GC Insights: Fostering transformative change for biodiversity restoration through transdisciplinary research

Bikem Ekberzade[1], A. Rita Carrasco[2], Adam Izdebski[3], Adriano Sofo[4], Annegret Larsen[5] Felicia O. Akinyemi[6], Viktor J. Bruckman[7], Noel Baker[8], Simon Clark[9], Chloe Hill[9], EGU Biodiversity Task Force[10]

[1] Eurasia Institute of Earth Sciences, Istanbul Technical University, Istanbul, 34485, Turkey.
[2] Centre for Marine and Environmental Research (CIMA), University of Algarve / ARNET- Aquatic Research Network, Faro, Portugal.
[3] Max Planck Institute for Geoanthropology, Jena, Germany, and Jagiellonian University, Krakow, 31-007, Poland
[4] Department of European and Mediterranean Cultures (DiCEM), Università degli Studi della Basilicata, Matera, 75100, Italy
[5] Environmental Science Group, Wageningen University, Wageningen, 6708, Netherlands
[6] Land System and Sustainable Land Management, Institute of Geography, University of Bern, Bern, 3012, Switzerland
[7] Austrian Academy of Sciences, Commission for Interdisciplinary Ecological Studies, Vienna, 1010, Austria.
[8] Royal Belgian Institute for Space Aeronomy, Brussels, Belgium
[9] European Geosciences Union, Munich, 81677, Germany
[10] EGU Biodiversity Task Force, European Geosciences Union, Munich, 81677, Germany

Correspondence to: Chloe Hill (policy@egu.eu)

Abstract

According to a 2019 United Nations' report, of all the known species, up to one million face extinction globally. Despite being considered a pressing global risk with several international efforts to protect and to restore, biodiversity loss and the degradation of ecosystems continue at an alarming rate. In December 2022, COP15 saw the adoption of the Kunming-Montreal Global Biodiversity Framework, where four overarching international goals for biodiversity, and 23 targets were set. While a positive step to addressing the drivers of biodiversity loss, to reach the goals and targets outlined, we will need not just public and political will, but also more effective methods to integrate and use scientific information. To facilitate this, scientists and research institutions need to establish alternative and new approaches to transform the way science is conducted, communicated, and integrated into the policymaking process. This will require the scientific community to become proficient at working in inter- and transdisciplinary teams, establishing connectivity across scientific disciplines, and engaging in the policymaking process to ensure that the best available scientific evidence is not only comprehensible to decision-makers, but also timely and relevant. This commentary details how scientists can embrace transformative change within and outside of their own communities to increase the impact of their research and help reach global targets that benefit society.

Keywords: biodiversity, transdisciplinarity, connectivity, policy

"Calls for 'transformative change' point to the fundamental reorganisation necessary for global conservation initiatives to stem ecological catastrophe. However, the concept risks being oversimplified or overcomplicated, and focusing too little on power and the political action necessary for change" (Fougéres et al., 2022).

Continuous and large-scale degradation of ecosystems by means of anthropogenic interference is one of the many pressures that is leading to irreversible biodiversity loss and, with it, the loss of potential knowledge about the world around us (Wilson et al., 2016). While societal efforts and policy regulations attempting to prevent and restore nature are genuine, they often fall short of meeting their targets. In the EU, for example, 81% of protected European habitats are reported to be in poor condition despite legislation such as Natura 2000, designated under the Birds and the Habitats Directives, that represents the largest coordinated network of protected areas in the world (Naumann et al., 2020). While the four goals and 23 targets outlined in the Kunming-Montreal Global Biodiversity Framework (GBF) (Convention on Biological Diversity, 2023) may catalyse effective action, to achieve this, transformative change and informed governance will be needed.

The Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) defines transformative change as a "fundamental, system-wide reorganisation across technological, economic and social factors, including paradigms, goals and values" (Transformative Change, 2021). Carrying this notion to the intersection of science and policy, we hereby recommend a plural and transformative way to do science by integrating transdisciplinarity, connectivity across disciplines and sectors, and informed policymaking through scientific advice for timely and maximum impact. We understand this

radical shift in our scientific approach will bring with it many challenges; however, this may be our last chance, as noted already more than 20 years ago by Edward O. Wilson, "to bring with us as much of the environment and biodiversity through the bottleneck as possible" (2001); Wilson's "bottleneck" acting here as a metaphor for the anthropogenic stressors on biodiversity, fast closing the window of opportunity for us to reverse this trend.

Thus, we propose meaningful strategic action on biodiversity by establishing biodiversity benchmarks and baseline data for transparency, replicability, and standardisation of the "research language" to foster connectivity across disciplines and sectors; and encourage the research community to actively engage in policymaking to ensure that timely and relevant scientific evidence reaches decision makers.

Methods of promoting transdisciplinarity for transformative change

Transdisciplinarity - being endowed with united knowledge from different fields of science - favours a holistic approach that facilitates a systemic way of addressing challenges across scientific boundaries. Transdisciplinary research, therefore, often seeks to engage stakeholders in meaningful ways throughout the research process (Rigolot, 2020). Comprehending the different levels at which ecosystems function, develop, interact, degrade, and are impacted by anthropogenic processes is fundamental to establishing impactful policies and methods to prevent further degradation and promote effective restoration. By adopting a transdisciplinary approach, scientists are better able to understand the multifaceted dynamics of changing ecosystems, in turn allowing the direct and indirect consequences of these changes to be understood and sustainable strategies to protect, conserve, and restore ecosystems to be identified (Naveh, 2005). However, conducting transdisciplinary scientific research, and in most cases with an

interdisciplinary team, requires both a theoretical and practical transformation in how we conduct our research as scientists: collaborating in diverse groups that encompass various scientific disciplines and sectors while carefully assessing how to achieve effective and usable outcomes through such collaborations.

As outlined by Rigolot (2020), for transdisciplinarity - and with it, interdisciplinary research - to be effective, it must be well planned and effectively implemented. Researchers suggest the transition to a transdisciplinary approach can be accomplished within a framework which recognises that knowledge is organised within a pyramid of four hierarchical layers as shown in Fig. 1. The bottom layer of the pyramid is composed of knowledge within empirical disciplines – the life sciences, Earth sciences, engineering sciences, and social sciences. Collaboration, connections, and communication occur across and between all levels in a process of mutual learning. Understanding the relevance of our own scientific expertise to other scientific disciplines and non-academic sectors can be the first step to thinking and subsequently working in a more inter- and transdisciplinary manner. Interacting with non-academic sectors and joining diverse working groups can also help to break down silos (Knapp et al., 2019). However, for transdisciplinarity to become the norm rather than the outlier, both its challenges (i.e. the time, effort and resources necessary to adapt this approach) and benefits (i.e. a multi-tiered approach to scientific analysis from a wider perspective) need to be recognised by institutions and purposefully incorporated into the way in which the organisation functions.

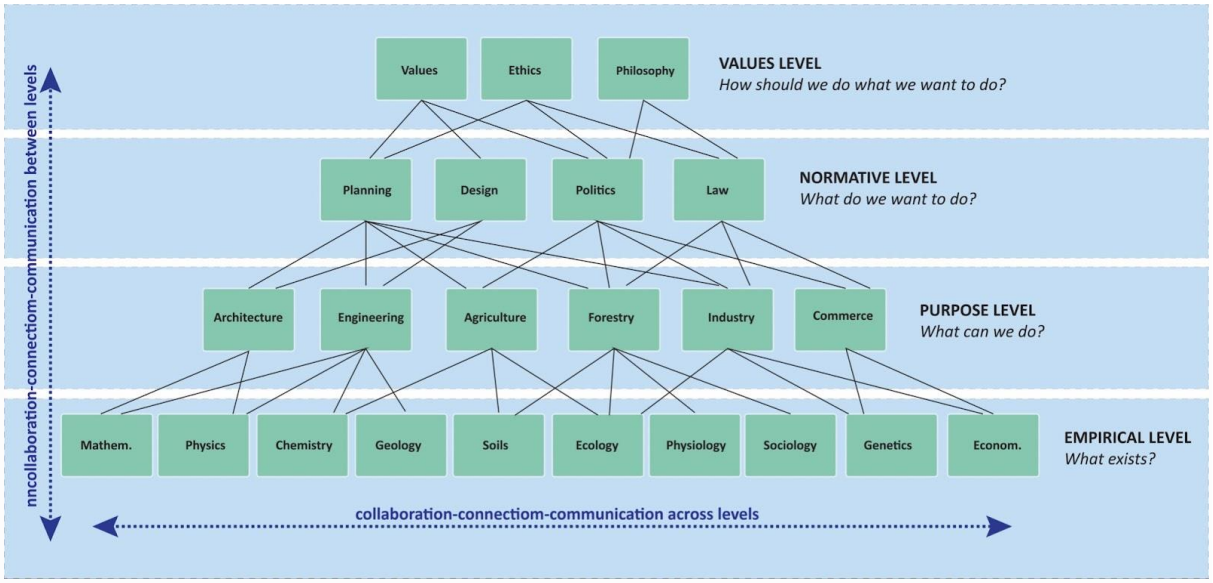

Figure 1. The pyramid of transdisciplinarity: continuous coordination/exchange between all hierarchical levels (adapted from Max-Neef, 2005; relations between tiers are suggestive and may change based on the project at hand).

Embracing connectivity through a systems approach

Connectivity involves multi-layered two-way interactions across science, society, and policy, where feedback from one component or discipline continuously morphs the results of the ones it feeds into. It is, in essence, a basic version of how nature operates: through an efficient feedback mechanism and information exchange, constantly morphing, changing, and evolving. Where transdisciplinarity in scientific practice encourages advances and provides new perspectives (Knapp et al. 2019), one can think of connectivity as the core, where these perspectives can be further shaped, changed, broken, and

rebuilt through continuous feedback. The benefits of connectivity between disciplines and iterative learning processes to scientific practices are further stimulated by transdisciplinarity and interdisciplinary research, and preferably, with the engagement of external stakeholders and community participation (Angelstam et al., 2013).

Engaging stakeholders and society for reversing biodiversity loss has been widely acknowledged by intergovernmental actors (Díaz, 2019) as an integral part of generating change which has enough momentum for transformation and impact. While stakeholder engagement in scientific processes and projects often falls short for conceptional reasons and lack of best practice examples (Lavery, 2018), small scale land practices frequently adopt sustainable approaches that are locally optimised to consider both the needs of the community and their environment. A growing number of studies (Newig et al., 2023; Flanagan et al., 2022; Holifield and Williams, 2019) indicate that considering the needs of the local population, including indigenous communities, through knowledge exchange and assessment provides greater research context, subsequently delivering more relevant and useful outcomes, and for the purposes of this commentary: aids the possibility for transformative change (Fougéres et al. 2022). In the context of the GBF and biodiversity-related goals, this is particularly relevant, as the environmental health of lands that are managed by local and indigenous communities are observed to decline more slowly (Díaz, 2019). Conversely, the atrophy in regional heritage and identity and the loss of local and indigenous knowledge has been shown to have significant adverse effects on biodiversity (Wilder et al., 2016).

The global nature of the biodiversity crisis demands that we transform the way in which we connect and collaborate across political borders to find solutions and achieve the goals and targets set by the

GBF (Convention on Biological Diversity, 2023). Ecosystems may span international boundaries, and nations managing such expansive ecosystems may fail to appropriately account for biodiversity due to conflict or international policy when weighing national interests against those of their neighbours (Dallimer & Strange, 2015). Often fragile ecosystems/biodiversity hotspots, such as the Eurasian grasslands and primary forests, the Sonoran Desert, Amazonia, and the Sahel, adjoin one or more international borders and subsequently, their management demands institutionalised cooperation. For this, it is essential that transboundary cooperation is established among scientists, policymakers, and local and regional authorities, to ensure delegation of responsibilities to facilitate the timely sharing of information, resources, and management approaches. Ensuring greater integration between adjacent nations by means of centralised data monitoring platforms and international forums (Bruckman et al. 2018), promoting dialogue, and encouraging the development of shared interests is vital for building evidence-based policy for greater impact.

More transdisciplinarity is needed for evidence informed policymaking

Embracing transdisciplinarity and connected science can help us define and analyse challenges from multiple perspectives and move towards workable and sustainable solutions. However, to meet the ambitious targets and goals of the GBF, we must also ensure that the underlying issues, various policy options, and their potential consequences are considered by policymakers and integrated into evidence-informed policies. For science advice to be transformative, it needs to be relevant, clear, timely, accessible, and useful to the policymakers who determine the priorities, biodiversity targets, and their implementation (Šucha & Sienkiewicz, 2020). It is therefore vital that scientists and their inter and

transdisciplinary teams understand the information needs of policymakers and the policy landscape in which they operate (Topp et al., 2018).

While organisations such as IPBES continue to produce excellent summary reports for policymakers for this purpose, the integration of science into the policymaking process requires a village rather than just a few individuals or organisations. Policymakers often need context or specific information that is tailored to individual policy discussions and legislations which is relevant to their region and may even need to be in the policymaker's native language. Therefore, it is important that scientific organisations and research institutions recognise their key supporting role in contributing to evidence-informed decision-making at a regional scale. Thus, to participate in and promote transformative change, we encourage the scientific community to not only generate transdisciplinary scientific information, but also to institutionalise the integration of this research into formats (i.e. simple infographics, sharable files, plain word summaries, open data) that are accessible and useful for policymakers. This requires the involvement of individual researchers who are willing to engage with policymakers to understand their needs and share relevant and timely information, as well as scientific institutions that create opportunities and activities for science-to-policy interaction. We encourage readers to consider how they can integrate these important aspects into their work and institutions, and become agents of transformative change.

Team list

Bikem Ekberzade, Eurasia Institute of Earth Sciences, Istanbul Technical University, Istanbul, 34485, Turkey.

A. Rita Carrasco, Centre for Marine and Environmental Research (CIMA), University of Algarve / ARNET- Aquatic Research Network, Faro, Portugal.

Adam Izdebski, Max Planck Institute for Geoanthropology, Jena, Germany, and Jagiellonian University, Krakow, 31-007, Poland

Adriano Sofo, Department of European and Mediterranean Cultures (DiCEM), Università degli Studi della Basilicata, Matera, 75100, Italy

Annegret Larsen, Wageningen University, Wageningen, 6708, Netherlands

Felicia O. Akinyemi, Land System and Sustainable Land Management, Institute of Geography, University of Bern, Bern, 3012, Switzerland

Viktor J. Bruckman, Austrian Academy of Sciences, Commission for Interdisciplinary Ecological Studies, Vienna, 1010, Austria.

Author Contributions

All authors contributed to the conceptualisation of this article and participated in writing the original draft. ARC supported the article's visualisations and formatted Figure 1. BE, ARC, and CH were the most active authors during the reviewing & editing process.

Ethical statement

This article was written and published on volunteered time by the authors. This work was not supported by any funding or grant award. This article did not contain any studies involving human or animal subjects and did not need to undergo ethical review.

Competing interests

The contact author has declared that none of the authors has any competing interests.

Acknowledgements

The European Geosciences Union (EGU) Biodiversity Task Force was established in February 2022. As eight independent experts, we were selected with the aim of creating an interdisciplinary group that would be able to connect with sectors outside of academia and provide clear, timely, and contextualised scientific information to relevant policymakers (EGU's Policy Priority Area 2022-2024, 2022). While incorporating transformative change into a scientific working environment is challenging, we believe that the success that the Task Force has thus far experienced demonstrates that it is possible.

References

Angelstam, P., Andersson, K., Annerstedt, M., Axelsson, R., Elbakidze, M., Garrido, P., Grahn, P., Jönsson, K. I., Pedersen, S., Schlyter,P., Skärbäck, E., Smith M., and Stjernquist I.: Solving Problems in Social–Ecological Systems: Definition, Practice and Barriers of Transdisciplinary Research, Ambio., 42, 254–265, https://doi.org/10.1007/s13280-012-0372-4, 2013.

Bruckman, V., Haruthaithanasan, M., Miller, M. O., Terada, T., Brenner, A. K., Kraxner, F., and Flashpoler, D.: Sustainable Forest Bioenergy Development Strategies in Indochina:

Collaborative Effort to Establish Regional Policies. Forests, 9, 223, https://doi.org/10.3390/f9040223, 2018.

Convention on Biological Diversity, The Kunming-Montreal Global Biodiversity Framework: https://www.cbd.int/doc/c/e6d3/cd1d/daf663719a03902a9b116c34/cop-15-l-25-en.pdf, last access: 20 June 2023.

Dallimer, M., and Strange, N.: Why socio-political borders and boundaries matter in conservation, Trends in Ecology & Evolution, 30, 132-139, https://doi.org/10.1016/j.tree.2014.12.004, 2015

EGU's Policy Priority Area 2022-2024: https://www.egu.eu/policy/biodiversity/, last access: 7 June 2023, 2022.

EGU (2022) EGU Biodiversity Task Force Response to the EU Nature Restoration Law https://cdn.egu.eu/static/6db624ee/policy/biodiversity/Nature_Restoration_Law_EGU_response.pdf Accessed 23 November 2022.

Flanagan NS, Navia-Samboni A, González-Pérez EN, Mendieta-Matallana H (2022) Distribution and conservation of vanilla crop wild relatives: the value of local community engagement for biodiversity research. Neotropical Biology and Conservation 17(3): 205–227. https://doi.org/10.3897/neotropical.17.e86792

Fougères, D., Jones, M., McElwee, P., Andrade, A., and Edwards, S.: Transformative conservation of ecosystems. Global Sustainability, 5, https://doi:10.1017/sus.2022.4, 2022.

Geijzendorffer, I. R., Regan, E. C., Pereira, H. M., Brotons, L., Brummitt, N., Gavish, Y., Haase, P., Martin, C. S., Mihoub, J-B., Secades, C., Schmeller, D. S., Stoll, S., Wetzel, F. T., and Walters, M.: Bridging the gap between biodiversity data and policy reporting needs: an essential biodiversity variables perspective. Journal of Applied Ecology, 53, 1341-1350 https://doi.org/10.1111/1365-2664.12417, 2016.

Holifield, R., & Williams, K.C. (2019). Recruiting, integrating, and sustaining stakeholder participation in environmental management: A case study from the Great Lakes Areas of Concern. Journal of environmental management, 230, 422-433

Transformative Change: https://www.ipbes.net/glossary-tag/transformative-change, Last accessed 23 November 2022, 2021.

Díaz, S., Settele, J., Brondízio E. S., Ngo, H. T., Guèze, M., Agard, J., Arneth, A., Balvanera, P., Brauman, K. A., Butchart, S. H. M., Chan, K. M. A., Garibaldi, L. A., Ichii, K., Liu, J., Subramanian, S. M., Midgley, G. F., Miloslavich, P., Molnár, Z., Obura, D., Pfaff, A., Polasky, A., Purvis, A., Razzaque, J., Reyers, B., Chowdhury, R. R., Shin, Y. J., Visseren-Hamakers, I. J., Willis, K. J., and Zayas, C. N.: Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-

Policy Platform on Biodiversity and Ecosystem, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, IPBES secretariat, Germany, 56 pp., 2019.

Knapp, C. N., Reid, R. S., Fernández-Giménez, M. E., Klein, J. A., and Galvin, K. A.: Placing transdisciplinarity in context: A review of approaches to connect scholars, society and action. Sustainability, 11, 4899, https://doi.org/10.3390/su11184899, 2019.

Lavery, J. V.: Building an evidence base for stakeholder engagement. Science., 361, 554-556, https://doi.org/10.1126/science.aat8429, 2018.

Max-Neef, M.: Foundations of transdisciplinarity. Ecological Economics. 53, 5-16, https://doi.org/10.1016/j.ecolecon.2005.01.014, 2005.

Naumann, S., Noebel, R., Gaudillat, Z., Stein, U., Röschel, L., Ittner S., Davis, M., Staneva, A., Rutherford C., and Romão, C.: State of nature in the European Union, Results from reporting under the nature directives 2013-2018, European Environmental Agency, 107-119 pp., ISSN 1725-9177, 2020.

Naveh, Z.: Epilogue: Toward a transdisciplinary science of ecological and cultural landscape restoration, Restoration Ecology 13, 228-234, https://doi.org/10.1111/j.1526-100X.2005.00028.x, 2005.

Newig, J., Jager, N.W., Challies, E., & Kochskämper, E.: Does stakeholder participation improve environmental governance? Evidence from a meta-analysis of 305 case studies. Global Environmental Change, 2022.

Rigolot, C.: Transdisciplinarity as a discipline and a way of being: complementarities and creative tensions. Humanities and Social Sciences Communications 7(1), 1-5, https://doi.org/10.1057/s41599- 020-00598-5, 2020.

Šucha, V., and Sienkiewicz, M.: Achieving policy impact, in: Science for policy handbook, Elsevier, European Union, 32-42, https://doi.org/10.1016/c2018-0-03963-8, 2020.

Topp, L., Mair, D., Smillie, L., and Cairney, P.: Knowledge management for policy impact: the case of the European Commission's Joint Research Centre. Palgrave Communications, 4(1), 1-10, https://doi.org/10.1057/s41599-018-0143-3, 2018.

Wilder, T., O'Meara, C., Monti, L., and Nabhan, G.: The Importance of Indigenous Knowledge in Curbing the Loss of Language and Biodiversity, BioScience, 66(6), 499–509, https://doi.org/10.1093/biosci/biw026, 2016.

Wilson, E. O.: The Diversity of Life. Penguin, UK, 2001

Wilson, MC, Chen, XY, Corlett, RT *et al.:* Habitat fragmentation and biodiversity conservation: key findings and future challenges. *Landscape Ecol* 31, 219–227 (2016). https://doi.org/10.1007/s10980-015-0312-3