Royal Society of **Biology**

Response from the Royal Society of Biology (RSB) to the Nuffield Council on Bioethics call for evidence on Considering future generations, the environment and the interests of non-human species in the analysis of emerging technologies, including solar radiation modification

March 2026

The Royal Society of Biology (RSB) is a single unified voice for biology, representing a diverse membership of individuals, learned societies and other organisations[1]. We aspire to build a world that values its contribution to improving life for all by advising Government and influencing policy, advancing education and professional development, supporting our members, and engaging and encouraging public interest in the life sciences.

We are pleased to provide comments informed by our membership of individuals and organisations with expert interests across the biosciences.

Summary

Effective policy for the use of emerging technologies and environmental interventions requires long-term, future-focused thinking that avoids locking future generations into narrowly constrained technological paths. The decision to implement or not implement technologies such as SRM should be based on clear, pre-agreed deployment thresholds, considering issues of accountability and irreversible ecological harms.

Ethical, responsible, and inclusive governance is essential to navigate the competing interests of humans, non-human species, and future generations in this space. Decisions should be based on input from broad stakeholder engagement, including scientific experts and public representatives. Embedding intergenerational perspectives also strengthens workforce planning and long-term strategic thinking. This is critical to ensure decisions are equitable, informed, and aligned with long-term planetary wellbeing.

Policies must also reflect the complexity of ecological and biological systems, including plants, animals, and microbes. Dynamic interactions, feedback loops, and rapidly shifting baselines mean that models, monitoring systems, and risk assessments must capture whole-ecosystem behaviour rather than just individual components. A One Health approach in policymaking allows for a greater understanding of system-level impacts and better anticipation for unintended consequences.

1. **What benefits or potential complications do you foresee or have you encountered in considering non-human species, the environment and/or future generations in policy and decision making?**

The benefits and complications of considering non-human (or future human) entities in policy and decision-making centre around **long-termism and complexity**. Policies which adequately incorporate the 'needs' of and predictions around these entities should be more fit for purpose in producing the desired benefit (including long-term if that is the design), based on a model better approximating the reality of the complex, dynamic world in which they will be implemented. However, policymaking for the long term and in the face of dynamic complexity, is challenging: political drivers may mean current governance prioritises short term benefits, or the societal need for speed in implementation may not align with the timelines needed to derive an appropriate evidence base.

[1] A list of RSB Member Organisations is available on our website

Long-termism

Policymakers should consider the risk of unintended lock-in for future generations. Emerging technologies such as SRM may not simply affect outcomes for future populations, but also restrict choices available for future policy decisions by introducing maintenance-dependent technological inheritance (e.g. termination risk). Existing tools already incorporate projected impacts on future populations and ecosystems. However, these typically do so by translating future harms into discounted present-day welfare losses, rather than treating future ecological or biological states as protected constraints. Environmental policy actions and the modelling on which they are based should instead distinguish between reversible environmental harms and alternative path-dependent interventions that may structurally narrow future autonomy. Developing future criteria and thresholds for when technologies should or should not be implemented, and criteria for identifying interventions likely to generate intergenerational technological dependence, would help long term preparedness in this area.

Considering future generations is key to ensuring long-term societal benefits through policy. It is essential to plan policies with them in mind. For example, a focus on current and future challenges and the corresponding workforce required to address these is key to ensuring capability within future generations to implement long-term policy goals. When developing the workforce of the future, including remediating skills shortages, sectors that will be critical in future environmental policy implementation are many and include ecology[2], engineering[3], and agriculture[4].

Consideration of future generations in all areas of climate policy is also beneficial as it allows long term strategic thinking in infrastructure development in this space. It also enables the development and deployment of policy that ensures preservation of natural resources for long-term sustainability[5]. Future population growth and urbanisation will exacerbate the demand for housing and infrastructure construction. Therefore, demand on resources and emissions impacts should be considered as part of this process, and solutions identified accordingly. For example, increasing the production and use of timber is considered to be a potential solution to help reduce construction emissions[6].

A challenge in implementing future-proof policy is accounting for the likelihood of changing baselines. The triple planetary crisis is a pan-civilisation threat to humanity, and policies which don't consider this will not be effective long term. Environmental policy actions need to consider future changes that may arise due to shifting environmental conditions. For example, tree planting can provide benefits such as carbon sequestration. However, for this to be effective, policymakers should utilise modelling data which accounts for the impact of climate change on certain regions of the country, as well as conflicting land use challenges, and the impact this might have on different tree

---

[2] Chartered Institute of Ecology and Environmental Management (2023): Vocational pathways into nature-based green jobs

[3] Department for Energy Security & Net Zero (2025): Assessment of the clean energy skills challenge

[4] Farming Profitability Review 2025

[5] Kalmamatova, Z., Mamaturaimova, G., Bakieva, S. (2024): Environmental Philosophy: Exploring Sustainable Development and Humanity's Ethical Responsibilities to the Environment and Future Generations. E3S Web of Conferences. 537.

[6] Churkina, G., Organschi, A., Reyer, C.P.O. et al. (2020): Buildings as a global carbon sink. Nat Sustain 3, 269–276

species populations, to ensure sites are adapted to environmental changes and will be effective and appropriately managed long term[7].

Complexity

One Health

Tackling challenges around visibility and coordination when implementing One Health frameworks such as the One Health Joint Plan of Action[8] would ensure a more effective and beneficial impact of policymaking in this space. These initiatives would also be enhanced through greater consideration of other areas, such as plant health, and the microbial ecosystem. This would allow the development of more holistic and effective environmental and health policies, including those that can enhance ecosystem biodiversity and resilience, human and veterinary public health protection, agricultural productivity, and environmentally sustainable technology development.

Long term commitment

A challenge when considering the environment in policymaking, and maximising its proposed financial, environmental, or societal benefits, is that actions may require long term commitment to ensure effectiveness. It's therefore imperative these actions are supported through to completion so that the benefits can be felt by future generations. An example of this is designated protected sites for nature, which must have ensured protection for the long term to ensure effectiveness, alongside ring fenced resources for site monitoring and management[9]. Barriers to this approach include high political instability and turnover, where changes in personnel as well as highly contrasting views across the political spectrum can affect long term commitment and certainty to these processes[10]. This includes the issue of R&D funding in this space[11].

Consideration of wider ecosystems

The complexity of predicting impacts of different technologies on the wider ecosystem is a significant challenge. As mentioned in our response to question 7, these threats could include the disruption of critical plant–soil microbiota interactions, as well as increased disease risks through changing vector distribution and dynamics. The full spectrum of diversity should be considered in this context, including within the microbial community. This brings clear benefits for signaling when systems are in a non-pathological, balanced state and when that balance is being disrupted. This will in turn allow better prediction of the impact of, and need for, emerging technologies[12] [13].

As acknowledged in the government Food Strategy, and the revised Environmental Improvement Plan, the consideration, and protection of, the health of the environment and wider ecosystem is

---

[7] Royal Society of Biology (2025): Response from the Royal Society of Biology (RSB) to the Defra Land Use Consultation
[8] UNEP (2022): One Health Joint Plan of Action (2022 - 2026)
[9] Royal Society of Biology (2025): Response from the Royal Society of Biology (RSB) to the Defra Land Use Consultation
[10] Vampa, D (2024): Subnational Policymaking in an Era of Political Instability: Developing a New Typology for Comparative Analysis. Journal of Comparative Policy Analysis: Research and Practice. 26(6), 585–603
[11] CaSE (2026): Preparing the R&D sector to navigate a shifting voter landscape
[12] Falkowski, P.G., Fenchel, T., Delong, E.F., (2008): The microbial engines that drive Earth's biogeochemical cycles. Science, 320 (5879), 1034–1039.
[13] Cavicchioli, R., Ripple, W. J., Timmis, K.N., et al. (2019): Scientists' warning to humanity: microorganisms and climate change. Nature Reviews Microbiology, 17 (9), 569–586.

critical for food security and a functioning, resilient food system, through processes such as soil health and nutrient cycling[14 15].

Microorganisms are early indicators of the relationship between living organisms and their environment. For example, in aquatic systems, microbial communities respond quickly to changes in nutrient loading, temperature, contaminants and host density, and microbial bioindicators have long been used to detect ecosystem change and stress[16]. However, there are complications in considering other ecosystems, including microbiomes, in policy and decision making. Organisms such as microbes do not fit to traditional ethical frameworks centred on individual units[17]. Existing legal and regulatory frameworks, designed with macroscopic life in mind, are often ill-equipped to address the unique challenges posed by the microbial world, from the regulation of synthetic organisms to the conservation of microbial biodiversity. Factors such as rapid evolutionary dynamics and limited assessment metrics for microbial biodiversity also make it difficult to predict the consequences of different policy actions, raising the risk of unintended and potentially harmful ecological disruptions. New methods both for categorisation and translation of data, as well as a greater understanding by policymakers of the role these organisms play, are required to effectively integrate these communities into policy actions.

Ethical trade-offs and conflicting values.

Designing policy that balances human and non-human needs and long-term positive outcomes inevitably involves ethical trade-offs. These can generate politically sensitive issues and areas for conflict for policymakers, particularly where the distribution of benefits and harms sits unevenly across geography, time or species. For example, existing policy frameworks which regulate the use of animals in science, such as the Animals (Scientific Procedures) Act 1986 (ASPA)[18], must weigh up the harms experienced by those animals against the societal benefits of biomedical advances and scientific knowledge that contribute to the protection of humans, animals and the environment. These are complex considerations. Even within the UK, societal views vary widely on where ethical boundaries lie[19]. At the international level, the absence of global harmonisation in regulatory standards further reflects differing value systems and creates challenges for international collaboration and agreed ethical standards.

2. **What methodologies or experiments are currently used to include non-human species, the environment and/or future generations in policy and decision making and/or the design or governance of technologies and interventions such as SRM?**

Monitoring and impact assessments

The One Health framework promotes a transdisciplinary approach that recognises the interconnectedness of human, animal, and environmental health. This framework is increasingly being expanded to incorporate greater aspects such as the full breadth of microbial diversity, moving beyond a focus on pathogens to encompass the entire microbiome. This involves using integrated surveillance systems that monitor microbial populations in different environments, bringing together experts from across the biosciences. This approach, combined with Environmental Impact

---

[14] Defra, 2025: A UK government food strategy for England, considering the wider UK food system
[15] Defra, 2025: Environmental Improvement Plan (EIP) 2025
[16] Paerl, H.W., Dyble, J., Moisander, P.H. et al. (2003): Microbial indicators of aquatic ecosystem change: current applications to eutrophication studies. FEMS Microbiology Ecology, 46(3),
[17] Sustainability Directory (2025): Global Conservation Policy Now Includes Earth's Essential Microbial Life
[18] Animals (Scientific Procedures) Act 1986
[19] Ipsos MORI (2018): Public attitudes to animal research 2018

Assessments (EIAs) as well as long term ecological monitoring, utilise microbial indicators to assess the health of the environment.

Risk assessments and data utilisation

Microbial risk assessment is a critical methodology essential for developing regulatory frameworks that can safely govern the development and release of new microbial technologies, including those involving emerging technologies such as GMOs. These risk assessments should consider ecological thresholds and earth system guardrails as part of scenario analysis and subsequent policy development. Incorporating technological path-dependency and termination dependence into these; particularly in relation to planetary-scale interventions such as SRM, would ensure a more reflective and holistic analysis when deciding to implement drastic technological interventions.

Data such as high-throughput sequencing and analysis techniques such as metagenomics, transcriptomics, proteomics, and metabolomics allow for the identification of the composition and functional potential of microbial ecosystems, which in turn can improve understanding of the wider role these organisms play in the environment. For example, the Earth Microbiome Project has used these techniques to map global microbial diversity, revealing key patterns of microbial distribution and function that can inform environmental policy[20].

Harm-benefit analysis

Under ASPA, the UK regulatory framework that governs the use of animals in science requires a robust Harm-Benefit Analysis (HBA) before project licences to conduct research are granted[21]. Harms to the animal, including pain, distress as well as cumulative lifetime experience caused by breeding, housing and transport, are weighed against the benefits of the research, which may include societal benefits from biomedical knowledge and treatments, but may also include advances in veterinary health outcomes, environmental protection or scientific knowledge that benefits non-human interests. Licences are only granted where the expected benefits justify the expected harms to the animals involved, and only where there are no valid non-animal approaches. This careful analysis ensures that decisions are ethically underpinned, as well as ensuring that research is conducted with integrity.

3. **What methodologies or frameworks would you propose, if any, for the inclusion of non-human species, the environment or future generations in decisions, including those related to emerging technologies and interventions with the potential to affect organisms and Earth systems?**

Support and development of existing frameworks

The continued development, expansion and application of systems such as the One Health framework[22], would strengthen the inclusion of non-human species, ecosystems and future generations in decisions about emerging technologies with global planetary implications.

These frameworks can be developed to ensure ecological processes are actively considered in decision-making. For example, plant, animal, and microbial communities play critical roles in regulating carbon, nitrogen and methane cycles. Explicitly incorporating these biological feedback

---

[20] Gilbert JA., Jansson JK., Knight R. (2014): The Earth Microbiome project: successes and aspirations. BMC Biol.
[21] Home Office (2024): Guidance on the operation of the Animals (Scientific Procedures) Act 1986
[22] Ginnan, N., Crandall, S, G., Imchen, M., et al. (2025): Ecologically expanding the One Health framework to unify the microbiome sciences. mBio, 16(6)

mechanisms into Earth system models used to evaluate SRM would help ensure that technological assessments reflect the complexity and interdependence of various living systems.

These frameworks should be supported by investment in multi-level ecological monitoring and data collection and standardisation. Integrating the data improvements which would arise from this into modelling could allow decision makers to better anticipate risk, evaluate the impacts of emerging technologies and guide interventions that respect both ecosystem integrity and the interests of future generations.

Emerging technologies and methodologies

For emerging technologies such as synthetic biology, a proportionate, adaptable and science-based regulatory framework is recommended. This should carefully balance risk and hazards against the consequence of inaction, which, as highlighted in question 5, may also constrain future agency; impose irreversible ecological harms; and reduce adaptive capacity. Short-term human benefit should not override potential systemic ecological disruption, as factors such as microbial evolution, once altered, cannot easily be reversed. These frameworks should include robust risk assessment methodologies, and ethical impact assessments, which include ecological ethics and intergenerational justice to evaluate long-term ecosystem impacts of novel technologies on areas such as microbial diversity and ecosystem function.

Bioethics mediation is an emerging methodology that offers a structured process for resolving ethical conflicts and making decisions that involve multiple stakeholders with competing interests. The formal integration of bioethics mediation into environmental and public health governance[23] could provide a valuable mechanism for navigating the complex ethical and social issues that arise when considering the interests of non-human species. This would require a workforce with the sufficient skills across these areas to successfully implement this approach. By bringing together diverse stakeholders - including scientists, policymakers, industry representatives, and the public - bioethics mediation can help to build consensus and ensure that a wide range of values and perspectives are considered in the decision-making process.

The decision to use large scale emerging interventionist technologies such as SRM should be based on specific trigger-based governance models. This would allow for defined pre-agreed thresholds under which non-intervention may impose greater intergenerational harm than conditional technological deployment, for example through the triggering of irreversible tipping points such as ice sheet collapse or rainforest die-back[24]. This would allow technologies such as SRM to be framed as a conditional emergency stabilisation measure, thereby avoiding both premature deployment and decision paralysis arising from abstract concerns about intergenerational lock-in.

4. **Can you highlight examples of existing legal, regulatory or ethical frameworks that are well designed to be inclusive of non-human species, the environment and/or future generations, and explain why you consider them to be good examples?**

Responsible innovation

The AREA (Anticipate, reflect, engage, act) approach is an example of a method for researchers to demonstrate awareness of and commitment to the principles of responsible research and innovation[25].

---

[23] Lioupi, O., Kostoulas, P., Monti, G., et al. (2025): Harnessing Medical Bioethics Mediation to Advance One Health Governance. Veterinary Sciences, 13(1), 8.
[24] Lenton, T.M., Milkoreit, M., Willcock, S., (2025): The Global Tipping Points Report 2025, University of Exeter
[25] Framework for responsible research and innovation

Emerging technologies create societal and governance challenges[26], and a commitment to responsible innovation and research practises underpinned by effective regulation, controls and culture, are essential to ensure future generations benefit through development of ethical, effective future technologies[27].

Proxy representation in governance

The Rights of Nature movement gives ecosystems a voice in the decision-making process and ensures that their interests are considered alongside those of humans[28]. This framework is effective as it challenges the legal status of nature as mere property and instead recognises ecosystems as rights-bearing entities. Examples of this include the Te Awa Tupua (Whanganui River Claims Settlement) Act 2017, which dictates that the Whanganui River is a living entity and a legal person with rights that can be judicially enforced by appointed guardians[29]. Legislation such as the Well-being of Future Generations (Wales) Act 2015[30] offers another example of proxy representation in policymaking, with the appointment of a Future Generations Commissioner for Wales whose role is to support and challenge Wales to make decisions in the best interests of people who aren't born yet[31]. Further work should be done to explore how programmes such as this can be further embedded into legal and regulatory systems.

Existing frameworks

An example of successful implementation of a One Health approach in framework development can be seen in the EU Water Framework Directive, which aims to provide an integrated approach to water management, considering whole ecosystems as part of this[32]. Water based surveillance has emerged as a governance-relevant tool for monitoring pathogens and resistance genes in Scotland. However, it should be noted that further work is needed to ensure this is scaled up and consistently implemented across other devolved nations[33].

The Nagoya protocol offers a legislative framework that can benefit future generations through the fair and equitable sharing of benefits arising out of the utilisation of genetic resources[34].

The ethical framework for emerging technologies proposed by the Presidential Commission for the Study of Bioethical Issues offers an example of a framework which promotes the balancing of innovation with responsible stewardship. This framework emphasises the importance of public beneficence, which requires that the development and deployment of new technologies should be aimed at promoting the public good, while also minimising risks[35].

---

[26] Stilgoe, J., Owen R., & Macnaghten, P., (2013): Developing a framework for responsible innovation, Research Policy, 42 (9)
[27] MRC and BBSRC (2025): Statement on research with potential misuse risk
[28] Center for Democratic and Environmental Rights. (n.d.). Rights of Nature Law Library
[29] Argyrou, A., Hummels, H., (2019): Legal personality and economic livelihood of the Whanganui River: a call for community entrepreneurship. Water International, 44(6–7), 752–768.
[30] Well-being of Future Generations (Wales) Act 2015
[31] Future Generations Commissioner for Wales: Challenging and supporting those in power to make good decisions today for a better tomorrow
[32] European Commission: Water Framework Directive
[33] Environment Agency (2023): Review: approaches to monitoring and surveillance of antimicrobial resistance in bathing waters - summary
[34] Regulations: Nagoya Protocol on access and benefit sharing (ABS)
[35] Presidential Commission for the Study of Bioethical Issues (2010): The Ethics of Synthetic Biology and Emerging Technologies

The UN Sustainable Development Goals provide a framework to address global challenges through a global context. The 17 goals and their 169 targets allow for the consideration of multiple, often interconnected factors in policymaking. The potential impact of technologies should be considered against this framework, both in terms of supporting and hindering progression towards different goals[36].

As highlighted in previous answers, the regulatory framework which governs the use of animals in science in the UK is a good example of how non-human interests can be embedded in law. Ethical trade-offs can be formally and carefully considered, requiring a robust justification of the expected harms to an animal against the expected benefits to human society, or the protections of animal health and the environment. In addition, research proposals must go through a multi-tiered governance structure, including assessment by local establishment-based ethical committees, Animal Welfare and Ethical Review Bodies (AWERBs), which are also responsible for reviewing the ethical justification and welfare impacts retrospectively, to ensure continuous ethical deliberation and reflection. AWERBs must also include non-scientist 'lay members'. Their inclusion ensures wider societal values and perspectives are represented in decision-making.

5. **How should we weigh the different values that arise in the consideration of current human generations, non-human species, the environment and future generations in policy and decision making, including across research, development and/or governance of emerging technologies such as SRM?**

Value in this context should not be considered solely in terms of GDP, but rather balanced with other metrics that better consider the wellbeing and impact on current and future generations, as well as the environment[37]. Recognising the intrinsic value of nature through alternative perspectives allows for the development of conservation initiatives aimed at protecting biodiversity, preserving habitats, and safeguarding ecosystems[38].

Standardised accounting and effective enforcement measures for both carbon and biodiversity calculations could allow a consistent approach in understanding value[39]. Factors such as biodiversity should extend beyond this to consider commercial and functional value. The idea of 'non-value' should also be considered. An example of this is ‘existence value’: the value people obtain from knowing that wild species continue to exist in their natural habitat. Methods to account for this could include using ‘no-loss’ or ‘net gain’ targets for factors such as biodiversity[40]. Including these on the appraisal of emerging technologies would allow decision makers to rule out options that reduce biodiversity, yet allows economic assessments of remaining options.

When considering the values of different policy initiatives on the environment, a systems thinking approach is critical. This involves looking at the full lifecycle of proposed initiatives, be these new technologies or consumer behaviour changes. Large scale technologies such as SRM may have unintended effects, as detailed in our response to question 7. This raises the question of how we

---

[36] United Nations Development Programme (UNDP): THE SDGS IN ACTION.
[37] Jansen, A., Wang, R., Behrens, P., et al. (2024): Beyond GDP: a review and conceptual framework for measuring sustainable and inclusive wellbeing. The Lancet Planetary Health, 8 (9)
[38] Kalmamatova, Z., Mamaturaimova, G. & Bakieva, S. (2024): Environmental Philosophy: Exploring Sustainable Development and Humanity's Ethical Responsibilities to the Environment and Future Generations. E3S Web of Conferences. 537.
[39] Royal Society of Biology (2025): Response from the Royal Society of Biology (RSB) to the Defra Land Use Consultation
[40] Royal Society of Biology (2019): Response from the Royal Society of Biology to the Dasgupta Review on the economics of biodiversity

value and prioritise the benefits of different emerging technologies against the negative impact they might have on other areas of the environment, given the interlinking roles these might have on one another.

The application of emerging technologies such as SRM will potentially have high economic costs. However, this should be considered against the costs of inaction on climate change, which could potentially be between 11-27% of cumulative GDP[41]. Subsequent remediation costs to resolve climate triggered events and impacts such as increased flooding should be considered as part of this. Inaction may also constrain future agency; impose irreversible ecological harms; and reduce adaptive capacity. As mentioned in our response to question 3, defined, pre-agreed thresholds under which non-intervention may impose greater costs than conditional technological deployment should be considered.

6. **What existing legal, regulatory or ethical frameworks could be more inclusive of non-human species, the environment and/or future generations, and how?**

Framework reform

Many existing legal, regulatory, and ethical frameworks could be made more inclusive of non-human species, including microbes, through targeted reforms and a shift in perspective. Frameworks such as the Convention on Biological Diversity (1992)[42] and the WHO Global Action Plan on AMR (2015)[43] provide foundations but require stronger operationalisation in areas such as microbial metrics. Reforming these frameworks would involve moving beyond a focus on pathogens and antimicrobial resistance to include the study of beneficial microbes and the value of microbial biodiversity, recognising these microbial communities in their explicit roles and embedding microbial ecosystem indicators into biodiversity strategies. These models and policies should be adaptive so that they can develop as the knowledge of the microbial system advances based on real-time monitoring.

Framework expansion

Environmental protection laws could be adapted to be more inclusive of the wider ecosystem. Many of these acts focus on the conservation of macroscopic plants and animals as opposed to microscopic microbial communities. To make these laws more inclusive of the entire ecosystem, investment is required to develop new criteria for identifying these endangered communities as well as the development of new legal and regulatory tools for their conservation. Integration of specialist groups into wider conservation authorities such as the IUCN can ensure these groups are given appropriate representation as part of wider conservation initiatives[44].

Ethical review processes for research and technology development could be made more inclusive of non-human species, for example considering microbial diversity and microbial functions in biosafety and biosecurity policies. This would involve ensuring that ethical review boards have the expertise to assess the potential long-term impacts of new research and technologies. It would also require the development of new ethical guidelines for research involving microbes, particularly in the context of emerging technologies like synthetic biology.

---

[41] Benayad, A., Hagenauer, A., Holm, L. et al. (2025): Why Investing in Climate Action Makes Good Economic Sense

[42] Convention on Biological Diversity

[43] World Health Organization (2015): Global Action Plan on Antimicrobial Resistance

[44] Gilbert, J.A., Peixoto, R.S., Scholz, A.H. et al. 2025: Launching the IUCN Microbial Conservation Specialist Group as a global safeguard for microbial biodiversity. Nat Microbiol 10, 2359–2360

7. **How can we ensure that ethical considerations regarding non-human species, the environment and/or future generations are adequately accommodated in policy and decision making, as part of our ethical analysis of SRM?**

Responsible delivery and accountability

Considerations should be taken that large scale infrastructure projects such as SRM may conflict with other urgent environmental priorities. Further research is therefore needed to address knowledge gaps in the potential accompanying environmental impacts of SRM[45]. This should be done within both global and local contexts, and include marine and terrestrial environments. Knowledge gaps and potential risks should be seriously considered and appropriate action taken to minimise these. A similar approach should be undertaken when assessing the benefits of other technologies such as ocean fertilisation, comparing the relative benefits of carbon sequestration against associated environmental risks these might pose, such as eutrophication[46].

Decisions to instigate these technologies should consider pre-agreed thresholds for implementation, as well as assessing reversibility and risk of termination. Proactive planning in this area would ensure policy decisions are not made reactively under crisis conditions, but rather instigated as a result of careful pre-planning.

Negative externalities need to be considered, and responsible delivery and effective regulation are critical parts of this. Careful consideration should be taken to both minimise risks of misuse, and ensure equitable access to benefits provided by these technologies. Clear lines of accountability and potential liability should be established at the beginning of this process. Decisions made by select individuals and governments could alter a shared planetary system, while the costs and risks are spread across the global population. For example, climate regional patterns which may be altered as a result of these technologies could affect plant–soil microbiota interactions, which are critical for ecosystem stability and functioning. There could also be impacts on pathogen and vector distribution. Both of these risk impacting local geographic areas and the communities within them, although these risks should be compared against scenarios of non-action, and the effect of climate change on these factors if not addressed. Future modelling, built on effective and reliable data, should incorporate long-term scenarios across multiple trajectories, so that we better understand the spectrum of risk for future generations.

Involving and engaging different communities

Multi-criteria decision analysis should be implemented in policymaking, which incorporates ecological thresholds, societal benefits, and long-term uncertainty[47] to ensure new technologies do not affect the factors required for future ecosystem stability. Representation of different stakeholders as part of this analysis is essential. This should include international perspectives, representation of indigenous communities, different socioeconomic representation, and proxies for the environment and future generations. Policy should explicitly consider both the intended impacts and the potential unintended consequences for human and non-human species together, given the interdependence of health across humans, animals, plants, and the wider environment[48]. Embedding this perspective

---

[45] The Royal Society (2025): Solar radiation modification – Policy Briefing

[46] Lampitt, R.S., Achterberg, E.P., Anderson, T.R. et al. (2008): Ocean fertilization: a potential means of geoengineering?. *Philos Trans A Math Phys Eng Sci*, 366 (1882)

[47] Raworth, K. (2017): *Doughnut economics: Seven ways to think like a 21st-century economist*. Chelsea Green Publishing.

[48] BBSRC, 2025: Bioscience for an integrated understanding of health

will help ensure that policy decisions are informed by a more holistic understanding of system-level effects and long-term implications.

Scientific and learned societies offer a source of trusted, reputable evidence that reflects the expertise of often thousands of experts within relevant fields[49]. Community initiatives and action plans such as the People's Plan for Nature also offer a method of considering the wants and needs of the public in policymaking on climate action and protecting and valuing the natural world[50]. By not involving these representatives, policymakers risk missing out an enormous amount of contextual evidence and expertise which is critical to the decision-making process[51].

Education and public engagement activities can also act as tools to increase awareness and consideration of ethical issues across relevant ecosystems and technologies. This can be achieved through targeted education and outreach initiatives. Fostering a greater appreciation for non-human species and the environment can create a more receptive environment for policies that take the interests of these organisms into account. Climate change and sustainability education is vital for all students, and by embedding this into the curriculum in a meaningful way it will help young people understand and respond to the global challenges that will shape their future. Integrating the consideration of technological and ecological solutions to climate change into the curriculum as part of this could help support structured learning and understanding of these technologies[52]. Learned Societies have a crucial role in this, bringing together different communities and perspectives to engage on overlapping issues.

[49] RSB Organisational Membership Directory
[50] People's Plan for Nature
[51] The Royal Society of Biology (2025): Response from the Royal Society of Biology (RSB) to the Energy Security and Net Zero Committee inquiry on International climate policy
[52] Royal Society of Biology (2023): Evolving 5-19 Biology: Sustainability Education