Earth and environmental science. The planet is a core pillar of sustainable development, and the engagement of Earth and environmental scientists is vital to achieving the UN Sustainable Development Goals (SDGs). In 2017, the British Geological Survey gathered 76 delegates from 48 organisations at three workshops in Nairobi (Kenya), Lusaka (Zambia), and Dar es Salaam (Tanzania). Using the SDGs as a reference tool, participants (i) identified development priorities at regional (eastern Africa) and national scales, (ii) explored the Earth and environmental science research and data needs to help address these, and (iii) co-designed relevant science-for-development projects. Participants identified sustainable development priorities to be basic (or immediate) needs, including zero hunger (SDG 2), education (SDG 4), ending poverty (SDG 1), and water and sanitation (SDG 6). Participants also described examples of Earth and environmental science research, training, technologies, monitoring and management to support sustainable development. Emerging themes included *environmental data* (collection, management, integration, access), *policy and regulations* (integrating environmental science, and policy coherence), *resource management* (degradation, pollution and environmental protection), and *scientific education and understanding* (training, knowledge exchange, public understanding of science). A comparative synthesis of existing regional and national development strategies indicates that current narratives of development interventions do not fully capture the opportunities from environmental data integration and policy coherence. Greater engagement with and by the Earth and environmental science community could help to advance these themes to support sustainable development in eastern Africa. This would support efforts to reduce environmental degradation, improve natural resource management, and inform the utilisation of natural resources to improve economic growth and social wellbeing.

## 1. Introduction

Here we use a participatory workshop methodology to identify sustainable development priorities in eastern Africa, and analyse the role of Earth and environmental science in achieving these. In 2017, we conducted workshops in Kenya, Zambia and Tanzania, gathering 76 participants from 48 different organisations. In this paper, we synthesise and compare the results from these workshops, contrasting them with existing global, regional and national expressions of sustainable development priorities. Throughout this

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**Table 1**

Global Development Trends.

Source: Adapted from UNDESA (2013).

Challenge	Description
Financial System	'Recurrence of financial crises needs to be prevented and the financial system has to be redirected towards promoting access to long-term financing for investments required to achieve sustainable development.'
Environmental Stress	'The impact of climate change threatens to escalate in the absence of adequate safeguards and there is a need to promote the integrated and sustainable management of natural resources and ecosystems and take mitigation and adaptation action in keeping with the principle of common but differentiated responsibilities.'
Hunger and Malnourishment	'Hunger and malnourishment, while decreasing in many developing countries, remain persistent in other countries, and food and nutrition security continues to be an elusive goal for too many.'
Rapid Urbanisation and Sustainable Cities	'Rapid urbanisation, especially in developing countries, calls for major changes in the way in which urban development is designed and managed, as well as substantial increases of public and private investments in urban infrastructure and services.'
Inequality	'Income inequality within and among many countries has been rising and has reached an extremely high level, invoking the spectre of heightened tension and social conflict.'
Energy	'Energy needs are likely to remain unmet for hundreds of millions of households, unless significant progress in ensuring access to modern energy services is achieved.'

paper, we define 'sustainable development' as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Brundtland, 1987).

The agreement of the UN Sustainable Development Goals (SDGs) in 2015 (UN, 2015) reflects a growing consensus that development patterns will need to change, as business as usual will not suffice (Spangenberg, 2017, p.1). The SDGs, together with the Sendai Framework for Disaster Risk Reduction (SFDRR), COP21 Paris Climate Change Agreement (Paris Agreement), and New Urban Agenda will be at the forefront of policy discourse until at least 2030. These frameworks are relevant to all contexts, including small island developing states, least developed and landlocked nations, and middle- and high-income nations. Addressing environmental challenges (Omisore, 2018) and advances in, and applications of, Earth and environmental science are central to the SDGs and other thematic frameworks (e.g., Lubchenco et al., 2015; Aitsi-Selmi et al., 2016; Gill, 2017; Gill and Bullough, 2017). Each framework relates to the interaction of anthropogenic activities with the natural environment, with 'planet' being a central pillar of sustainable development alongside people and prosperity.

Significant development trends, relevant to many parts of the world, include both a distinct theme of 'environmental stress', and other challenges with an environmental component (UNDESA, 2013; UNEP, 2015; AfDB et al., 2016). Table 1 includes six trends identified by UNDESA (2013), environmental stress (change, shocks, degradation), hunger and malnourishment, rapid urbanisation and sustainable cities, inequality, energy, and the financial system. These trends are underpinned by a need for strengthened policy formation and delivery, ensuring the best available science supports policy (UNEP, 2015). The perceptions of Earth and environmental scientists are therefore important to exploring sustainable development priorities and challenges, together with developing the research and innovation to address these.

We begin this paper by outlining the scope, structure, and activities of three participatory workshops in Kenya, Zambia and Tanzania (Section 2). We present (Section 3) and discuss (Section 4) the results of these workshops, synthesising expressed development priorities, specific development challenges, and the perceived role of Earth and environmental science in tackling these priorities. We also contrast these results with information from regional and national development strategies to identify how Earth and environmental scientists can maximise their impact. While specifically profiling and analysing sustainable development priorities in eastern Africa, we suggest that replicating our approach in other settings (both Global North and Global South), and comparing these, would prove insightful.

## 2. Overview of participatory workshops

In 2017, we coordinated three two-day workshops in eastern Africa to explore sustainable development priorities and the role of Earth and environmental science in addressing these. In this section, we outline the scope and purpose of these workshops, setting out how they fit into a wider *science-for-development* strategy (Section 2.1), the diversity of workshop participants (Section 2.2), the workshop structure and activities used (Section 2.3), and briefly note limitations associated with our approach (Section 2.4).

### 2.1. Workshop scope and purpose

Critical to developing effective science-for-development is increased dialogue to understand development priorities and information needs. Capacity building needs should not be based on assumptions made from a distance (Hewitson, 2015) about community needs (e.g., a village, a geological survey, a research community, policy makers). Science-for-development programmes have greater impact if they are truly collaborative, involving meaningful consultation with all relevant groups, working together as equal partners (Gill, 2017). Engaging diverse stakeholders from the start of the research process helps to ensure clarity regarding the problem and data needs, and increases the likelihood of useful knowledge being co-produced (Weichselgartner and Kasperson, 2010).

As part of the UK Government's commitment to international development, the British Geological Survey (BGS) is developing new collaborations to co-design and deliver a science-for-development programme that supports the implementation of the SDGs. The long-term ambition of this work and these partnerships is to develop research and capacity building that enables partners in countries receiving Official Development Assistance (ODA) to strengthen resilience to environmental change and shocks and use their natural resources to maximum benefit in an environmentally acceptable manner. Building on other initiatives to enhance African Earth and environmental science (e.g., [Martinez-Frias and Mogessie, 2012](#); [Scholes et al., 2013](#); [Jessell et al., 2017](#); [UNESCO, 2017](#)), this work aims to build scientific collaborations, foster networks of scientists across the Global South, and support capacity building through focused training and research interactions.

In this context, BGS organised three workshops in eastern Africa to explore sustainable development priorities and the role of Earth and environmental science. Workshops were held in Nairobi (Kenya), Lusaka (Zambia), and Dar es Salaam (Tanzania), and there objectives were:

1. **Stakeholder Mapping:** Better understand existing stakeholder networks, responsibilities, and research interests and capabilities.
2. **Needs Assessment:** Determine development priorities in eastern Africa at a range of scales (i.e., from broad overview development goals to specific challenges associated with these), and consider the Earth and environmental science research and innovation required to inform solutions. Include diverse science and sectoral perspectives (e.g., academia, think tanks, NGOs, government).
3. **Partnership Building.** Facilitate respectful dialogue between BGS and potential in-country partners, and enhance professional relationships during the workshop. Build trust and respect through delivering a workshop centred on meaningful engagement and listening.

We outline the activities used to achieve these objectives in [Section 2.3](#).

## 2.2. Workshop participants

We recruited workshop participants through an open application procedure. Existing contacts in Kenya, Tanzania and Zambia were invited, who also promoted the workshop to their wider networks. We identified additional organisations using online profiles, and invited appropriate representatives to participate. The three workshops gathered 76 participants from 48 organisations, as outlined below:

- **Nairobi, Kenya:** 28–29 March 2017, 33 participants from 22 organisations. Following this workshop, we made some changes to the tasks in the next two workshops to enrich the data collected.
- **Lusaka, Zambia:** 14–15 September 2017, 26 participants from 14 organisations. This workshop included two representatives from Malawi, and two representatives from Zimbabwe.
- **Dar es Salaam, Tanzania:** 18–19 September 2017, 17 participants from 12 organisations.

All three workshops included international participants, participants working for international organisations, and participants with research interests extending beyond the workshop host-country. They also included both male and female, and senior and early-career participants. Diverse sectors were represented ([Fig. 1](#)), with most participants from academia and the public sector, and others from the private sector, civil society, and intergovernmental organisations. While all participants were interested in the environmental component of sustainable development, they came from disciplinary backgrounds ranging from agriculture, hydrology, geology, economics and social science.

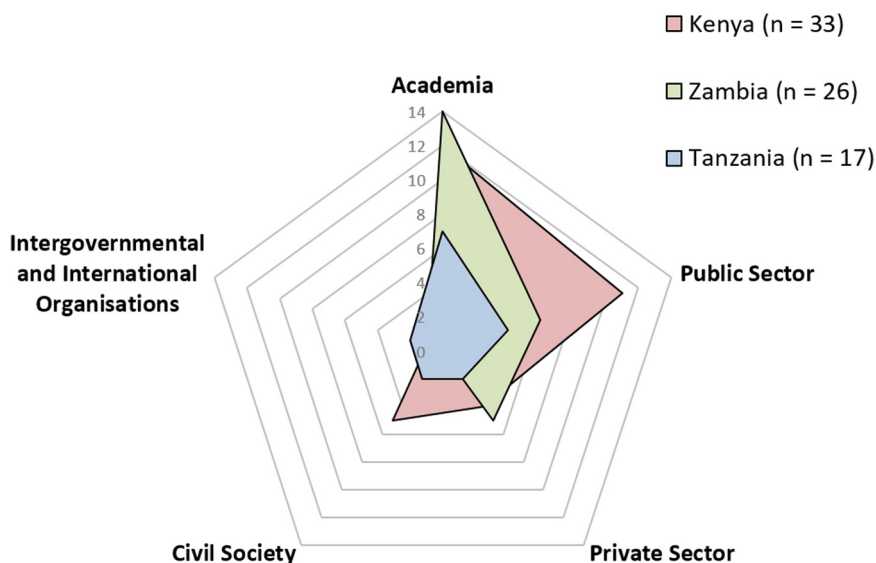
## 2.3. Workshop structure and activities

Each workshop lasted for two days, and was conducted in a hotel conference centre. We selected neutral, comfortable and convenient venues for participants. Workshops were in English, facilitated by the BGS (to develop positive rapport), and used interactive and participatory approaches. We engaged participants through six tasks (of which four are relevant to this paper), including both independent and small group tasks.

**Task 1. Stakeholder mapping exercises** (*group exercise, not discussed further in this paper*). Groups discussed and mapped the spatial and thematic range of their activities, with areas of mutual interest identified. In Zambia and Tanzania, groups created network diagrams to explore existing collaborations, and examined these in the context of different pathways to development impact.

**Task 2. Individual prioritisation of the SDGs** (*individual exercise*). Using a blank matrix, participants identified four SDGs that they consider to be of highest importance (a) in an eastern African context, and (b) in their own national context (e.g., Kenyan, Tanzanian, Zambian). This task was anonymous to enable participants to express their perceived priorities without being influenced by others.

**Task 3. Group prioritisation of the SDGs** (*group exercise*). (a) Mixed-sector groups discussed and came to a consensus on the four SDGs that they believed to be of greatest importance in eastern Africa. Group discussions were prolonged and dynamic, with groups critically examining why they (and others) considered key SDGs more relevant and important than others did. Following



**Fig. 1.** Workshop participants by sector. Representation of the workshop participants in Kenya (red shading), Zambia (green shading) and Tanzania (blue shading) according to their primary sector. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

discussions, each group had 10 voting stickers to allocate to their four priority SDGs. Groups could allocate their 10 votes in any proportion, to best suit their conclusions (e.g., 4-4-1-1 or 4-3-2-1 or 3-3-2-2 or 4-2-2-2 were all allowed). (b) Groups and individuals also added notes on specific challenges in eastern Africa associated with priority SDGs.

**Task 4. Characterising the role of Earth and environmental science in addressing SDGs (individual exercise).** (a) Participants reflected on which of the 17 SDGs would most benefit from greater understanding of Earth and environmental science. Each workshop included short talks to set context, and ensure common understanding of 'Earth and environmental science' by participants with diverse backgrounds. Each individual participant had four voting stickers to place on the 17 SDG posters that they considered to have a high requirement for Earth and environmental science research. (b) In Zambia and Tanzania, participants added notes on specific ways in which Earth and environmental science can support the delivery of the SDGs.

**Task 5. Draft projects to support the SDGs (group exercise).** The results of *Tasks 2 to 4* were used by workshop participants to propose three thematic working groups. This was done by asking participants to review the priorities emerging from *Tasks 2 to 4*, propose three possible working group themes, and to come to a consensus on the final three. We facilitated this discussion, but the final themes chosen were a reflection of the participant's priorities. Individuals then selected which group to join. These working groups discussed and prioritised specific challenges, and developed example projects aiming to address high-priority challenges. The workshop in Kenya (March 2017) used a flexible approach, with projects developed alongside broader discussion of context. Following a review of the first workshop, in Zambia and Tanzania (September 2017) we used a modified theory of change approach (outlined in Gill and Mankelov, 2017a) to provide better structure for the group discussions. Groups considered the steps required to bring about change, before determining the research, capacity building or innovation required.

**Task 6. Effective partnerships (individual exercise, not discussed further in this paper).** Participants completed a questionnaire that documented previous experiences of *science-for-development* partnerships, and the characteristics of positive partnerships.

These exercises enabled us to listen to and collate the perspectives and ideas of workshop participants. In this paper, we present and analyse the results of **Tasks 2 to 5** (Sections 3 and 4).

#### 2.4. Workshop limitations

While our workshop methodology generated data to address our objectives (set out in Section 2.1), it also had limitations. The results we present are a *function of the sectors, disciplines, personal expertise, and experience of individuals attending the workshop*. Across the three workshops, a high diversity of sectors (Fig. 1) and disciplines were present, however some key groups were still under-represented. For example, in Kenya there was good representation from many Earth science sub-disciplines (e.g., water, energy, minerals, agriculture), but less representation from the social and economic sciences. In Zambia, there was good representation from agricultural science, but less from mineral resource disciplines. In Tanzania, there was good representation from early-career geoscientists, but less from senior geoscientists. It is also likely that development priorities reflect participants' interests and expertise.

The workshop also crossed *language and cultural barriers*. Recognising cultural differences and similarities has implications on how to manage workshop contexts to ensure that they are fruitful (Schneider and Barsoux, 2003). The workshop coordinating group and

participants may have different perspectives, value systems, customs and social behaviours affecting their interpretation of workshop tasks, and the subsequent data collected. Factors such as *race, nationality, age, gender, social and economic status, and prior personal and professional experiences* can influence our position in social and cultural structures, which in turn influences the way we run workshops and interpret their results (Madge, 1993; Sultana, 2007; Fisher, 2015).

*Power dynamics* may also affect the information offered by participants. During the workshops, there was the potential for an unequal power dynamic to exist between the coordinating group and participants, with this influencing the results (Qu and Dumay, 2011). Variation in age, gender, educational level, ethnicity and socio-economic status have the potential to create such a dynamic, and influence the workshop process and results (e.g., Valentine, 1997; Kitchin and Tate, 2000; Qu and Dumay, 2011). This dynamic can be minimised by ensuring there is genuine rapport, respect and trust (Kitchin and Tate, 2000; DiCicco-Bloom and Crabtree, 2006), together with a respect of cultural differences. Power dynamics between participants was also possible, with both senior and early-career professionals attending. In all three workshops, we observed open and positive dialogue between participants, with traditionally underrepresented and early-career groups challenging other perspectives offered. Nevertheless, *peer influence* may have affected the workshop results. While a controlled environment was encouraged during some activities, it was difficult to prevent exchange of ideas and opinions during individual tasks. Finally, participants had a *limited amount of time* to complete the workshop activities, meaning it is possible that the results will not represent their complete understanding, or express their best level of thoughtful judgement.

Our workshops were interactive, and created a safe place for the exchange of ideas. Participant feedback was overwhelmingly positive (see Gill et al., 2017; Gill and Mankelow, 2017a; Gill and Mankelow, 2017b), with participants enjoying the dynamic and interactive nature of the workshop. Workshop feedback indicated that we had built the trust needed for effective dialogue, helping to minimise the likelihood of some of these limitations affecting the workshop results. We encourage reflection on these limitations, however, when viewing our results and the discussion (), and in the design of similar events.

### 3. Workshop results

Results from our three workshops were originally documented in three open reports (Gill et al., 2017; Gill and Mankelow, 2017a, 2017b). Here we integrate these results, and synthesise information from across the three workshops. We first describe participants' perspectives on development priorities and specific challenges in both regional (eastern Africa) and national contexts (Section 3.1). We then describe perspectives on the role of Earth and environmental science (Section 3.2), and conclude with specific research, training and innovation projects to connect this science to expressed development priorities (Section 3.3).

#### 3.1. Development priorities

##### 3.1.1. Eastern Africa (Regional)

Individuals first expressed their personal perspectives on regional development priorities, selecting the SDGs that they consider

UN Sustainable Development Goal	Individual Perspectives on Development Priorities in Eastern Africa																				
	Kenya Workshop (n=22)					Zambia Workshop (n=19)					Tanzania Workshop (n=15)					Total (n=56)					
	1st	2nd	3rd	4th	Weighted Total*	1st	2nd	3rd	4th	Weighted Total*	1st	2nd	3rd	4th	Weighted Total*	1st	2nd	3rd	4th	Weighted Total*	
1. No Poverty	4			1	5	23	2		1	2	12	2	3	1		19	8	3	3	7	54
2. Zero Hunger	5	2	1	2		30	4	6	3	1	41	2	2	2		18	11	10	6	3	89
3. Good Health and Well-Being	2	3	2			21	1	1		3	10	1		1	1	7	4	4	3	4	38
4. Quality Education	1	5	2	3		26	2	3	2		21	2	2	1	1	17	5	10	5	4	64
5. Gender Equality		3	1			11	1			1	5				1	1	1	3	1	2	17
6. Clean Water and Sanitation	4		2	3		23	2	3	3		15	2		2	1	13	6	2	7	7	51
7. Affordable and Clean Energy	1	1				7			1		2			1	1	3	1	1	2	1	12
8. Decent Work and Economic Growth	1	1	2	1		12		1	2	2	9		1	2		7	1	3	6	3	28
9. Industry, Innovation and Infrastructure		2	1	1		9		2	2		10	1		1	1	7	1	4	4	2	26
10. Reduced Inequalities		1	2	1		8			1	2	4				1	1	0	1	3	4	13
11. Sustainable Cities and Communities			1	1			1	1	1				1	1		1	2	3	1		17
12. Responsible Consumption and Production				1		1					0	1	1	2		7	0	1	1	3	8
13. Climate Action		1	1			5	2	1	1		13	1	1			5	2	3	3	0	23
14. Life Below Water			1										1			0	1	1	0		5
15. Life on Land		1	2	2		9			1		2	2		1	2	12	2	1	4	4	23
16. Peace, Justice, and Strong Institutions	1	2	1	1		13	4	2	1	2	26		3	2		11	5	7	2	5	50
17. Partnerships for the Goals	3		2			16	2		3		11	3		2		14	8	0	2	5	41

\* Weighted Total = 4[n<sub>1st</sub>]+3[n<sub>2nd</sub>]+2[n<sub>3rd</sub>]+1[n<sub>4th</sub>]

**Fig. 2.** Individual prioritisation of the SDGs in eastern Africa. Participants selected the SDGs that they consider the first, second, third and fourth priority in the context of the eastern Africa region. (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.)

1st, 2nd, 3rd and 4th in terms of priority in eastern Africa (*Task 2a*, outlined in [Section 2.3](#)). [Fig. 2](#) shows the results of this exercise, synthesising information from the three workshops. The 17 SDGs are listed in the first column, and results from **Kenya** (n = 22, red shading), **Zambia** (n = 19, green shading) and **Tanzania** (n = 15, blue shading) in the proceeding columns.

Numbers in the sub-columns labelled 1st, 2nd, 3rd and 4th relate to the number of participants at each workshop that identified the SDG to be a priority. The sub-column labelled ‘*Weighted Total*’ sums the number of participants in each sub-column, applying a weighting depending on whether participants selected it as their 1st, 2nd, 3rd or 4th choice. The formula used for this weighting is expressed in Eq. (1).

$$\text{Weighted Total} = 4[n_{1st}] + 3[n_{2nd}] + 2[n_{3rd}] + 1[n_{4th}] \quad (1)$$

The cumulative of these three workshops is shown in the final column (n = 56, orange shading), including both the number of votes and a weighted total. The results in [Fig. 2](#) help to identify the top five development priorities across eastern Africa, as expressed by our participants.

- **Zero Hunger** (SDG 2) ranked #1 at the Kenya workshop, #1 at the Zambia workshop and #2 at the Tanzania workshop, with an overall Weighted Total (WT) of 89, ranking #1.
- **Quality Education** (SDG 4) ranked #2 at the Kenya workshop, #3 at the Zambia workshop, and #3 at the Tanzania workshop, with an overall Weighted Total (WT) of 64, ranking #2.
- **No Poverty** (SDG 1) ranked #3 (*jointly with SDG 6*) at the Kenya workshop, #6 at the Zambia workshop, and #1 at the Tanzania workshop, with an overall Weighted Total (WT) of 54, ranking #3.
- **Clean Water and Sanitation** (SDG 6) ranked #3 (*jointly with SDG 1*) at the Kenya workshop, #4 at the Zambia workshop, and #5 at the Tanzania workshop, with an overall Weighted Total (WT) of 51, ranking #4.
- **Peace, Justice and Strong Institutions** (SDG 16) ranked #7 at the Kenya workshop, #2 at the Zambia workshop, and #7 at the Tanzania workshop, with an overall Weighted Total (WT) of 50, ranking #5.

Interactions/interdependencies exist between these priorities. For example, sufficient and good quality food, water, and education are fundamental components of ensuring that there is no poverty. This is underpinned by peace and access to justice, supported by strong institutions and effective governance at all levels.

*Participants also* explored sustainable development priorities in eastern Africa in mixed sector groups (*Task 3a*, outlined in [Section 2.3](#)), discussing and forming a consensus on the four SDGs that they believe to be most important, and allocating votes to reflect this consensus. Mixed sector groups helped to ensure that identified priorities reflected research, policy and practice perspectives. [Fig. 3](#) shows the results of this exercise. It includes the 17 SDGs, the percentage of the total votes cast that each SDG received at each workshop, and an overall ranking. We calculated the latter by adding the three percentages received at each workshop, and ranking these from highest to lowest.

The results in [Fig. 3](#) identify the top five development priorities determined by group consensus to be **Quality Education** (SDG 4), **Clean Water and Sanitation** (SDG 6), **No Poverty** (SDG 1), **Life on Land** (SDG 15) and **Good Health and Well-Being** (SDG 3). While we asked participants to consider the wider eastern Africa region when discussing and identifying priorities, it is feasible that their focus was on their own national context. We discuss these results further in [Section 4](#).

### 3.1.2. National contexts

Individuals proceeded to express their personal perspectives on national development priorities (in contrast to regional priorities), selecting the SDGs that they consider to be 1st, 2nd, 3rd and 4th in terms of priority in their respective national contexts (*Task 2b*, outlined in [Section 2.3](#)). [Fig. 4](#) shows the results of this exercise for Kenya, Zambia, and Tanzania, using the same format as [Fig. 2](#). We again note the 17 SDGs in the first column, and results from workshops in **Kenya** (n = 24, red shading), **Zambia** (n = 19, green shading) and **Tanzania** (n = 15, blue shading) in the proceeding columns. The Zambian workshop included 15 participants from Zambia, and 2 participants from each of Zimbabwe and Malawi. While contributions from Zimbabwe and Malawi are included for reference, we note the very small number of participants consulted and subsequent difficulty in drawing conclusions from this sample size.

Workshop participants identified the following to be national development priorities (from [Fig. 4](#)).

- **Kenya:** Zero Hunger (SDG 2), Clean Water and Sanitation (SDG 6), No Poverty (SDG 1), and Quality Education (SDG 4), and Good Health (SDG 3), with a weighted total of 47, 35, 34, 26 and 21 respectively.
- **Zambia:** Zero Hunger (SDG 2), No Poverty (SDG 1), Quality Education (SDG 4), Clean Water and Sanitation (SDG 6), and Climate Action (SDG 13), with a weighted total of 31, 20, 15, 14 and 14 respectively.
- **Tanzania:** Quality Education (SDG 4), Clean Water and Sanitation (SDG 6), Zero Hunger (SDG 2), No Poverty (SDG 1), and Good Health (SDG 3), with a weighted total of 24, 22, 19, 16 and 16 respectively.

All three countries selected **No Poverty** (SDG 1), **Zero Hunger** (SDG 2), **Quality Education** (SDG 4), and **Clean Water and Sanitation** (SDG 6), aligning with the perspectives on regional priorities in [Section 3.1.1](#).

### 3.1.3. Specific challenges

Individuals and groups were invited to add notes on specific challenges in eastern Africa to 17 posters, one for each SDG (*Task 3b*,

UN Sustainable Development Goal	Percentage of the total votes cast at each workshop (Red = Kenya, Green = Zambia, Blue = Tanzania)	Total ( $\Sigma\%_{0-3}$ )	Rank
1. No Poverty	16 18 07	41	3
2. Zero Hunger	12 10 00	22	6
3. Good Health & Well-Being	12 10 07	29	5
4. Quality Education	12 25 30	67	1
5. Gender Equality	00 05 07	12	8
6. Clean Water & Sanitation	26 13 03	42	2
7. Affordable & Clean Energy	00 00 00	00	=16
8. Decent Work and Economic Growth	00 08 00	08	9
9. Industry, Innovation & Infrastructure	04 05 10	19	7
10. Reduced Inequalities	00 00 07	07	=10
11. Sustainable Cities & Communities	00 05 00	05	13
12. Responsible Consumption & Production	00 00 00	00	=16
13. Climate Action	04 03 00	07	=10
14. Life Below Water	00 00 03	03	14
15. Life on Land	06 00 27	33	4
16. Peace, Justice, & Strong Institutions	06 00 00	06.0	12
17. Partnerships for the Goals	02 00 00	02.0	15

**Fig. 3.** Group prioritisation of the SDGs. Group identification of development priorities at three workshops in eastern Africa, expressed as a percentage of the total votes cast by groups. Shading represents different workshops Kenya (red, top bar), Zambia (green, middle bar) and Tanzania (blue, bottom bar). The total for each colour, across all 17 SDGs totals approximately 100% (with any variation from 100% being a result of rounding). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

outlined in Section 2.3). Participants could add notes to any of the SDGs, but they were encouraged to prioritise those with a high ranking after group discussions (Fig. 3). All contributions to these posters are tabulated in Appendix A (Table A1). We synthesise this information in Table 2 to identify six common themes that cut across multiple goals and workshops. These include both distinct topics such as ‘water’ and ‘climate’, and crosscutting processes such as a lack of ‘training’ or ‘regulation’. This information is a function of the expertise of participants attending the workshops. While a different set of challenges may emerge if the workshop participants were primarily from social science and economics backgrounds, this does not change the validity of the information expressed. The natural environment is central to sustainable development and the implementation of the SDGs. The perceptions of Earth and environmental scientists as to specific development challenges are therefore important to consider.

### 3.2. Earth and environmental science

Participants individually reflected on and voted for the SDGs where they perceive that Earth and environmental science can make the greatest contribution to development impact in eastern Africa (Task 4a, outlined in Section 2.3). Each workshop participant had four votes. Fig. 5 shows the results of this exercise, including the 17 SDGs, the percentage of the total votes cast that each SDG received at each workshop, and an overall ranking. We calculated the latter by adding the three percentages received at each workshop, and ranking these from highest to lowest. The results in Fig. 5 identify the SDGs where participants perceived Earth and environmental science to make the greatest contribution to development impact in eastern Africa to be **Clean Water and Sanitation** (SDG 6), **Climate Action** (SDG 13), **Life on Land** (SDG 15), **Zero Hunger** (SDG 4), and **Industry, Innovation and Infrastructure**

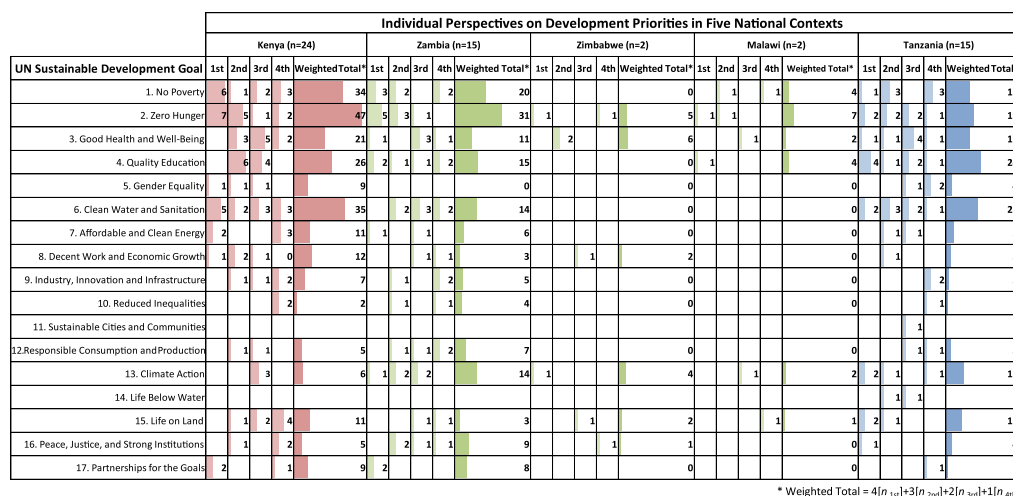


Fig. 4. Individual prioritisation of the SDGs in five national contexts. Participants were asked to select the SDGs that they consider the first, second, third and fourth priority in the context of their national context. Zimbabwe and Malawi are included for reference, but we note the very small number of participants consulted. (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.)

Table 2

Common themes emerging from a discussion of development challenges in eastern Africa. Six themes that cut across multiple SDGs are presents, with examples of specific challenges identified by workshop participants.

Theme	Sub-Themes	Associated SDGs	Examples
Climate	Climate Change, Climate Variability Climate Shocks	No Poverty (1), Zero Hunger (2), Clean Water and Sanitation (6), Climate Action (13), Life on Land (15).	Changes in planting and harvesting seasons, appropriateness of crops, crop yields, resilience of agriculture to variability and shocks, resilience of water supplies, communities lacking awareness of climate change and its impacts.
Water	Floods, Droughts, Irrigation	No Poverty (1), Zero Hunger (2), Good Health and Wellbeing (3), Quality Education (4), Clean Water and Sanitation (6), Decent Work and Economic Growth (8), Industry, Innovation and Infrastructure (9), Life Below Water (14), Life on Land (15)	Rainfall dependence and limited use of irrigation technologies threaten food security. Water quality as well as quantity was emphasised, with links to health and ecosystem services.
Infrastructure	N/A	Zero Hunger (2), Good Health and Wellbeing (3), Quality Education (4), Clean Water and Sanitation (6), Industry, Innovation and Infrastructure (9).	Physical infrastructure needs includes health centres and well-equipped schools (including basic services, such as toilets). Network infrastructure is needed for food security, water supply, and transportation.
Environmental Degradation	Degradation, Pollution, Contamination	Zero Hunger (2), Good Health and Wellbeing (3), Clean Water and Sanitation (6), Climate Action (13), Life on Land (15).	Degradation and pollution of land, soil, water and air, resulting from poor farming practices, industry, economic growth, poor catchment management, mining, poor sanitation infrastructure, and urban development. Lack of regulation or lack of effective application of existing regulation was associated with degradation.
Education	Knowledge, Education, Training, Skills	No Poverty (1), Good Health and Wellbeing (3), Quality Education (4), Gender Equality (5), Clean Water and Sanitation (6), Affordable and Clean Energy (7), and Industry, Innovation and Infrastructure (9), Sustainable Cities and Communities (11), and Life Below Water (14).	Improvements in the quality of education and training were emphasised, and education at multiple scales. For example, public health education (nutrition, hygiene) as well as formal schooling. Teacher training, vocational education, and supporting female students.
Legal	Policy, Laws and Regulation, Governance	No Poverty (SDG 1), Good Health and Wellbeing (SDG 3), Quality Education (SDG 4), Gender Equality (SDG 5), Clean Water and Sanitation (SDG 6), Decent Work and Economic Growth (SDG 8), Reduced Inequalities (SDG 10), Life on Land (SDG 15), Peace, Justice, and Strong Institutions (SDG 16), and Partnerships (SDG 17).	Enhanced regulation can strengthen most basic services, with targeted changes to enhance female inclusion. Natural resource governance can be strengthened, with a lack of regulation or effective application of existing regulation resulting in degradation and pollution.



UN Sustainable Development Goal	Percentage of the total votes cast at each workshop (Red = Kenya, Green = Zambia, Blue = Tanzania)	Total ( $\Sigma\%_{1-3}$ )	Rank
1. No Poverty	06 04 02	12	=9
2. Zero Hunger	10 11 05	26	4
3. Good Health & Well-Being	02 10 00	12	=9
4. Quality Education	02 04 07	13	8
5. Gender Equality	02 00 03	05	14
6. Clean Water & Sanitation	20 13 22	55	1
7. Affordable & Clean Energy	10 10 00	20	6
8. Decent Work and Economic Growth	01 00 02	03	16
9. Industry, Innovation & Infrastructure	04 09 10	23	5
10. Reduced Inequalities	00 00 00	00	17
11. Sustainable Cities & Communities	05 06 07	18	7
12. Responsible Consumption & Production	02 05 00	07	13
13. Climate Action	15 15 14	44	2
14. Life Below Water	03 00 07	10	11
15. Life on Land	11 10 20	41	3
16. Peace, Justice, & Strong Institutions	04 00 00	04	15
17. Partnerships for the Goals	02 04 02	08	12

**Fig. 5.** Earth and environmental science and the SDGs in eastern Africa. Individual perspectives on how Earth and environmental science can have the greatest development impact in eastern Africa, expressed as a percentage of total votes cast by participants. Shading represents different workshops Kenya (red, top bar), Zambia (green, middle bar) and Tanzania (blue, bottom bar). The total for each colour, across all 17 SDGs totals approximately 100% (with any variation from 100% being a result of rounding). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

(SDG 9). That these results differ from those in Fig. 3 suggests that the development priorities expressed by participants (Section 3.1) do not merely reflect topics that they are professionally interested in. This was a concern expressed in the limitations (Section 2.4) and so it is positive to note this difference.

During the workshops in Zambia and Tanzania, individuals and groups identified specific ways in which Earth and environmental science can support the implementation of the 17 SDGs (Task 4b, outlined in Section 2.3). Table A2 outlines these contributions in full, with key themes being:

- **Research:** Many proposed topics for additional research linked to the poverty-food-health nexus, ensuring food security and good nutrition. For example, participants specifically discussed research into natural fertilisers, micronutrient deficiencies, soil mapping, efficient irrigation, crops in water stressed environments, smart agriculture, and resource resilience in the context of climate change.
- **Education and Training:** In the context of SDG 4 (Quality Education), participants identified a clear role for Earth and environmental science education to increase understanding of Earth system sciences (with specific examples relating to water, climate change, and natural hazards). Environmental understanding was noted in the context of public understanding, tertiary

**Table 3**

Thematic Working Groups. Working group themes (labelled A–C), and high priority challenges expressed as project objectives (labelled i–iv).

Theme	Projects
<b>Kenya</b>	(A) Food-Water-Energy Nexus <ol style="list-style-type: none"> <li>i. Improve access to clean water.</li> <li>ii. Improve access to cheap and clean energy.</li> <li>iii. Improve crop productivity, lakes and rivers, and animal husbandry.</li> </ol>
	(B) Water & Sanitation <ol style="list-style-type: none"> <li>i. Improve understanding of water availability.</li> <li>ii. Improve access to data, to constrain data gaps.</li> <li>iii. Strengthen water policy, governance and management.</li> <li>iv. Improve partnerships, training and knowledge exchange.</li> </ol>
	(C) Natural Resources (Minerals) <ol style="list-style-type: none"> <li>i. Collect and integrate data to characterise the Mombasa to Kisumu corridor.</li> <li>ii. Review artisanal and small-scale mining in Kenya.</li> </ol>
<b>Zambia</b>	(A) Food Security & Nutrition <ol style="list-style-type: none"> <li>i. Reduce micronutrient deficiencies.</li> <li>ii. Improve baseline data, access to data, and training/development.</li> </ol>
	(B) Water & Sanitation <ol style="list-style-type: none"> <li>i. Reduce water pollution from geological pollutants and anthropogenic activity.</li> <li>ii. Improve regulation and management of water resources.</li> </ol>
	(C) Energy & Climate <ol style="list-style-type: none"> <li>i. Improve access to clean and appropriate energy.</li> <li>ii. Enhance awareness among all stakeholders of climate change and its impacts.</li> </ol>
<b>Tanzania</b>	(A) Climate-Smart Agriculture, Food Security, & Nutrition <ol style="list-style-type: none"> <li>i. Enhance socio-economic management of agricultural products.</li> <li>ii. Improve land and soil resource quality.</li> <li>iii. Improve awareness of climate-adaptation.</li> </ol>
	(B) Water & Sanitation <ol style="list-style-type: none"> <li>i. Optimise wastewater treatment and reuse.</li> <li>ii. Reduce exposure to fluoride.</li> <li>iii. Improve data awareness and availability.</li> </ol>
	(C) Sustainable Land & Water Management <ol style="list-style-type: none"> <li>i. Reduce land degradation.</li> <li>ii. Improve the integration of policy interventions.</li> <li>iii. Implement and strengthen strategic environmental assessment/spatial planning.</li> <li>iv. Enhance the use of Geo-ICT (e.g., new technologies/data management).</li> </ol>

education, and specific industries. For example, improving safety in the extractive sectors through workshops and training.

- **Innovation and Technologies:** Participants highlighted the need for science to drive innovation, and inform the development of tools and technologies. Environmental technologies are solutions (in part) to environmental degradation, climate change, mineral extraction, and improving crop yields.
- **Environmental Monitoring and Management:** Participants emphasised environmental monitoring (e.g., groundwater, nutrient flows, and industrial activity), and data collection and management. Monitoring data, together with environmental expertise, could inform policy and strengthen environmental management. Participants discussed strengthening water and land management, and the creation of policies to support environmental sustainability.

### 3.3. Earth and environmental science research, training and innovation projects

Each workshop included thematic working groups to discuss high priority challenges and propose Earth and environmental science activities to help address these (*Task 5*). The group themes were a function of (i) the results of earlier exercises (*Tasks 2 to 4*), and (ii) the expertise of participants attending the workshops. [Table 3](#) shows the group themes at each workshop (labelled A–C), and the high priority challenges identified by the groups and expressed as project objectives (labelled i–iv).

From [Table 3](#) we identify common SDG themes to be **Zero Hunger** (SDG 2) and **Clean Water and Sanitation** (SDG 6), with secondary themes being **Affordable and Clean Energy** (SDG 7), **Climate Action** (SDG 13), and **Life on Land** (SDG 15), reflecting the results of earlier tasks. Specific projects ranged from reducing land degradation ([Table 3](#), Tanzania C-i) and water pollution ([Table 3](#), Zambia B-i), to reducing micronutrient deficiencies ([Table 3](#), Zambia A-i) and reviewing the extent and practices involved in artisanal and small-scale mining to understand supply chains and determine strategies to improve health and safety ([Table 3](#), Kenya C-ii).

While these research, training and innovation projects are location-specific, and a function of those present, we can identify several crosscutting themes that indicate how Earth and environmental scientists can help sustainable development.

- **Environmental Data Collection, Management, Integration, and Access.** Projects in Kenya, Zambia and Tanzania converged on a common problem of limited collection, management and integration of environmental data, and a lack of access to existing environmental data. In this context, environmental data refers to all types of data that help to characterise the natural environment, including how anthropogenic activities (e.g., agriculture, urbanisation) affect the natural environment. This includes field-based data collection, secondary data derived from the analysis of maps and existing datasets, and terrestrial and satellite based instrumental records and Earth observation data. Participants also noted challenges to accessing data arising from different agencies holding different datasets relating to a key theme. Existing data may be in analogue form, rather than digital form also hindering access to the data. If in digital form, data is often not backed up or on a secure server. These challenges hinder the

identification of data gaps, and the ability to conduct complex analyses that rely on access to multiple datasets. Improving the management, integration, and access to data (e.g., through open, online data portals) could help to advance diverse issues, such as reducing micronutrient deficiencies and land degradation, or improving water resource or mining regulation. For example, understanding micronutrient deficiencies requires baseline data on climate, soil, livestock, plant and crop types, population, and health data. By collating and integrating this data within one data portal, it would be easier to identify data gaps and explore spatial relationships between soil chemistry, plant types, and health challenges. This information could then help to improve the targeting of interventions.

- **Resource Degradation, Pollution and Environmental Protection.** Projects in Zambia and Tanzania identified environmental degradation as a priority, considering both land and water resources. Pollution could be from geological pollutants (e.g., fluoride) or anthropogenic activity (e.g., mining, agriculture), with both needing consideration. Discussions across national and thematic contexts converged on projects that first strengthened understanding of the resource degradation (e.g., collecting and analysing Earth and environmental science data) and then proceeded to improve regulations, integration of policy interventions, strengthen spatial planning, or strengthen governance procedures.
- **Training and Knowledge Exchange.** Projects in Kenya, Zambia and Tanzania identified opportunities for enhanced training and knowledge exchange. **Quality Education** (SDG 4) was repeatedly emphasised as a development priority in the results of *Tasks 2* and *3*. Although Earth and environmental scientists cannot deliver on all aspects of SDG 4, there are ways in which they can support some of the targets (outlined in full in [United Nations, 2015](#)), such as Target 4.3 (“ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university”) and Target 4.7 (“ensure that all learners acquire the knowledge and skills needed to promote sustainable development”). Groups highlighted the need to improve training of both scientists (e.g., [Table 3](#), Kenya B-iv) and communities (e.g., [Table 3](#), Zambia C-ii).

These themes mirror some of the common development challenges noted in [Section 3.1.3](#). Data access, management and integration, together with training and knowledge exchange, are important to strengthening policy, regulations and governance.

#### 4. Discussion

The results in [Section 3](#) provide an insight into sustainable development priorities and potential Earth and environmental science interventions to address such challenges. While the perspectives are limited by the individuals represented ([Section 2.4](#)), they capture an important contribution from a community not commonly represented in discussions regarding sustainable development ([Stewart and Gill, 2017](#)). Engaging with Earth and environmental scientists can provide insights into the actions needed to tackle widely recognised challenges (e.g., land degradation, urbanisation) over the coming years and decades. In this section, we first contrast identified development priorities with wider development strategies ([Section 4.1](#)), before reviewing the extent to which these strategies incorporate key themes raised by participants ([Section 4.2](#)).

##### 4.1. Development priorities and regional strategies

Tanzania, Malawi and Zambia are all in the ‘least developed’ classification of the DAC list of ODA recipients, with Zimbabwe classified as ‘other low income’ and Kenya a Lower Middle Income country ([UN, 2018](#)). Least developed countries are typically characterised by their vulnerability to economic and environmental shocks, and their lack of access to basic services ([Alcantara-Ayala, 2002](#); [Bergstrand et al., 2015](#)). The population and working-age population of East Africa will more than double by 2050 ([AfDB et al., 2016](#)), with most growth concentrated in urban areas ([UNDESA, 2013](#)). In the coming decades, global population increase will be geographically concentrated, with eight countries (including Tanzania) accounting for half of the projected increase ([UNDESA, 2013](#)). [Canning et al. \(2015\)](#) notes that (subject to uncertainties) the population of Tanzania could grow from 45 million people in 2010–200 million in 2060. For this demographic change to drive economic growth there will need to be improvements in training, skills development, employment, food security, and health care ([Canning et al., 2015](#); [AfDB et al., 2016](#)). The rate of progress of human development in many eastern African countries, however, has fallen since 2010 ([AfDB et al., 2016](#)). A renewed focus is needed to sustain and accelerate progress in improving human development to leverage the benefits of a growing population.

Set against this context, it is understandable that immediate basic needs dominate the priorities identified in [Section 3.1](#). Participants prioritised tackling **poverty** (SDG 1), **food security** (SDG 2), **health** (SDG 3) **education** (SDG 4), and **clean water and sanitation** (SDG 6) as they underpin broader development objectives of economic growth and employment. Some workshop participants in Zambia invoked Maslow’s hierarchy of needs ([Maslow, 1943](#)) to explain their selection of physiological and safety needs (food, water, health), above needs relating to community and equality (e.g., SDG 10, SDG 11). Participants in Zambia noted that tackling basic needs was foundational and a pre-requisite to progress in other aspects of sustainable development. Participants in Tanzania suggested that interactions between development priorities result in a pressing case to invest in education (SDG 4) to support other development objectives. They asserted that ‘education improves access to jobs, which provides the finance to invest in health’ ([Gill and Mankelov, 2017a](#)). Given the environmental background of participants, it is understandable that participants recognised the links between land ecosystems (SDG 15) and basic needs and inequalities, ranking this 4th of 17 SDGs in [Fig. 3](#).

The priorities expressed by participants (poverty, food, health, education, water and sanitation, life on land) strongly align with

those conveyed in regional and national development strategies. For example, Agenda 2063, a pan-African vision for development, aims to harness the “*creativity, energy and innovation of Africa’s youth*” to ensure modern agriculture (SDG 2), ensure well-educated and skilled citizens (SDG 4), promote “*equitable and sustainable use and management of water resources*” (SDG 6), and protect Africa’s unique natural endowments (SDG 15) (AU, 2015a). The East Africa Community (EAC) Vision 2050, incorporating perspectives from Kenya and Tanzania, seeks to address themes such as skills development (SDG 4), food security (SDG 2) and environmental degradation (SDGs 11, 14, 15 and others) (EAC, 2016). Kenya Vision 2030 also prioritises action on poverty (SDG 1), food security (SDG 2), health (SDG 3), education (SDG 4), and water and sanitation (SDG 6) (Government of Kenya, 2007).

Both the Agenda 2063 and EAC Vision 2050 also emphasise the need to improve urbanisation, economic growth, employment, and infrastructure. These strategies highlight modernised cities and settlements (SDG 11) and improved energy supply (SDG 7) as critical to the region’s future. For example, the EAC vision 2050 projects that urban population across member states will increase from 39% in 2014 to 70% in 2050 (EAC, 2016). The EAC vision 2050 aims to increase energy production to 31 times the megawatt output in 2014, with an 8-fold increase in geothermal energy production (EAC, 2016). Kenya’s Vision 2030 also includes specific reference to urbanisation and energy (Government of Kenya, 2007).

In contrast, workshop participants in Kenya, Tanzania and Zambia ranked sustainable cities and communities (SDG 11) and affordable and clean energy (SDG 7) as very low priorities relative to other SDGs (Fig. 3). This is unlikely to be due to limited buy-in by environmental scientists to these themes, with cities and energy ranked highly in their assessment of where environmental science can support the delivery of the SDGs in eastern Africa (Fig. 5). In the case of cities, this could be due to SDG 11 being perceived to be secondary to access to basic needs. The African Union and East African Community development strategies are looking ahead to 2050–2063 (long term), and the SDGs to 2030 (medium term). With respect to energy, this discrepancy is less clear as energy access (SDG 7) could be considered a basic need. Its low prioritisation suggests there is scope for enhanced communication and outreach regarding its relationship to agriculture, health, education, and economic growth. The phrase ‘*affordable and clean energy*’ may not have resonated with groups struggling with issues such as energy access, efficiency and reliability. The expanded “*ensure access to affordable, reliable, sustainable and modern energy for all*” (United Nations, 2015) may have more universal appeal.

The priority given to urbanisation and energy within existing regional and national strategies also suggests an opportunity for the Earth and environmental science community in eastern Africa to increase their engagement with these themes. Further consideration, for example, could be given to how urban development can help to tackle immediate challenges, such as water and health (Bricker et al., 2015).

#### 4.2. Crosscutting themes and development strategies

In addition to contrasting high-level development priorities, we can also examine the extent to which regional and national development strategies discuss specific themes raised at the workshops. Emerging themes through Section 3 include (i) environmental data (collection, management, integration, and access), (ii) integrated policy and regulation for effective environmental management, (iii) environmental degradation and pollution, and (iv) science education and capacity building. We note that there are interconnections and areas of mutual reinforcement within these listed themes (e.g., lack of scientific data resulting in uninformed policies that fail to prevent environmental degradation). Table 4 examines the extent to which these themes are profiled and discussed in two expressions of a continental development strategy, three different regional strategies, and three national strategies. Each strategy examines a different spatial and temporal extent, resulting in large variation in the level of detail included. Where themes (i) to (iv) are included within the strategy documents, there are also differences in the depth and breadth of the discussion. For example, some strategies focus on land degradation while others include land, water and air quality issues.

The results in Table 4 indicate variation in the extent to which priority themes identified by Earth and environmental scientists are embedded into development strategies. Science education and capacity building, for example, features in all of the strategies in one form or another (e.g., science at secondary schools, public understanding of science, science research and development capacity). The AU Agenda 2063 promotes “*investments in universities, science, technology, research and innovation*” (AU, 2015a, p.15). The SADC strategic development plan highlights “*capacity building, information sharing and awareness creation on problems and perspectives in environmental management*” (SADC, 2005, p.62) and “*programmes to promote public understanding of science and technology through various activities including national and regional science, engineering and technology campaigns*” (SADC, 2005, p.73). The Zambia Vision 2030 articulates a vision for a “*nation in which science, technology and innovations are the driving forces in national development and competes globally by 2030*”, with an emphasis on building and sustaining the “*human resource capacities and capabilities*” required for science (Government of Zambia, 2006, p.30).

Environmental degradation and pollution features in many of the strategies in Table 4, highlighting a range of degradation types. The AU Agenda 2063 implementation plan for 2014–2063 highlights ocean pollution from both land and sea-based sources, land degradation and deforestation, and the need for Africa Quality Standards for air pollution (AU, 2015b). The EAC vision 2050 refers to land degradation and urban pollution, but air and water pollution is not discussed (EAC, 2016). Some of the strategies highlight the causes of degradation, but there is scope for expanded and more specific discussion. The COMESA strategy focuses on industry as a source of pollution (COMESA, 2016) and Zambia’s Vision 2030 highlights deforestation for energy and mining activities as causes of pollution (Government of Zambia, 2006). There is even greater scope for more specific discussion on the approaches needed to tackle

**Table 4**

Extent to which continental, regional and national development strategies profile crosscutting themes. Each strategy included in this table covers a different time extent, with variation in the level of detail included. Where the theme is discussed in full or in part this is indicated using a tick (✓), where the theme is not discussed we use a cross (X). Page numbers give examples of relevant sections of the strategy documents (listed in the references).

	Environmental Data Collection, Management and/or Integration	Policy and Regulation for Environmental Management	Environmental Degradation and Pollution	Science Capacity and Education (at all levels)
<b>Pan-Africa Development Strategies</b>				
African Union (AU) Agenda 2063	X	X	X	✓ (p. 2–3, 15)
African Union (AU) Agenda 2063 (2014–2023 Implementation Plan)	✓ (p. 60–62)	✓ (p. 58, 61)	✓ (p. 58–61)	✓ (p. 43, 51–52)
<b>Regional Development Strategies</b>				
East African Community (EAC) Vision 2050	✓ (p. 51, 61)	X	✓ (p. 48, 63)	✓ (p. 51, 68, 85)
Southern African Development Community (SADC) Regional Indicative Strategic Development Plan (2005–2020)	✓ (p. 62)	✓ (p. 32, 62)	✓ (p. 36, 62)	✓ (p. 47, 59)
Common Market for Eastern and Southern Africa (COMESA) Medium Term Development Strategy (2016–2020)	X	X	✓ (p. 67)	✓ (p. 67)
<b>National Development Strategies</b>				
Kenya Vision 2030 (Popular Version)	X	✓ (p. 19)	✓ (p. 19)	✓ (p. 8–9, 16)
Tanzania National Five-Year Development Plan: 2016/17–2020/21	✓ (p. 147, 184, 190, 213)	✓ (p. 58, 110)	✓ (p. 58, 71, 152)	✓ (p. 17, 61)
Zambia Vision 2030	X	X	✓ (p. 20, 30, 33)	✓ (p. 30)

environmental degradation. Some strategies do highlight methods, for example, Kenya's Vision 2030 aims to improve "pollution and waste management through the design and application of economic incentives" (Government of Kenya, 2007). Generally, degradation types are set out, but there is much less detail on the causes of degradation and the specific actions needed to reverse it.

The themes 'environmental data collection, management, integration and access' and 'policy and regulation for environmental management' were less well described in the examined set of development strategies. Some of the strategies highlight opportunities to improve data collection relating to specific environmental data (e.g., fluoride in water, meteorological data), but there is less emphasis on data management and integration. Section 3 highlighted participant's concerns about disparate data being stored in analogue forms, and the lack of data back-up systems. Greater impact could be leveraged from integrated data (e.g., looking at soil, water, geochemistry, and land-use data within one portal) that is more widely accessible. This would allow more sophisticated data analysis, the identification of potential research questions, and the development of integrated solutions to environmental challenges, such as degradation. Considering what environmental data could be appropriately disaggregated (e.g., by gender, urban development or income levels), as recommended by SDG 17.18 (United Nations, 2015), could also help when connecting environmental understanding to policy development. SADC do emphasise the need to "build capacity for collection, management and exchange of information/data for the sustainable management of environment and natural resources" (SADC, 2005, p.62). In contrast, the EAC Vision 2050 suggests improvements in environmental data collection, but does not discuss data management or the integration of environmental data (EAC, 2016).

It is feasible that the broader societal benefits of environmental data management and integration are less well understood than the need to collect data in the first place. The training of Earth and environmental scientists in 'Earth system science' and the recognition of interactions in the natural environment may enable them to take a more holistic look at environmental data and recognise the opportunities that data integration can provide to national and regional development. Such interactions also mean that environmental policies need to take an integrated approach (Margerum, 1999; Marques et al., 2015), with environmental links to urban development, industrialisation and resource security. The repeated emphasis in Section 3 on environmental and resource degradation was largely attributed by participants to a lack of effective policy frameworks and regulation (or effective implementation of existing regulation) around agriculture, industry, catchment management, mining, domestic water supply and sanitation, and urban development. Underlying many of these challenges is a segmented policy and regulatory framework, with cross-sectoral policies and institutional partnerships required for effectiveness (UNEP, 2015; Getenet and Tefera, 2017).

While strengthened policy and regulation is discussed across all of the development strategies, many do not apply this specifically to integrated environmental management. The SADC strategy does endorse the "integration of environmental and sustainable development issues into sectoral, national and subregional socio-economic planning" (SADC, 2005, p.62). The Kenya Vision 2030 notes that "the country will harmonise environment related laws for better environmental planning and governance" (Government of Kenya, 2007, p.19). Tanzania also emphasises "integrating, harmonizing and coordinating environmentally sustainable policies and strategies for growth in key

growth sectors, including climate change adaptation and mitigation” (Government of Tanzania, 2016, p.58).

Environmental science needs to play a stronger role in effective policy formation (UNEP, 2015), integrating diverse data types to understand environmental stresses and the impact of potential interventions (Howes et al., 2017). There are likely to be other root causes of degradation, such as institutional and market failures, (Emerton, 1999), but policy failures are recognised to be of major importance (Emerton, 1999; Panayotou, 2003; Howes et al., 2017). Reasons for policy failure can be (i) structural, a result of economic incentives to continue degradation or a lack of incentives to promote conservation (Emerton, 1999; Wunder, 2000; Das and Chatterjee, 2015; Howes et al., 2017), or (ii) a lack of capacity to draft, implement or enforce effective policies, including having the environmental science expertise to understand the problem, inform the policy, and evaluate its impact (Manuel-Navarrete et al., 2007; Lockie, 2013; Howes et al., 2017).

The development strategies in Table 4 all recognise the importance of science to sustainable development in eastern Africa. By contrasting our workshop results with these development strategies, we propose three ways by which Earth and environmental scientists can further support sustainable development: (i) education and capacity building, (ii) improved data collection, management and integration, and (iii) the use of this data to inform coherent environmental policy-making. Together, these three activities can help to reduce environmental degradation and pollution as prioritised by both published strategies and workshop participants.

## 5. Conclusions

Earth and environmental science is a critical pillar of sustainable development (Lubchenco et al., 2015; Gill and Bullough, 2017; Omisore, 2018), meaning Earth and environmental scientists have a strong role to play in discussions on this theme. Their perspectives can inform development priorities, and identify crosscutting themes that inform the policies and practices needed to achieve the SDGs. Engagement or dialogue with stakeholders is critical to understanding development priorities, and co-designing potential research and innovation activities to address these. Engaging with partners as equals at all stages of the research process – from design to dissemination – is necessary and helps to maximise capacity building opportunities (Weichselgartner and Kaspersen, 2010).

Through an interactive workshop methodology, we listened to the perspectives of 76 people from the eastern African Earth and environmental science community, representing 48 organisations in Kenya, Malawi, Tanzania, Zambia and Zimbabwe. In this paper, we have collated and synthesised these perspectives to support our understanding of how Earth and environmental science can support sustainable development in eastern Africa. Workshop participants focused on immediate (or ‘basic’) needs, expressed in the SDGs relating to **food, health, education, water, and ‘life on land’**. Published national and regional development strategies included these basic needs, alongside perspectives on employment, urbanisation, industrialisation, and infrastructure.

The results and discussion presented through highlight that Earth and environmental science research, training, innovation, monitoring and management has the potential to support actions to address these priorities, and the implementation of the SDGs in eastern Africa. While regional and national development strategies capture some of the interventions needed to secure sustainable development, our workshop engagement identified activities critical to realising these objectives. This information can be used by Earth and environmental scientists in eastern Africa to guide their activities on the science-policy-practice interface, and leverage greater impact to support sustainable development. Our results particularly emphasise the importance of the following three activities:

- **Improving environmental data collection, management, integration, and access** (e.g., through online data portals) to better understand complex environmental and social challenges. Combining data sets on geology, soils, water, demographics and health can support action to improve food security and reduce poverty and health challenges.
- **Coherent, integrated environmental policies to support environmental management.** Discussions across national and thematic contexts converged on projects that informed policy and regulations, emphasising the integration of Earth and environmental science into spatial planning, and coherence across policy interventions to maximise impact.
- **Enhancing scientific training and capacity, and greater public understanding of science.** Emphasised in continental, regional and national development strategies, as well as by workshop participants, are the benefits of increasing scientific capacity at all levels. This includes both the quality and quantity of professional scientists, and raising the level of scientific literacy in the general population. The range of environmental challenges faced by many countries (e.g., climate change, water security) means that Earth and environmental science is a key area for enhanced engagement.

The results presented in this paper highlight a range of applied science research and innovation opportunities in eastern Africa, where Earth and environmental science can help to address stakeholder-expressed priorities. Within the three themes noted above, there were opportunities highlighted relating to food security, health, water, minerals, energy and climate change. These results will inform the activities undertaken through the ODA work of the British Geological Survey. For example, working collaboratively with scientific capacity in ODA recipient countries, we will proactively identify opportunities where environmental data integration will help to tackle societal challenges.

This information can shape future research collaborations between organisations in eastern Africa and those elsewhere, and collaborations between the environmental science community and those engaged in policymaking and development practice. We believe the information we present can help the international community to build equitable and positive research partnerships with those in eastern Africa, understanding their priorities and how they relate to existing national and regional development strategies. Furthermore, this comparative synthesis demonstrates the value of Earth and environmental science to other disciplines engaged in sustainable development in eastern Africa. We propose that incorporating environmental expertise into national and regional

sustainable development strategies will support the delivery of the UN Sustainable Development Goals.

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## Appendix A

See Appendix [Tables A1 and A2](#).

**Table A1**

Specific challenges in eastern Africa associated with the SDGs. Bold, coloured words indicate recurring themes, discussed in [Section 3.1.3](#).

SDG	Summary	Kenya	Zambia	Tanzania
1	No Poverty	Uncoordinated aid; ineffective and poor <b>governance</b> ; corruption; resilience to <b>climate</b> ; lack of income and property; equal pay for equal work; gender inequality; illiteracy; cultural barriers; local attitudes and perceptions.	Job opportunities for new graduates; impact of <b>droughts</b> and <b>floods</b> ; desertification in Western Province; lack of quality <b>education</b> ; dependence on traditional ways of making money, and the need to consider preparing people for entrepreneurial careers in modern unconventional areas; lack of enabling environment to support farming; limited access to good/improved technologies by smallholder farmers and high costs; less meals per day and no balanced diet; resilience to <b>climate</b> shocks and natural hazards; malnutrition in under 5s and adults; lack of key nutrients (Vitamin A).	Unemployment.
2	Zero Hunger	Crop productivity; poor farming practices; implementation of technology and mechanisation; land <b>degradation</b> ; poor production and preservation methods; lack of dietary diversity; cultural barriers to food; lack of access due to cost; lack of good <b>infrastructure</b> ; <b>climate</b> change, environmental and seasonal variability; shifts in planting and harvesting seasons.	Poor farming methods and <b>irrigation</b> , causing soil <b>degradation</b> ; loss of workforces due to disease; not enough use of <b>irrigation</b> for small-scale agriculture; food security is hard for many families – especially in rural areas – due to <b>climate</b> change, will need to look at local crops for genetic solutions; high input costs of fertilisers and seeds in production; lack of access to markets; hidden hunger, need for good nutrition and better quality and diversity of food; lack of food and people skipping meals or going without food altogether; rising populations; soil <b>degradation</b> and erosion; new pests and crop diseases; dry spells and <b>droughts</b> ; low agricultural productivity; rural to urban migration results in a loss of labour; animal nutrition; market prices are too low (economics).	<b>Climate</b> conditions; <b>rain</b> fall dependence; game reserves use productive land; value chain and lack of stable markets (no buyers); land use conflict.
3	Good Health and Well-Being	Lack of funding and capacity; cheap and clean energy; hunger; <b>governance</b> ; remoteness; corruption; ignorance; lack of clean <b>water</b> ; inadequate <b>infrastructure</b> ; conflict; witchcraft; cultural barriers; poor waste management in urban areas; air/ <b>water/soil pollution</b> ; affordability of lifestyles; environmental factors; cultural and lifestyle habits.	Lack of access to quality health facilities; insufficient numbers of medical personnel like doctors; lack of facilities and personnel in rural areas; lack of good <b>knowledge</b> and habits in nutrition (junk food); hidden hunger; access to healthcare; lack of clean <b>water</b> causing disease; lack of proper access to health services in rural areas; few clinics; few doctors; lack of drugs; poor health <b>infrastructure</b> ; unavailable drugs; rising rates of disease (e.g., AIDS and cancer); unexploited local nutritional diversity; access to nutritional and health <b>information</b> .	Low quality medical services in rural areas due to high poverty; poor nutrition; poor <b>water</b> quality; rural <b>groundwater</b> containing fluoride; lack of <b>information</b> regarding where fluoride is; lack of treatment facilities and medicines; lack of trained personnel, lack of working tools for doctors/nurses; lack of national health insurance/subsidised services.
4	Quality Education	Cost; poor <b>governance</b> ; poverty; education system not valued; unemployment.	Not enough qualified teaching staff; not enough funds allocated to education (all levels, including vocational); poor reading culture; lack of proper libraries; lack of <b>infrastructure</b> for formal schools; need for proper science educational capabilities; access to tertiary and vocational <b>education</b> ; research and development within tertiary education; funding for <b>infrastructure</b> ; too few schools and teachers; need for skills development; girls dropping out due to lack of adequate sanitation facilities, lack of study materials such as books.	Lack of innovation in teaching by teachers; early marriages and girls finish school too young; <b>education</b> costs; lack of science teachers; lack of teacher <b>training</b> ; poor teaching facilities; <b>education</b> is focused on <b>training</b> people to be labourers rather than innovators and entrepreneurs; lack of opportunities for secondary and higher education; lack of books and teaching materials; need for practical <b>education</b> ; lack of buildings and teaching <b>infrastructure</b> s (e.g., schools, laboratories, toilets); gender inequalities; need for more specialisms within curricula; lack of vocational <b>training</b> .
5	Gender Equality	Empowerment of women.	Under-representation of women in responsible positions; female children disadvantaged by culture and society; deserves renewed attention especially in the <b>governance</b> of our countries; involvement of women's perspectives is necessary for prosperity; females are dropping out of higher <b>education</b> ; archaic traditions and lack of deliberate <b>policies</b> to promote female child education.	Culture and traditions; poor school toilets can cause girls to drop out; patriarchal societies cause problems; lack of awareness of the importance of gender equality; negative perceptions of gender equality.
6	Clean Water and Sanitation	Corruption in the <b>water</b> sector, illegal connections; poor management and <b>degradation</b> of catchment areas; resources put into maintenance; <b>pollution</b> and <b>water</b> quality; resource mapping; loss of <b>water</b> mobility; inability to close <b>water</b> budget (e.g., leakage, over-abstraction, <b>water</b> waste); lack of <b>data</b> on <b>water</b> availability; poor <b>water</b> conservation; lack of awareness raising in communities; deforestation; <b>climate</b> change; depletion of <b>groundwater</b> ; management of <b>water</b> sources; life cycle of <b>water</b> -supply solutions; maintenance of systems; lack of skills in <b>water</b> conservation and harvesting; low <b>water</b> availability; inadequate harvesting and storage; bad <b>water</b> management; management of <b>infrastructure</b> ; inadequate and expensive technology for extraction and distribution; environmental <b>degradation</b> ; exposure to sewage and contaminated, dirty <b>water</b> .	Untreated <b>water</b> ; distance to <b>water</b> sources; drilling not regulated; unplanned city expansion; use of agrochemicals; unmatched provision of <b>water</b> to <b>infrastructure</b> (housing); <b>contamination</b> with faecal matter; unregulated pit latrines and septic tanks; <b>groundwater contamination</b> from mining; lack of access to clean <b>water</b> in urban areas; lack of sanitation impacts on access to education for girls; on site sanitation causing <b>contamination</b> ; <b>regulation</b> of <b>groundwater</b> resources; large scale and industry abstraction of <b>groundwater</b> is unregulated; <b>contamination</b> with sewage; lack of understanding, <b>data</b> and <b>knowledge</b> of <b>water</b> resources in Zambia; <b>pollution</b> of <b>water</b> (and soils) from mine tailings; <b>water</b> is untreated and long distances from homes; growing <b>irrigation</b> could threaten <b>water</b> resources and cause <b>pollution</b> if not managed well; conflicting demands on <b>water</b> resources (e.g., industry vs. residential); lack of <b>laws</b> that give people the right to access <b>water</b> .	Lack of access results in disease; lack of hygiene <b>knowledge</b> ; people live in remote areas; non-functional <b>water</b> sources (e.g., dry, broken); cultural barriers to supporting projects; lack of a viable and sustainable financial structure for rural <b>water</b> supplies – communities need to contribute something; pit latrine <b>contamination</b> ; <b>water</b> loss due to seepage – how do we monitor this?; open defecation; need for increased urban <b>water</b> supply.

(continued on next page)

Table A1 (continued)

7	Affordable and Clean Energy	<i>None stated.</i>	Power is not stable; common to lose power; greater need for shift to sustainable energy sources; lack of institutional support for renewables; lack of technical skills for renewables; lack of human resources for renewables; poor awareness of renewables potential; lack of alternative energy sources for rural households; identification of appropriate technology energy options.	Open burning pollutes the air; slow implementation of and communication regarding renewable energy sources; inadequate trained personnel to implement projects; lack of funding.
8	Decent Work and Economic Growth	<i>None stated.</i>	Little prioritisation of occupational health and safety; corruption that sways policies to suit individuals; women spending too much time collecting water and having no time for economic activities.	<i>None stated.</i>
9	Industry, Innovation and Infrastructure	Harness science and technology in our development.	Lack of access to markets due to no good roads; lack of access to required infrastructure to facilitate growth in innovation; lack of industries; few jobs related to improving infrastructure.	Poor networking and technical knowledge; low education quality; lack of investment; focus on economic and social development with less regard to the environment; growth of private water supply companies (e.g., drillers and pump manufacturers); high constructions costs; poor planning and lack of infrastructure innovation; substandard constructors; lack of storage facilities; lack of processing industries; need to empower local scientists; need to take nature into account when developing infrastructure.
10	Inequality	<i>None stated.</i>	<i>None stated.</i>	Implementation of existing policies; traditional beliefs.
11	Sustainable Cities and Communities	<i>None stated.</i>	Unplanned settlements; rural to urban migration; land encroachments; unplanned cities; no roads; no electricity; limited knowledge on sustainable industrialisation; lack of coordinated planning; unplanned cities with urban sprawls (slums).	<i>None stated.</i>
12	Responsible Consumption and Production	<i>None stated.</i>	Too much plastic waste and not enough action on this; lack of proper recycling centres; deforestation for charcoal production.	Plastic bags are killing fish, with a ban needed.
13	Climate Action	<i>None stated.</i>	Deforestation; open burning; lack of awareness of communities about climate change and the impacts of certain actions on the environment.	Economic growth is resulting in pollution; lack of climate-smart agriculture; air pollution; lack of community empowerment; variability leads to increased vulnerability of crops to extreme weather events.
14	Life Below Water	<i>None stated.</i>	No interest in aquaculture.	Lack of sustainable conservation; lack of sustainable marine industries; lack of early warning systems; lack of knowledge on utilising marine resources; less technology for marketing and development; human activities are conducted below standards and affect life below water.
15	Life on Land	Integrated program of assessment and mitigation (science and solutions).	Biological degradation; deforestation; loss of productive agricultural land and connections between this and food security.	Lack of means to utilise land resources effectively; insufficient resources and personnel to monitor illegal activities; unsustainable farming; soil erosion and degradation; deforestation; land tenure systems limit initiation of development due to lack of proper land use planning; increasing climate variability leading to unpredictable crop yields and outputs; over-utilisation of land; climate change; unfair resource distribution; population growth; balancing development of agriculture and environmental regulation; lack of community awareness on environmental degradation effects; disturbing of wetland areas and water sources; mercury use in artisanal and small scale mining; lack of comprehensive management plan for potential resources; soil pollution (e.g., heavy metals from industry).
16	Peace, Justice, and Strong Institutions	<i>None stated.</i>	<i>None stated.</i>	Poor governance; lack of awareness of the role of law, regulations and rights.
17	Partnerships	Integration of serious, meaningful and responsible (with decision-making powers) partnerships at all levels and among sectors.	Lack of proper linkages; lack of funding and time for proactive development of partnerships.	Government policies that hinder development of partnerships.



Table A2

Specific Earth and environmental science interventions that could support the SDGs. Bold, coloured words indicate recurring themes, discussed in Section 3.2.

SDG	Summary	Zambia	Tanzania
1	No Poverty	Use of science to support cheaper and sustainable livelihoods; reduction of hunger.	<b>Research</b> could help identify geographic regions suitable for planting different crop types.
2	Zero Hunger	Sustainable agriculture; increase crop yields through crop resistant seeds; assessment of environmental <b>pollution</b> due to animal waste; improving nutrition and food security through <b>research</b> ; <b>technologies</b> to increase crop yields while maintaining high environmental standards; soil mapping; <b>research</b> into natural fertilisers; micronutrient rich food crops; development of rural infrastructure development.	Environmental <b>management</b> for more sustainable production; mature irrigation systems; sharing of agricultural knowledge; <b>technologies</b> for adapting to climate change; drought resistant crops; climate resilient agriculture; poor nutrition due to deficiencies in the soil.
3	Good Health and Well-Being	<b>Research</b> into micronutrient deficiencies.	<i>None stated.</i>
4	Quality Education	Embedding of contemporary Earth science ideas into <b>education</b> , to help improve public reactions to issues such as climate change.	Support <b>teaching</b> of environmental issues; prepare geological maps for <b>teaching</b> ; improve practical <b>teaching</b> within geosciences and field courses; seminars and workshops to help educate people involved in extractive industries (including improving safety); develop resources and improve facilities for teachers; <b>teaching</b> resources (Earth system sciences).
5	Gender Equality	<i>None stated.</i>	Programmes to encourage and support female students; create women in geology networks.
6	Clean Water and Sanitation	<b>Monitoring</b> and understanding of groundwater; understand health risks from contaminated ground and surface water; identify and access clean/quality water; <b>regulation</b> of groundwater drilling in Lusaka; integration of hydrogeological and GIS skills; understanding of water and soil <b>contamination</b> to reduce <b>pollution</b> ; improve sanitation facilities; guidelines for groundwater protection zones; natural geologic <b>contaminants</b> ; groundwater <b>education</b> ; <b>research</b> into efficient irrigation.	Improve understanding of available groundwater resources; <b>research</b> issues of water reuse; implement practices of water treatment; permeability maps for pit latrine control; collect/interpret/disseminate key groundwater information to support sustainable development, <b>management</b> of groundwater; improved data management and sharing; improved collaboration between stakeholders; use of rainwater harvesting; surface water and groundwater <b>monitoring</b> ; <b>monitoring</b> industrial activity associated with <b>pollution</b> ; decentralised waste water treatment; incentives on efficient water use.
7	Affordable and Clean Energy	Exploration of geothermal energy; carbon capture and storage; advocate for greener growth economics; energy storage; solar pumping; bioenergy and competition for land/food with crops.	<i>None stated.</i>
8	Decent Work and Economic Growth	<i>None stated.</i>	<i>None stated.</i>
9	Industry, Innovation and Infrastructure	Innovation in development minerals can create wealth and jobs for society, including products for construction; environmental considerations for infrastructure development.	Provide financial support; provide technical support to encourage export growth; introduce environmentally friendly <b>technologies</b> ; use of ICT for easy transfer of information and work processes; support understanding of sustainable development requirement in each project; responsible supervision of ongoing projects to ensure high quality of work.
10	Inequality	<i>None stated.</i>	<i>None stated.</i>
11	Sustainable Cities and Communities	National planning; integration of urban planning information into geological survey work; mapping of areas with poor drainage to avoid construction of settlements; understanding of links between sub-surface and surface water to support drainage and flood <b>management</b> .	Understanding of natural hazards through <b>education</b> about tectonically active areas, flood-prone areas and other geological hazards; increase integration of geological features into the planning and construction processes; understanding of weather dynamics to improve sustainable cities.
12	Responsible Consumption and Production	Identify resources; reduce environmental <b>pollution</b> and related ailments; improve recycling of resources through understanding of raw materials; improved <b>technologies</b> in the mining sector; planned resource use to support future generations.	Maximise opportunities for recycling materials.
13	Climate Action	Impacts of climate change on agriculture, poverty and disasters; understanding of climate dynamics to help <b>manage</b> changes; predicting/mitigating/adapting to climate change; building resilience to disasters; help switch to low carbon energy; sustainable land <b>management</b> ; understanding of science to support decision making; <b>research</b> on efficient crop varieties to survive in water-stressed environments; evidence for past climates; help develop climate records using groundwater as a proxy; potential for droughts; <b>research</b> into traditional practices that may help with climate change resilience.	Earth <b>monitoring</b> and modelling; development of clean energy and <b>technologies</b> ; reconstruction of past climates to improve understanding of how the environment has behaved and help predict future changes; education on use of organic waste to reduce reliance on fossil fuels; climate <b>pollution</b> control measures ( <b>regulation</b> ); afforestation and improved <b>management</b> incentives; promote <b>research</b> and practice which support Tanzania's contribution to United Nations Framework Convention on Climate Change; improved understanding of adaptation and preparedness in the context of Tanzania; improved public communication.
14	Life Below Water	<i>None stated.</i>	Need integrated water resources <b>management</b> , environmental <b>conservation</b> and hydrological modelling; <b>research</b> into coral reefs, their bleaching and possible restorative actions.
15	Life on Land	Provide evidence and ways of sustaining land resources; sustainable agriculture and crop production; methods to reduce soil <b>degradation</b> ; <b>manage</b> land resources for sustainable productivity; understanding of groundwater and potential <b>contamination</b> pathways; prevention of water <b>pollution</b> ; prevention of soil <b>pollution</b> .	Sustainable <b>conservation</b> ; responsible utilisation of resources; ecosystem restoration projects; payment of ecosystem services; advice on the creation of <b>policy</b> to support environmental sustainability; soil quality maps; follow the movement of elements/chemicals through the environment (water, soil, air); climate services; soil investigations; <b>research</b> to better understand the challenges; forest restoration; <b>research</b> on smart agriculture; <b>conservation</b> ; <b>technologies</b> to reduce <b>pollution</b> ; promote land-use planning; <b>monitor</b> nutrient flow from agricultural land; increase awareness of the effects of environmental <b>degradation</b> .
16	Peace, Justice, and Strong Institutions	<i>None stated.</i>	<i>None stated.</i>
17	Partnerships	<i>None stated.</i>	<i>None stated.</i>

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