Sustainability Science
https://doi.org/10.1007/s11625-024-01542-1

REVIEW ARTICLE

Biosphere Reserves as model regions for transdisciplinarity? A literature review

Caroline Hélène Dabard[1,2] · Charlotte Gohr[1,3,4] · Fabio Weiss[1,3,5] · Henrik von Wehrden[6] · Frederike Neumann[1] · Solomiia Hordasevych[1] · Bruno Arieta[1] · Jenny Hammerich[1,3] · Caroline Meier[1,8] · Janine Jargow[1,7] · Vera Luthardt[1] · Pierre L. Ibisch[1,4] · Ana Filipa Ferreira[1]

Received: 8 December 2023 / Accepted: 8 July 2024

Abstract

The World Network of Biosphere Reserves promotes learning sites for sustainable development, designated under the UNESCO Man and the Biosphere programme (MAB). The programme aims to strengthen biodiversity conservation, economic development and capacity building. Scientific research in and about Biosphere Reserves is expected to support these objectives. In response to a strong focus on natural sciences and conservation issues, calls for transdisciplinary approaches emanated from science and the newest MAB Lima Action Plan. Yet, the extent and contributions of transdisciplinary research in Biosphere Reserves remains unexplored. This study provides a comprehensive and systematic screening of 3304 scientific publications in and about Biosphere Reserves published since 1975. Research within Biosphere Reserves spans a broad spectrum, encompassing social to political to ecological investigations, with a focus on natural sciences and studies conducted mainly in Europe and Asia. We identified an emerging field of transdisciplinary science in research, represented in 336 publications. Most transdisciplinary studies were conducted in Mexican and Indian Biosphere Reserves. While transdisciplinary research provided insights about participation, management and governance in Biosphere Reserves, its transformative potential could be enhanced, notably through stronger forms of participation of non-academic actors in research processes. Our review suggests strengthening knowledge co-creation about transformative solutions and interventions addressing deep leverage points. Scientific research could thereby enhance the role of Biosphere Reserves as model regions for sustainability transformations.

Keywords Systematic literature review · Leverage points · Protected areas · Transformative research · Participation

Caroline Hélène Dabard and Charlotte Gohr have contributed equally to this work and share first authorship.

Handled by André Derek Mader,Institute for Global Environmental Strategies, Japan.

✉ Caroline Hélène Dabard
caroline.dabard@hnee.de

[1] Biosphere Reserves Institute, Eberswalde University for Sustainable Development, Schicklerstraße 5, 16225 Eberswalde, Germany

[2] Social-Ecological Systems Institute, Leuphana University Lüneburg, Universitätsallee 1, 21335 Lüneburg, Germany

[3] Leuphana University Lüneburg, Universitätsallee 1, 21335 Lüneburg, Germany

[4] Centre for Econics and Ecosystem Management, Eberswalde University for Sustainable Development, Schicklerstraße 5, 16225 Eberswalde, Germany

[5] Cawthron Institute, 98 Halifax Street East, Nelson 7010, New Zealand

[6] Center of Methods and Faculty of Sustainability, Leuphana University, Universitätsallee 1, 21335 Lüneburg, Germany

[7] Fakultät Mathematik und Naturwissenschaften, Technische Universität Dresden, Professur für Allgemeine Psychologie, 01062 Dresden, Germany

[8] Faculty of Philology and History, Augsburg University, Universitätsstraße 10, 86159 Augsburg, Germany

Published online: 09 September 2024

Introduction

Acknowledging the need for integrated approaches to mainstream sustainable development, the UNESCO Man and the Biosphere (MAB) Programme promotes Biosphere Reserves as areas dedicated both to nature conservation and sustainable human development (UNESCO 2017). Biosphere Reserves have three core missions: (1) biodiversity conservation, (2) economic development and (3) logistic support and capacity building, in particular through research (UNESCO 1996). Scientific research is expected to contribute to the other missions, i.e. conservation and development. However, recent reviews have shown that research on Biosphere Reserves has been largely confined to the natural sciences (Kratzer 2018; Pool-Stanvliet and Coetzer 2020). Research conducted in Biosphere Reserves merely used these study sites for a broad range of issues, but hardly focussed on the factors influencing a successful implementation of the MAB Programme (Ferreira et al. 2020; Pool-Stanvliet and Coetzer 2020).

Hence, there is a need for a better appraisal of research contributions to the MAB Programme goals and to the effective management of Biosphere Reserves worldwide. To gain a solid overview of scientific contributions about Biosphere Reserves, there is a need to elicit the evolution of the research over time and its geographic distribution. Furthermore, as the MAB Programme calls for co-production of knowledge, notably with participation of local communities, practitioners and researchers (UNESCO 2017), there is a need to better understand the representativity of scientific production about Biosphere Reserves. Here, we record the relationship between geographic location of study sites and location of author affiliations, as well as gender representation in authorship as means to capture diversity and representativity in scientific production. Indeed, in sustainability science, recent studies have criticized the discrepancy between the geographic location of researchers and their study sites—where researchers from the Global North study the Global South (Brandt et al. 2013; Ghosh 2020; Sultana 2022; Zonta et al. 2023). Furthermore, while sustainability science calls for a better representation of women and minorities, recent findings show that women are still often underrepresented in scientific publications (Hofstra et al. 2020; Zonta et al. 2023). Such an overview is so far lacking for research in Biosphere Reserves. Although other diversity-related aspects are relevant, we focus here on available data on the geographic distribution of study sites versus authors' affiliations and on the gender balance in authorship.

Research is expected to contribute to the MAB Programme goals, yet it seems that most publications have been related to the natural sciences (Kratzer 2018). Against this background, there has been an increasing call to investigate pressing issues related to effective management, governance and participation of relevant actors in Biosphere Reserves (Ishwaran et al. 2008; Ferreira et al. 2020; Barraclough et al. 2023). There is a need for up-to-date evidence about the topics addressed by research in and about Biosphere Reserves.

Scholars have also increasingly called for more co-productive, inter- and transdisciplinary approaches in Biosphere Reserves research (van Cuong et al. 2017; Ferreira et al. 2020; Barraclough et al. 2023). Alongside scholarly voices for transdisciplinarity, the current MAB strategy and its Lima Action Plan also highlight the potential role of Biosphere Reserves in the operationalization of transdisciplinarity sustainability science. In particular, the Lima Action Plan calls for involvement of local communities and relevant actors in Biosphere Reserves, including Indigenous People, women and the youth (UNESCO 2017). Yet, there is still a lack of evidence about the deployment of transdisciplinarity research in Biosphere Reserves worldwide.

Transdisciplinary sustainability research is increasingly expected to promote solution-finding processes for real-world sustainability issues (Kates et al. 2001; Lang et al. 2012; Norström et al. 2020). This field emerged rather recently and encompasses a diverse array of approaches, e.g. participatory research, transformative research or knowledge co-production (Norström et al. 2020; Chambers et al. 2021). In this article, we follow the definition proposed by Lang et al. (2012), in that transdisciplinary sustainability science is "a reflexive, integrative, method-driven scientific principle aiming at the solution or transition of societal problems and concurrently of related scientific problems by differentiating and integrating knowledge from various scientific and societal bodies of knowledge". The following two key features of transdisciplinary research can be highlighted: (1) the combination of different types of knowledge through the participation of non-academic actors (Pohl and Hirsch Hadorn 2008; Talwar et al. 2011; Jahn et al. 2021) and (2) a focus on developing sustainability solutions to real-world problems and thus producing transformative impacts (Lang et al. 2012; Pereira et al. 2020; Chambers et al. 2021; Lawrence et al. 2022).

Regarding the participation of non-academic actors, a stark contrast has been identified between ideal transdisciplinarity (i.e. methodologies committed to strong collaboration and empowerment of non-academic actors) and the widespread application of transdisciplinary approaches, often limited to consultations in the forms of surveys or interviews (Brandt et al. 2013; Zscheischler and Rogga 2015; Jahn et al. 2021). Hence, the level of participation, from consultative to collaborative to empowering (Brandt et al. 2013), as well as the inclusion of various actor groups,

in particular underrepresented groups (Staffa et al. 2022; Caniglia and Vogel 2023), remain common challenges in sustainability transdisciplinary science to date. In Biosphere Reserves research, the limited involvement of non-academic actors has been pointed out as well (Stoll-Kleeman et al. 2010; Reed 2016; Barraclough et al. 2021). Hence, there is a need to better assess which actor groups are involved in transdisciplinary research in Biosphere Reserves—and how deeply they are involved.

As to the transformative impacts of sustainability transdisciplinary research, there is a need for empirical evidence about the deployment and the impacts of transdisciplinarity in Biosphere Reserves. Indeed, it has been suggested that transdisciplinary research may support the successful implementation of the MAB Programme, for example by improving management and enhancing participation (Reed 2016; UNESCO 2017; Ferreira et al. 2020; Barraclough et al. 2023). Few studies examine these issues to date. One example is a comparative study of four co-productive projects in the area of Kristianstad Vattenrike Biosphere Reserve, in Sweden (Malmborg et al. 2022). Here, we follow recent reviews (Brandt et al. 2013; Riechers et al. 2021b; Zimmermann et al. 2023) and examine the transformative potential of transdisciplinary research in Biosphere Reserves in terms of (1) the different types of produced knowledge (systems, target, transformation and process knowledge) (Brandt et al. 2013; Lawrence et al. 2022) and (2) the leverage points addressed, i.e. the potential interventions, policies, innovations or practices and their more or less systemic impacts in focal situations (Meadows 1999, 2012; Abson et al. 2017).

This article aims to provide a comprehensive review of Biosphere Reserves research to date. We address the identified research needs on (1) geographic and temporal evolutions of Biosphere Reserves research, (2) diversity and representativity of research production in Biosphere Reserves, in terms of geography and gender balance, (3) current research topics. With a focus on transdisciplinary research, we also aim to assess (4) the participation of non-academic actors and (5) the transformative potential of transdisciplinary research for Biosphere Reserves. In this article, we refer to Biosphere Reserves research as the research conducted in, with or about Biosphere Reserves. For this purpose, we carried out a systematic literature review in two steps: (1) we analysed 3,304 scientific publications conducted in Biosphere Reserves through meta-data and word occurrence analysis, and (2) we analysed in depth the contributions of 336 publications from the latter, general dataset, which applied transdisciplinary approaches. We aim to answer the following questions:

1. How is (transdisciplinary) Biosphere Reserves research globally distributed and how has it evolved over time?
2. Is Biosphere Reserves research representative in terms of gender balance in authorship?
3. What topics has (transdisciplinary) Biosphere Reserves research addressed so far?
4. Which actor groups participate in transdisciplinary research in Biosphere Reserves and how strongly are they involved?
5. What is the transformative potential of transdisciplinary research in Biosphere Reserves?

Methods

Data extraction

We created a general dataset with publications from the two databases, Web of Science and Scopus, searching for "biosphere reserve*" OR "biosphere region*" OR "biosphere area*" in the title, keywords, abstract and text. We built a transdisciplinary dataset by identifying transdisciplinary publications within the general dataset based on a broad range of keywords (Table S2). The keywords selection followed recent reviews or conceptualizations of transdisciplinary science (e.g. Lang et al. 2012; Brandt et al. 2013; Knapp et al. 2019; Chambers et al. 2021; Schäfer et al. 2021). The raw datasets were cleaned and only publications written in English and including at least one study site in a Biosphere Reserve were selected. The detailed selection process can be found in the supplementary material.

The data extraction and organization were carried out by C.G. The transdisciplinary keywords were selected by C.H.D and approved by all authors. For transparency and accountability purposes, we follow the MeRIT guidelines proposed by Nakagawa et al. (2023) and report throughout the methods section who has contributed to which steps of the study.

Coding

We encoded the selected 3304 publications, including the 336 transdisciplinary publications as follows. First, we identified the geographic location of the study sites and of authors' affiliations, and recorded authors' gender. We then encoded the 336 transdisciplinary publications through a full-text analysis, including the identification of non-academic actors, their level of participation in the research process, knowledge types and leverage points (Box 1).

We tagged the gender of the first and last authors, classified as female or male using genderize.io. Names with a probability of less than 95% accuracy were tagged as

unknown, as proposed by Fox et al. (2019). We acknowledge the limitations and potential bias of this binary gender approach.

For the full text analysis of the transdisciplinary dataset, we encoded non-academic actors involved as authors or mentioned in the acknowledgements, type and level of involvement of actors involved in the study (Ferreira et al 2020; Brandt et al. 2013; Fritz and Binder 2020; Jahn et al. 2021). We categorized produced knowledge types and addressed leverage points of the transdisciplinary publications (Brandt et al. 2013; Lawrence et al. 2022; Dorninger et al. 2020; Riechers et al. 2021a; Zimmermann et al. 2023) (Box 1). See supplementary material for a detailed description and Table S2 for a summary of the review process. The selection of the variables resulted from a test round of coding conducted by C.H.D, C.G., F.W., C.M. and J.H. The final selection of variables was decided by C.H.D, C.G., F.W., H.v.W. and A.F.F. The coding was conducted by: F.N., S.H., B.d.F.A., C.H.D., C.G., F.W., C.M. and J.H. and the data cleaning by C.H.D., C.G. and F.W.

Box 1. Assessing transformative impacts of transdisciplinary publications through knowledge types and leverage points

1. Knowledge types

Different knowledge types have been identified based on the different objects of study in transdisciplinary research (e.g. Hirsch Hadorn et al. 2006; Brandt et al. 2013; Lawrence et al. 2022). Systems knowledge explores the history, root causes and functioning of specific situations and systems, e.g. exploring the root causes of ecosystem degradation. Target knowledge contributes insights into how a situation should or could be, for example studying local actors' preferences towards different land use and management systems. Transformation knowledge explores how to change a situation to the desired outcomes, and how solutions could be implemented, for instance studying how to foster value and behaviour shifts. Finally, process knowledge addresses how to carry out transdisciplinary research, e.g. sharing insights on ethical requirements for transdisciplinary processes or developing new methodologies for participation. In this review, we assumed that transdisciplinary studies have stronger transformative impacts when they produce target or transformation knowledge rather than systems knowledge.

2. Leverage points

Leverage points refer to interventions' shallow or deep impacts on a targeted system, i.e. the capacity of interventions to radically change a system (Meadows 1999, 2012; Abson et al. 2017). For instance, the level of parameters targets very shallow leverage points, such as adapting the level of resource use quota (Fischer and Riechers 2019). These shallow leverage points are rather easy to implement, but have limited systemic impacts. Feedbacks refer to systemic interactions and feedback loops between elements of a system, such as delays and time in which the ozone hole can change after a stop on emissions (Fischer and Riechers 2019). Design leverages are more radical in that they affect information flows, the way systems are structured and organized and the power to change the systems rules, such as changes in policies or self-regulation of communities (Abson et al. 2017). Finally, leverages on the intent level, such as value shifts and institutional change, are more difficult to implement but are expected to have strong systemic, radical outcomes (Abson et al. 2017; Riechers et al. 2022). We categorized transdisciplinary publications according to whether they produced knowledge about interventions targeting parameters, feedbacks, design and/or intent and assumed that transdisciplinary publications have stronger transformative impacts when they address deep (design and intent), rather than shallow (parameters and feedbacks) leverage points.

Data analysis

To identify clusters within the body of literature we examined, we used a multivariate statistical approach first developed by Abson et al. (2014). We created a corpus containing all words within each individual publication and reduced this exhaustive list to words included in at least 5% of the publications. This list was then manually refined to contain only words that transport a meaning, thereby excluding stopwords. Clusters were then derived based on a cluster analysis using Wards method, aiming to identify relatively equally sized groups. Based on an indicator species analysis (Dufrene and Legendre 1997), we identified significant indicator words for each group, which were subsequently visualized in a detrended correspondence analysis. This linguistic analysis was conducted for the whole dataset as well as for the subset of papers containing a transdisciplinary approach. We used the R programming language v.4.3.1 (R Core Team 2023) with RStudio v.2023.06.1 + 524 (Rstudio Team 2023) for all descriptive statistics and analyses. C.G., F.W. and H.v.W. analysed and visualized the datasets.

Results

Research in Biosphere Reserves

Spatial distribution

Our analysis of 3,304 scientific publications showed a research focus on Biosphere Reserves in North America

with 27%, Asia with 25% and Europe with 22% of all publications (Fig. 1). Mexican and Indian Biosphere Reserves were most represented with 825 and 390 publications, respectively (see Box 2). As of 2023, 35% of the 748 Biosphere Reserves designated by UNESCO to date were located in Europe, followed by Asia and North America. The share of publications per continent for the general dataset and the transdisciplinary dataset were relatively indifferent compared to each other. Europe had the highest number of general studies and, together with Mexico, the highest number of transdisciplinary studies. Studies with a transdisciplinary approach were predominantly conducted in Europe, North America and particularly Mexico and India (see Box 2). Having a high number of designated Biosphere Reserves did not translate, however, into a high number of publications in the same country, with Mexico being a notable exception (Fig. S1).

Research in Biosphere Reserves was primarily conducted in the continent of the first author's affiliation (Fig. 2A). The institutions of the first and last authors also tended to be in the same continents. This regional research focus applied to the transdisciplinary publications on Biosphere Reserves as well (Fig. 2B). Nonetheless, a recurrent pattern can be observed: if researchers from Europe and North America study Biosphere Reserves outside of the Global North, they focus on the Asian and African continents; while hardly any researchers from Asia or Africa work in the Global North.

Temporal distribution

The annual number of publications about Biosphere Reserves increased from a few publications during the late 1970s to more than 300 in 2020 (Fig. 3A). Generally, we observed an increasing trend of annually published studies compared to the number of designated Biosphere Reserves, which is highlighted by numbers on the logarithmic scale (Fig. 3B, supplementary material Fig. S4). UNESCO designated substantially more Biosphere Reserves per year starting in the mid-1990s. Participating states can, and did in the past, withdraw a Biosphere Reserve from the world network, if the goals do not comply with the statutory framework or for other reasons (UNESCO 2024).

We explored global trends at the continent level (Supplementary Material, Fig. S2). There have been designated Biosphere Reserves in all continents (excluding Antarctica) since the late 1970s. The number of publications from North America (including Mexico) increased from the mid-1990s,

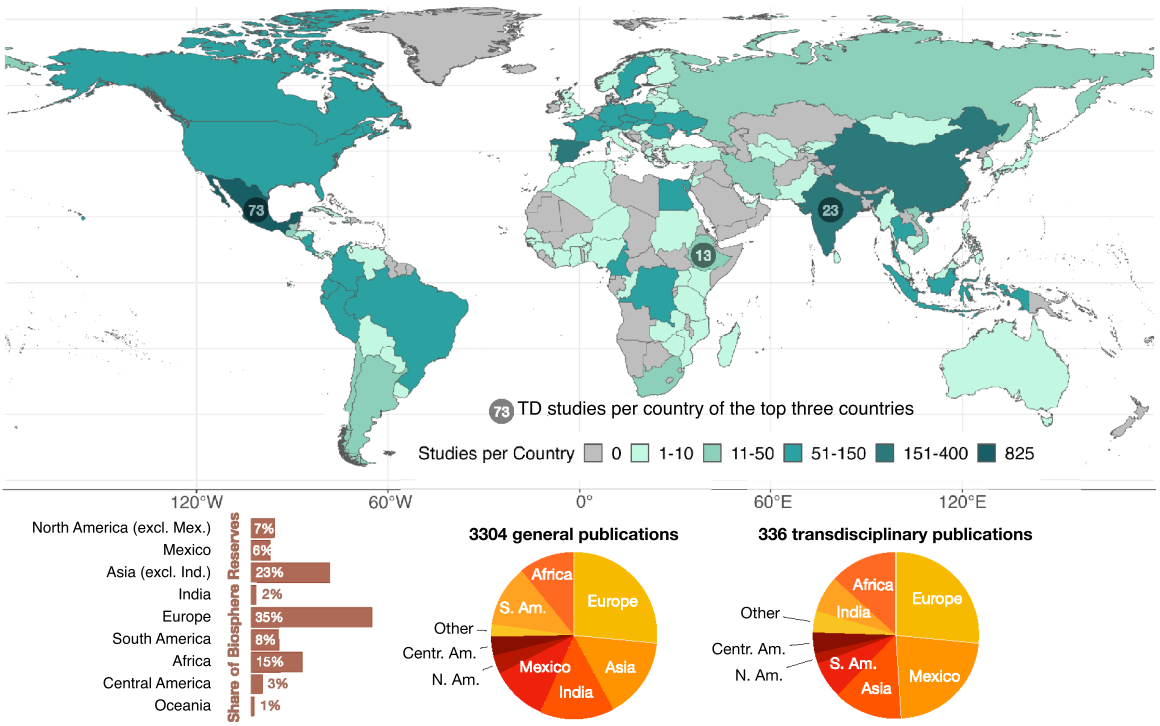

Fig. 1 World map of the general dataset with 3304 publications of research in UNESCO Biosphere Reserves. The colour coding illustrates the number of publications on Biosphere Reserves per country. The two countries with the highest numbers of general studies are India with 390 and Mexico with 825 studies. The countries with the highest numbers of transdisciplinary studies are highlighted: Mexico 73, India 23 and Ethiopia 13. The share of publications per continent for 336 transdisciplinary publications and the general 3304 publications is depicted in the pie charts. Bar plot: Share of Biosphere Reserves per continent considering all 748 designated Biosphere Reserves as of 2023

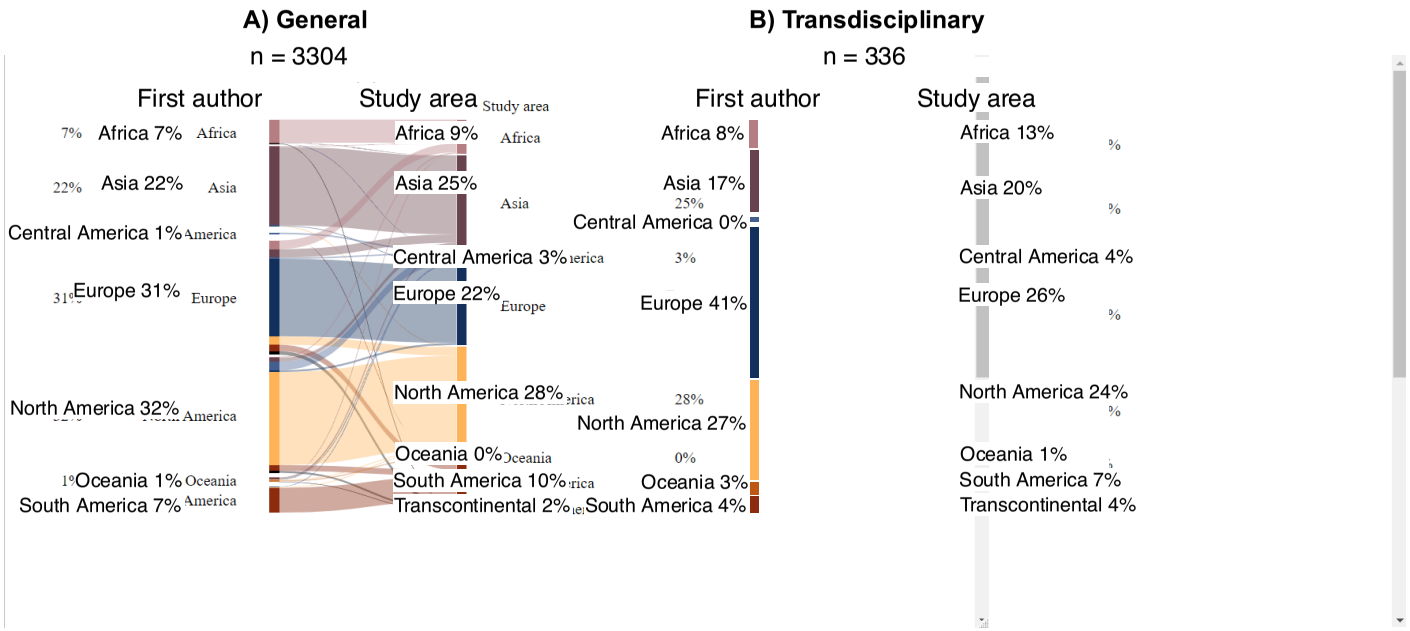

Fig. 2 Geographic location of first authors' institution at the time of publication, in relation to the location of the study areas for **A** the general dataset and **B** the transdisciplinary dataset

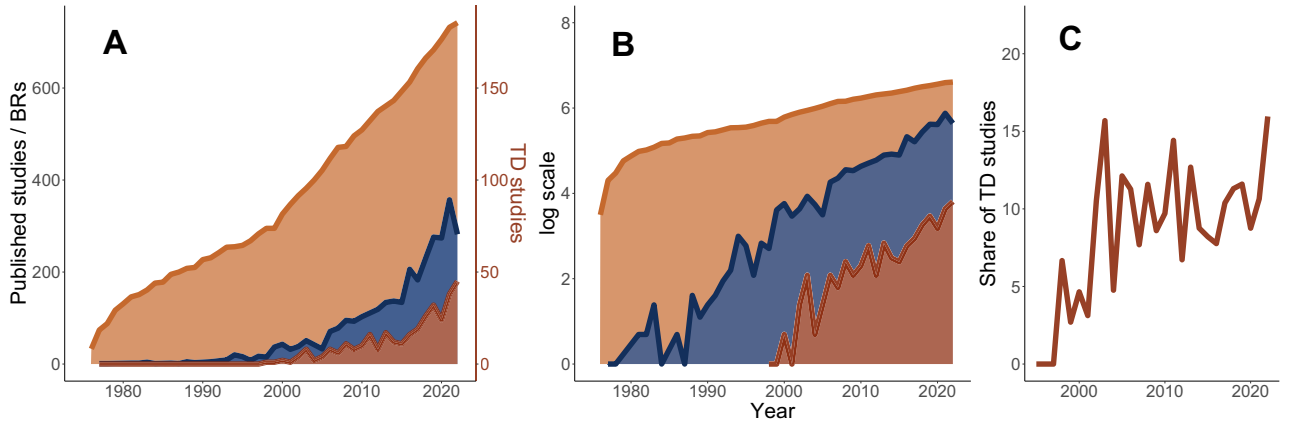

Fig. 3 **A** Cumulative number of designated Biosphere Reserves (BRs) in yellow, annual numbers of general publications in blue $n = 3304$ and transdisciplinary publications (TD) in red $n = 336$ from 1975 to 2023 (note the different *y*-axis scales). **B** The same on the log scale. **C** Share of transdisciplinary publications in the general dataset from 1995 onwards

faster than in other continents, while the number of studies from Europe, Asia (including India) and South America increased only after 2000. Annual publications from African Biosphere Reserves saw only little growth until the mid-2010s, after which they experienced a steep increase. First publications from Central America and Oceania also appeared during the late 1990s and early 2000s, but numbers remain relatively low until today. Overall, there is an overproportional (compared to the share of designated Biosphere Reserves) amount of publications originating from Asian, North American, South American and lately African Biosphere Reserves, while European, Oceanian and Central American Biosphere Reserves tend to be underrepresented in published research. Publications of transdisciplinary studies in Biosphere Reserves increased most notably after 2000 (Fig. 3A in red). The share of transdisciplinary publications to all publications increased over time, but fluctuated over the years (Fig. 3B and C).

Gender representation in authorship

We identified a higher percentage of male first authors (48%) and last authors (55%), compared to female first authors (31%) and last authors (24%) for publications studying Biosphere Reserves (Fig. 4). Female first authors work with male (51%) and female (41%) last authors, whereas male first authors mostly work with male last authors (70%) (see Supplementary Material, Fig. S3A). The pattern was similar across continents, although South America and Asia had higher numbers of female first authors. In South America there were even more female first authors than male first authors. There is likely a geographic bias in these results due to a very high share of unknown gender for Asia, Africa and Oceania. This originates from genderize.io generally showing lower accuracies for non-Western names. With 43% male and 47% female first authors, the ratio for publications with a transdisciplinary approach was closer to parity, although 55% of the last authors were male and only 32% female. Regardless of the continent, the transdisciplinary publications showed a more balanced ratio than the general dataset (see Supplementary Material, Fig. S3B). It shifted not exclusively from male to female author shares, but showed a lower share of unknown gender in the transdisciplinary studies. For additional percentages, see the interactive supplementary material of the online version of this article.

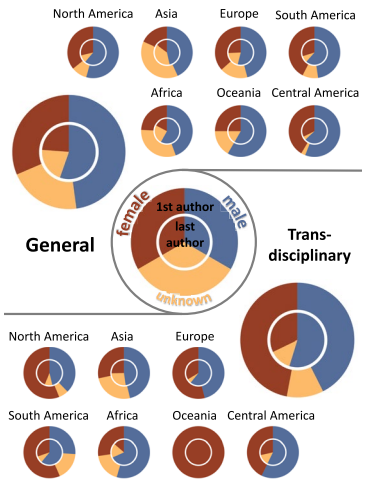

Fig. 4 Share of the gender (binary) of the first and last author for the general dataset (top) and for the transdisciplinary dataset (bottom). Each dataset is visualized with its overall shares (large circles) and differentiated per continent of the study area (smaller circles). Absolute numbers (general/transdisciplinary): overall (3,304/336), North America (924/82), Asia (834/67), Europe (720/89), South America (335/23), Africa (306/44), Oceania (12/3) and Central America (111/14). Transcontinental studies were excluded from this figure

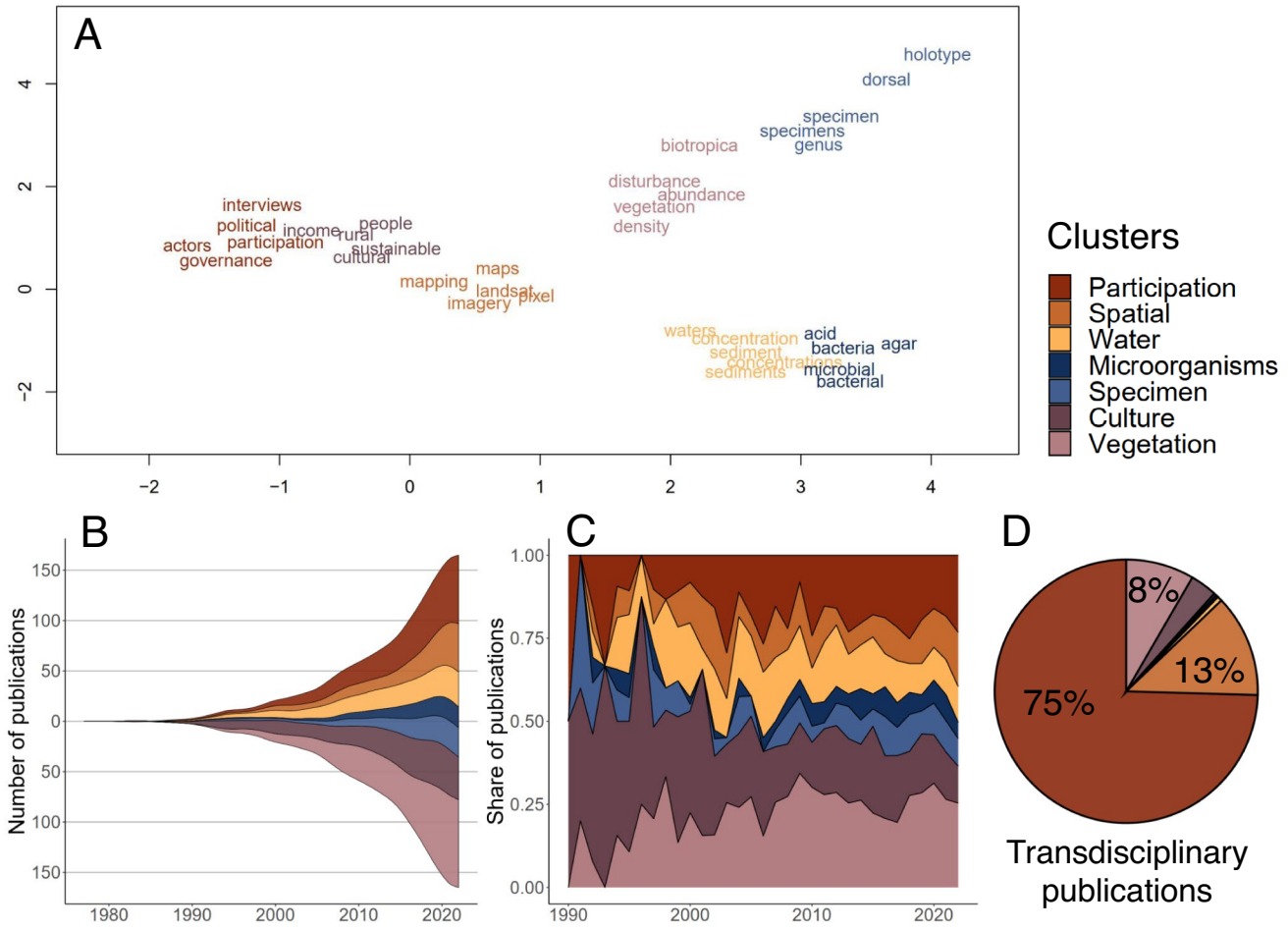

Fig. 5 Research clusters of 3304 publications of research in Biosphere Reserves: **A** Detrended component analysis results of the clusters. **B** Annual total numbers, **C** annual share and a **D** pie chart showing the representation of these groups in the transdisciplinary dataset ($n = 336$) only (top right)

Research clusters

We identified seven clusters best suited to describe the thematic foci of the publications on Biosphere Reserves (Fig. 5A). Publications with a social focus, including words such as participation, interviews or governance, covered similar research areas than publications on perspectives of people and cultural studies. Most of the transdisciplinary publications belonged to the participation group (within the general dataset). Spatial studies, using words such as maps and pixel, were found close to the participation and culture clusters. Publications focusing on the biological environment, including words such as water and sediment, grouped close to microbiological publications, with words such as acid, bacteria or microbial. Botanical studies, represented by words such as vegetation and abundance, were grouped close to studies on genes. The share of publications with a focus on people, using words such as rural, sustainable and cultural (Fig. 5B, C, culture), decreased over time, while the share of publications with words such as participation, governance and actors increased (Fig. 5B, C, participation).

We found more clusters with a focus on natural sciences for publications in the general dataset than for transdisciplinary publications. The transdisciplinary studies were clustered in groups of social and political sciences within the general dataset. Generally, clusters were more delineated and separated in the general dataset than in the transdisciplinary publications.

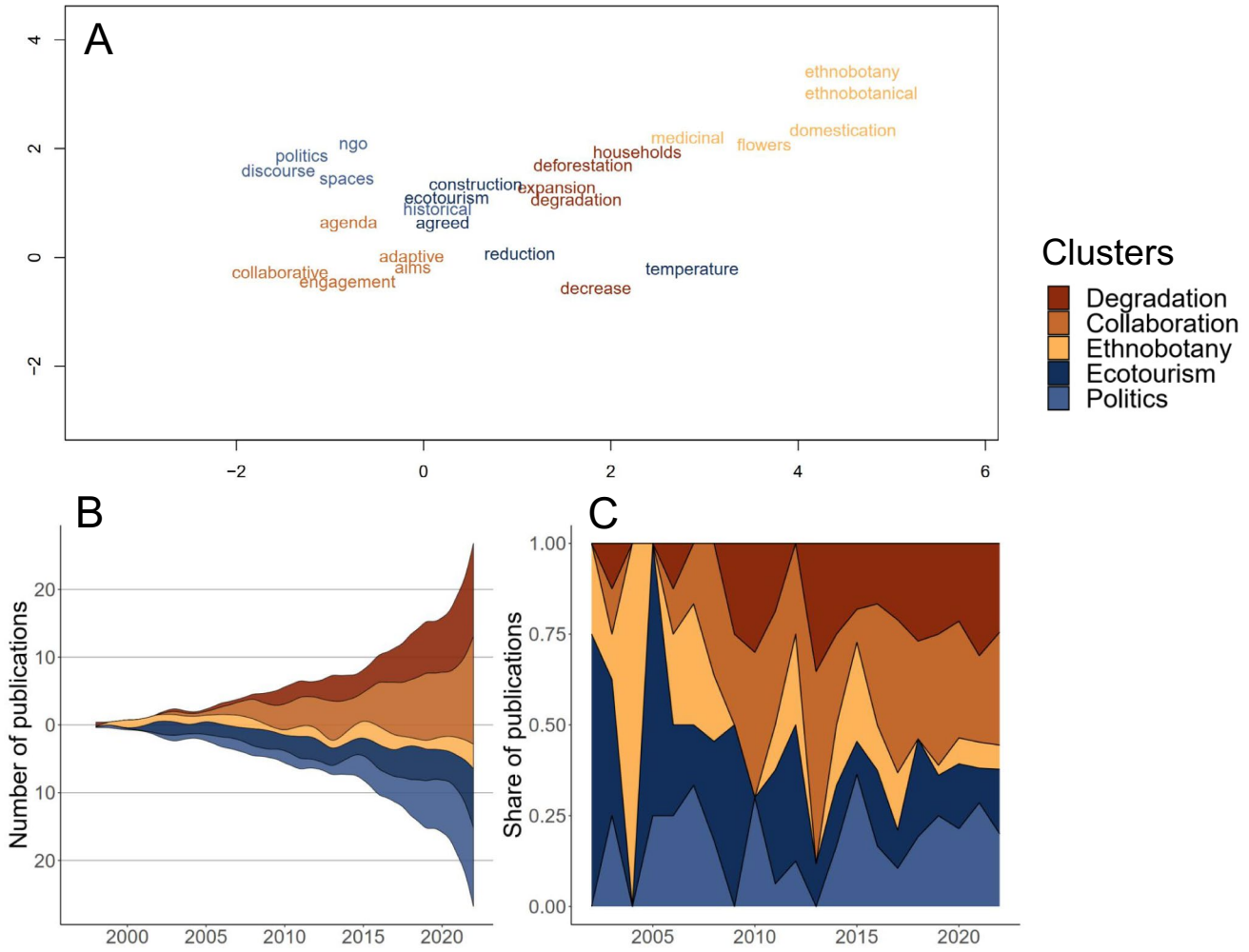

Fig. 6 Research clusters in transdisciplinary publications in Biosphere Reserves ($n = 336$). **A** Word cloud of research fields with five clusters, **B** Annual total numbers and **C** Annual share

We identified five natural clusters best suited to describe the topics of transdisciplinary publications on Biosphere Reserves (Fig. 6A). Research clusters focusing on politics were grouped, while studies on ethnobotany were most distant. Publications tackling deforestation and degradation increased over time (Fig. 6B, C, degradation), as well as those focussing on collaborations and stakeholder engagement (Fig. 6B, C, collaboration).

Actor participation in transdisciplinary research

Land users, Indigenous People, government organizations and Biosphere Reserves management bodies were most frequently involved in transdisciplinary publications on Biosphere Reserves. In comparison, youth and women groups were least frequently involved (Fig. 7). Despite this general pattern, some differences can be identified among clusters of publications. Ethnobotany-related research largely involved Indigenous People and land users, and also showed a higher involvement of women groups compared to other research clusters. Publications included in the politics cluster showed, in general, a higher diversity of actors.

Regarding the extent of participation, actors were predominantly involved in a consultative role (98%). Many studies (41%) built on collaboration with non-academic actors in the study design and only few publications (7%) reported about empowering actors. Fifty-three of the 336 transdisciplinary publications (16%) were (co-)authored by participating actors. Of all publications with a transdisciplinary approach, 51% acknowledged the actors, regardless of the type of participation.

Transformative potential of transdisciplinary research

We identified the creation of systems knowledge for most of the 336 transdisciplinary publications (Fig. 7). Few studies

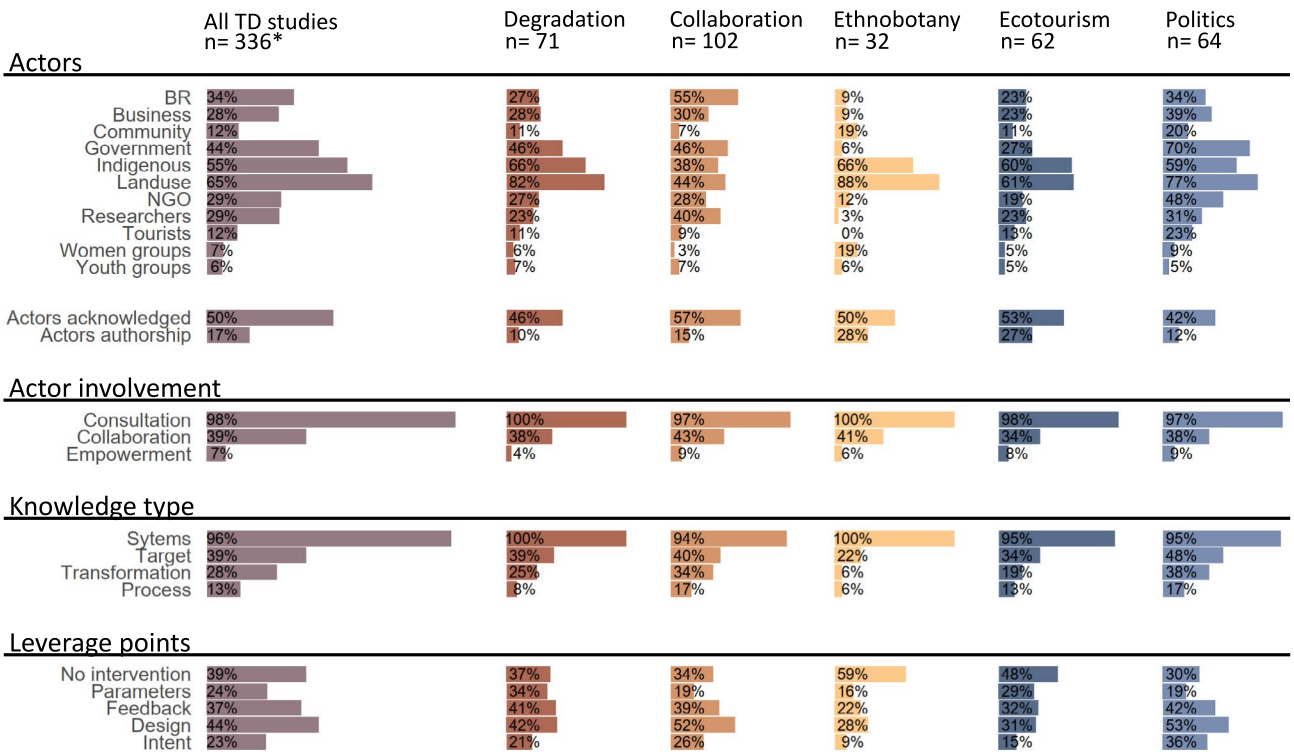

Fig. 7 Shares of actor groups, their involvement type, generated knowledge types and leverage points in transdisciplinary publications, overall (far left) and for the five assigned research clusters. Shares for the categories of the individual variables do not add up to 100% as more than one or none of the categories could be valid for a single study. * Five studies were not assigned to any actor group

produced transformative (28%) or process knowledge (28%). This is reflected in the research clusters as well. Highest shares of target knowledge were identified in the (environmental) degradation, collaboration and politics research clusters. Process knowledge was mainly discussed in the collaboration and politics research clusters.

We found leverage points at a design level in 44% and at a feedback level in 37% of the transdisciplinary publications. Parameters and intent were least studied. A rather large number of studies did not specifically explore any interventions (39%). Patterns were again similar in all research clusters, although the highest shares of design and intent leverage points were found in the collaboration and politics research clusters.

Discussion

Temporal and spatial trends in Biosphere Reserves research

Our results showed that scientific publications about Biosphere Reserves have increased steadily in the last decades, in line with recent reviews (Kratzer 2018; Ferreira et al. 2020). However, the number of publications on Biosphere Reserves can be expected to increase substantially, as the number of scientific publications published annually is generally increasing (Fire and Guestrin 2019). The share of transdisciplinary studies in Biosphere Reserves has increased slightly in comparison to all Biosphere Reserves research, in accordance with a general uptake of transdisciplinary research in sustainability science (Brandt et al. 2013; Ghodsvali et al. 2019). The Seville Strategy, in 1995, recognized the need for more social sciences and humanities in exploring good practices for the implementation of the MAB programme, and the most recent MAB strategy calls for biosphere reserves to operationalize sustainability science using transdisciplinary approaches (UNESCO 2017). While these strategies have set agendas and proposed relevant issues for governance and research, Biosphere Reserves are still widely dedicated to nature conservation (Reed 2016; Pool-Stanvliet and Coetzer 2020)—and Biosphere Reserves research is still more broadly dedicated to natural sciences, in which transdisciplinarity plays a limited role so far.

Spatial trends in Biosphere Reserves research revealed that Europe, North America (mostly Mexico) and Asia (mostly India) contributed most publications, in both the general and transdisciplinary datasets. The particularly high number of publications from Mexico and India has been pointed out in recent reviews (Kratzer 2018; Ferreira et al. 2020). These numerous publications are likely due to funding opportunities from dedicated governmental agencies and specific research institutions with long-standing research history in those areas (Box 2). Although most researchers studied areas on the same continent as their professional affiliation, researchers located in the Global North worked in Biosphere Reserves in the Global South more often than the other way around, as was identified in recent reviews in Biosphere Reserves research (Ferreira et al. 2020), and in transdisciplinary research (Brandt et al. 2013). In Africa, this pattern was even more pronounced for transdisciplinary research, with an even higher proportion of publications than in the general dataset being produced by researchers affiliated to Europe. These results may concur with what has been identified as a neocolonial pattern in scientific publications across many disciplines (Dahdouh-Guebas et al. 2003), in particular in climate and sustainability science (Sultana 2022, 2023), as well as transdisciplinary sustainability research (Zonta et al. 2023). To address power imbalances and neocolonialism in sustainability science, scholars have, for example, proposed strategies to centre knowledge, philosophies and people from the Global South (Chilisa 2017; Sultana 2023)—or methodologies and practices to foster reflexivity, safe spaces, respect and meaningful benefits for communities (Pereira et al. 2020; Thambinathan and Kinsella 2021; Reed et al. 2023). In this regard, we acknowledge that the authors' team is international and interdisciplinary, mostly affiliated in Europe, and that we thus proposed a perspective from the Global North.

Box 2. Focus on Biosphere Reserves research in Mexico and India

With 25% (825 publications) and 22% (73 publications), respectively, scientists from Mexico published the most general and transdisciplinary studies on Biosphere Reserves as compared to all other countries. Of the 41 designated Mexican Biosphere Reserves, Calakmul, La Sepultura, El Viscaino, Sian Kaan and Mariposa Monarca were mostly studied with a transdisciplinary research design with six to ten studies each. There seems to be several catalysts for transdisciplinary research in Mexico: The National Council for Science and Technology in Mexico (CONACYT) subsidized 22 of the 73 transdisciplinary studies with grants and scholarships. 12 transdisciplinary papers were written by scientists of the National Autonomous University of Mexico. Additionally, "El Colegio de la Frontera Sur, Unidad Campeche (ECOSUR)" subsidized 10 of the transdisciplinary papers with knowledge, financial and logistical support.

India has 12 designated Biosphere Reserves and represented 12% of the general publications related to Biosphere Reserves. Remarkably, the MAB programme in India was only launched in 1986 and the first Biosphere Reserve was established in 2000. All 23 transdisciplinary papers on Indian Biosphere Reserves were conducted in five Biosphere Reserves, namely Nanda Devi (11), Khangchendzonga (5), Nilgiri (3), Sunderban (3) and Nokrek (1). The GB Pant Institute of Himalayan Environment and Development alone supported one-third of the transdisciplinary research papers and may therefore act as a catalyst for transdisciplinary research.

Publications on Biosphere Reserves in Mexico and India increased considerably in the last 10 years (Fig. Box 2). In Mexico, UNESCO designated 18 new Biosphere Reserves only in 2006. Both countries are characterized by distinct and highly vulnerable biodiversity, comprising priority regions for global conservation (Olson and Dinerstein 2002). Conservational efforts in both countries are high and research is supported. In Mexico, the National Commission of Natural Protected Areas (CONANP) manages and supports the Network of Biosphere Reserves, protecting in total more than 12% of Mexican land. In India government agencies, such as the Ministry of Environment, Forest and Climate Change and the National Biodiversity Authority provide support for scientific studies and conservation initiatives. The high research output in Mexico and India could be related to external funding as well. Mexico and India are amongst the highest recipients of biodiversity aid. From 1980 to 2008, India was first and Mexico fourth place with 9% and 3%, respectively, of worldwide biodiversity funding (Miller et al. 2013).

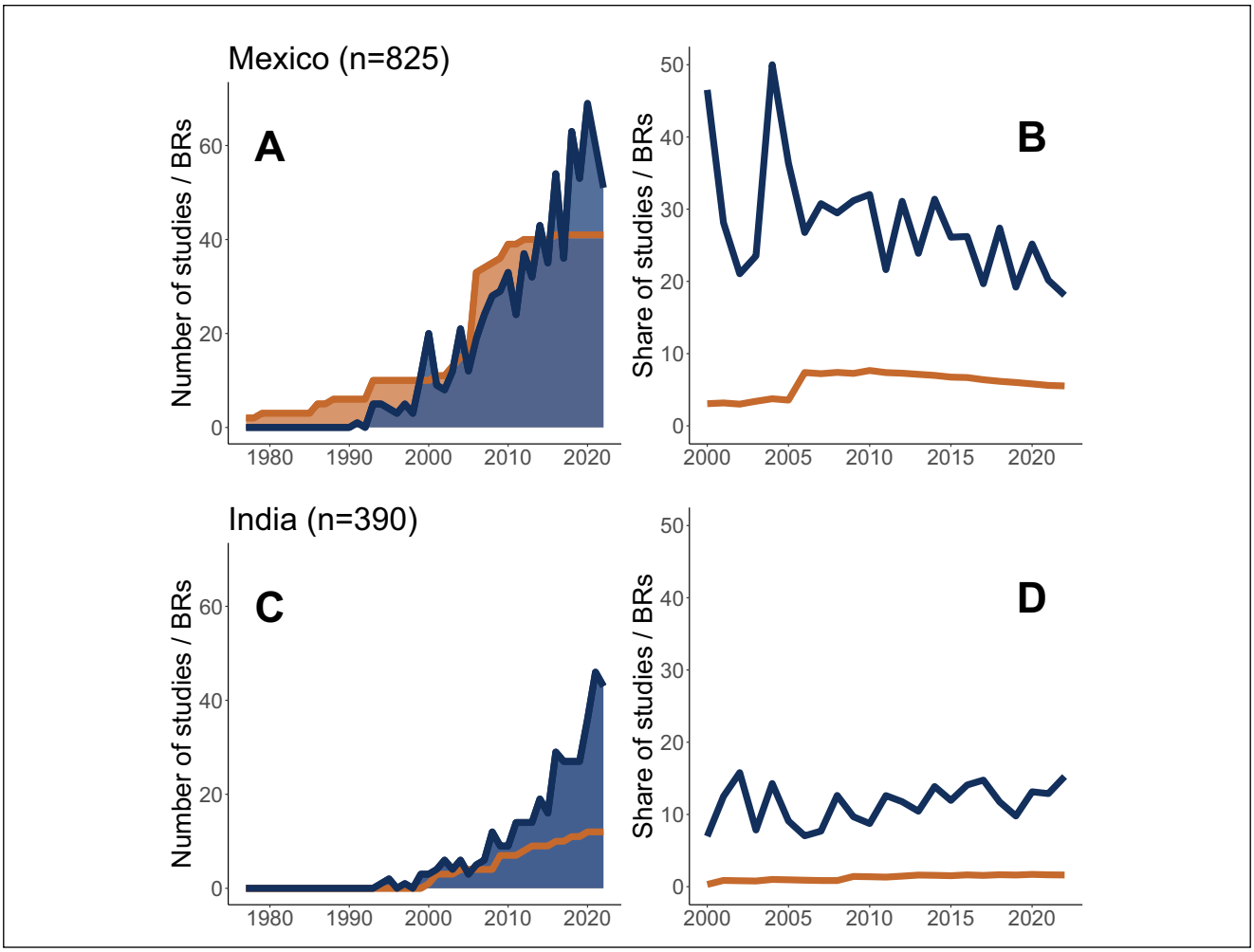

Fig. Box 2 Number of annually published studies in blue and cumulative number of designated Biosphere Reserves in yellow from 1975 to 2023 for Mexico (A) and India (C). Share of annual publications and designated Biosphere Reserves after 2000 for Mexico (B) and India (D)

Gender representation in Biosphere Reserves research

Biosphere Reserves research involved significantly fewer female than male authors across all continents. There were significantly fewer female last authors, often considered as principal investigators (PIs). These results are in line with recent reviews showing that women are still underrepresented in science, especially when it comes to senior positions (Huang et al. 2020; Hofstra et al. 2020; Ross et al. 2022). In transdisciplinary research in Biosphere Reserves, the share of female authors increased remarkably in comparison to the general dataset, although it remained well below parity. Why women proportionally authored more transdisciplinary publications remains unclear. Global reviews have shown that women are better represented in specific disciplines, e.g. political science and psychology (Huang et al. 2020), or brain science and jurisprudence (Holman et al. 2018). However, there is no clear evidence so far, and to our knowledge, about the representation of women in sustainability science, or in transdisciplinary research. Our results call for a stronger commitment to gender equality in (transdisciplinary) Biosphere Reserves research. Many guidelines have been provided to address gender inequalities in science. Examples include feminist and slow scholarship (Mountz et al. 2015), mother-friendly measures within research laboratories (Leventon et al. 2019), policies against early-career dropout (Cardel et al. 2020) and a feminist ethos of care in transdisciplinary sustainability science (Staffa et al. 2022). We acknowledge that gender is only one aspect of diversity and representativity in science and that there is a need to better understand other relevant aspects beyond gender.

Research clusters

The research clusters in the general dataset revealed a disciplinary gradient, from social sciences dedicated to participation and culture, to natural sciences dedicated to species-related studies. However, most clusters included publications investigating topics related to microorganisms, water, species, vegetation and spatial analysis. It is likely that this part of the research mostly contributes knowledge to the conservation mission of the MAB programme, while broadly generating interest and attention about Biosphere Reserves. Note, however, a slight increase in the number of publications dedicated to participation—which in turn might contribute to a better understanding of how to implement the human development mission of the MAB programme. While these results confirm recent findings showing that most research in Biosphere Reserves is still restricted to natural sciences (Kratzer 2018; Pool-Stanvliet and Coetzer 2020), the clusters also pinpointed a potential developing trend towards issues of participation and governance.

Within the general dataset, transdisciplinary publications were located mostly in the clusters related to participation and spatial studies, i.e. closer to clusters related to social sciences. This seems unsurprising, as the call for more transdisciplinarity in Biosphere Reserves is closely related to a need for effective management, acceptance by local communities or participatory governance (Ishwaran et al. 2008; Ferreira et al. 2020; Barraclough et al. 2023).

Transdisciplinary research in Biosphere Reserves also revealed a gradient from publications with a governance focus (politics and discourses) to social–ecological and ecological studies (ethnobotany, domestication, medicinal). Topic-wise, current transdisciplinary research in Biosphere Reserves could be classified into five clusters: ethnobotany, degradation, ecotourism, politics and collaboration. These transdisciplinary clusters were less differentiated than those in the general dataset, suggesting that there are no clear schools within transdisciplinary research in Biosphere Reserves. The politics and collaboration clusters accounted for most publications, with a shared focus on governance.

Therefore, Biosphere Reserves seem to be used merely as interesting and logistically attractive sites to carry out research, rather than as objects of research per se. The analyses also highlighted a coherent, albeit developing, literature bundle aiming to address issues related to Biosphere Reserves governance and management, and to the successful implementation of the MAB Programme and Agenda 2030 for Sustainable Development. There is still much room to explore conditions for successful Biosphere Reserves governance—and to highlight the contributions of the World Network of Biosphere Reserves to support place-based knowledge co-production in sustainability science (Barraclough et al. 2023).

Actor participation in transdisciplinary research

To better understand the participation of non-academic actors in transdisciplinary Biosphere Reserve research, we also analysed which actor groups were involved in transdisciplinary publications and to what extent. Our analysis revealed that land users, governmental and Biosphere Reserve representatives, but also Indigenous People were involved in many studies, regardless of research clusters. It has been shown that transdisciplinary research too often relied on elite participants, e.g. government or large NGOs, while underrepresented groups are often least involved (Turnhout et al. 2020). While this holds true in our study for women and youth, it is remarkable that Indigenous People were involved in more than half of the transdisciplinary studies. Note that Indigenous People, women, the youth and local communities are mentioned as target groups for effective and equitable participatory planning in the most recent MAB strategy (UNESCO 2017). Nonetheless, participation was very limited, usually to extracting information through e.g. interviews, questionnaires or surveys. This transdisciplinary theory–practice gap has been identified in former reviews (Brandt et al. 2013; Jahn et al. 2021). Barriers to collaborative and empowering practices include funding contexts that e.g. require short-term results (Jahn et al. 2021), difficulties in ensuring participation of various actors (Lang et al. 2012; Lawrence et al. 2022) or underlying power relations and conflicts that fail to be addressed (Turnhout et al. 2020; Pereira et al. 2020). The aspirational character of transdisciplinarity has been criticized as an extractive, power-laden and often neocolonial pattern that should be addressed more stringently in research (Zonta et al. 2023). To address this theory–practice gap, guidelines and recommendations have been provided—notably calling for a radical engagement with power relations and conflicts (Ghosh 2020; Turnhout et al. 2020; Pereira et al. 2020; Fritz and Binder 2020; Barraclough et al. 2023). An exemplary study reporting about empowering processes was found in Rivera-Arriaga et al. (2021), who reported about participatory governance processes in collaboration with governmental, scientific and Mayan community representatives, to prevent ecological degradation and address local socio-political issues in Los Petenes Biosphere Reserve (Mexico).

Transformative potential of transdisciplinary research

Our analysis showed that most transdisciplinary studies were limited in their transformative potential. Most studies were restricted to producing systems knowledge, i.e. to understand the current state and root causes of a specific system or issue. This held true for all research clusters. The Ethnobotany cluster produced even less target, transformation or process

knowledge than all other clusters. This cluster seemed to build on citizen science to collect e.g. botanical data and to provide insights based on local people's knowledge, such as Indigenous People and land users. On the contrary, the collaboration and politics clusters featured a stronger transformative potential, with more studies producing target and transformation knowledge. Yet, these results confirm the aspirational character of transdisciplinary research (Brandt et al. 2013; Zscheischler and Rogga 2015; Turnhout et al. 2020) and call for a stronger engagement to produce transformative and solution-oriented knowledge, notably to support Biosphere Reserves management and the successful implementation of the MAB programme (Barraclough et al. 2023). An example of a study producing knowledge about potential solutions for a Biosphere Reserve (target knowledge) can be found in Choudhary et al. (2021), in which strategies are developed for community-based tourism, with the goal to ensure conservation and rural development in the Majang Forest Biosphere Reserve (Ethiopia).

This review showed that transdisciplinary studies had mixed results in addressing concrete interventions for transformative change at different leverage points. For instance, a large part of the publications (regardless of research clusters) did not address any particular intervention, and only a quarter of all studies addressed interventions at intent level or the deepest leverage. These mixed results mirror recent literature reviews on leverage points in research about various social–ecological systems (Dorninger et al. 2020; Riechers et al. 2021a; Zimmermann et al. 2023). The collaboration and politics clusters seemed more impactful than all others, with many studies addressing deep leverage points at design and intent level. While the Lima Action Plan (UNESCO 2017) calls for inter- and transdisciplinary research to better understand how to improve the management and governance of Biosphere Reserves, there is much room to address potential interventions in this regard. Strengthening research that addresses issues of collaboration, politics and governance could enhance this transformative potential and help bridge the gap between the concept of Biosphere Reserves and its implementation. An example of a study addressing deep leverage points can be found in Sharip et al. (2018). The study involves local actors to identify management challenges and formulate recommendations for improved local communication and coordination for environmental protection and governance in the Tasik Chini Biosphere Reserve (Malaysia).

Methodological challenges

Systematic literature reviews face common methodological challenges. Following recent reviews about Biosphere Reserves research (Kratzer 2018; Ferreira et al. 2020) and transdisciplinary research (Brandt et al. 2013; Zscheischler and Rogga 2015; Ghodsvali et al. 2019), we concentrated on publications available to a broad international readership, i.e. written in English in peer-reviewed scientific journals. We acknowledge that publications in other languages might be relevant for a complete overview of global literature to date, notably for transdisciplinary research.

To study diversity in authorship, we followed recent reviews (Fox et al. 2019; Hofstra et al. 2020; Ross et al. 2022) in categorizing authors as female, male or unknown gender based on their first names, using the genderize.io algorithm. Further empirical data would be necessary for a better understanding of authorship diversity and intersectionality. We acknowledge that this algorithm was based on a binary understanding of gender and did not account for other gender identities. This algorithm also revealed a geographic bias, as first names of authors affiliated in Asia and Africa were significantly more often categorized as unknown than in Europe or North America. These results call for more precise and gender-sensitive tools. Furthermore, information about all co-authors would give a more accurate overview, for example for fields where the second author is usually the PI.

Finally, we followed a common procedure in reviewing transdisciplinary research through peer-reviewed publications only (Brandt et al. 2013; Ghodsvali et al. 2019). However, transdisciplinary research still rarely monitors societal impacts in scientific publications (Newig et al. 2019; Jahn et al. 2021; Schäfer et al. 2021) and impacts may become visible only in the long term (Pereira et al. 2020; Chambers et al. 2021). Thus, we acknowledge that gray literature could support a more precise evaluation of the transformative potential of transdisciplinary research (Jahn et al. 2021; Schäfer et al. 2021; Chambers et al. 2021). Our review analysed the research landscape related to Biosphere Reserves and consequently the results are restricted to this branch of science.

Conclusion

The World Network of Biosphere Reserves provides ample opportunities for knowledge co-production about a wide array of sustainability issues and for contributing to global scientific debates with place-based insights. Yet, this review showed that a large portion of Biosphere Reserves research is located on few continents with a focus on natural sciences. Definitely, transdisciplinary research has contributed to exploring the conditions for successful Biosphere Reserves governance. However, there is room for enhancing the transformative potential of Biosphere Reserves research. In this regard, a stronger commitment to gender equality, decolonial practices, empowering forms of participation and knowledge integration about a broader range of topics is

necessary. Further procedures and resources are required to promote transdisciplinarity research by easing data sharing, funding, publication management and supporting collaborations with different Biosphere Reserves' actors (Eberswalde Declaration; Aschenbrand et al. 2023). The formulation of the new roadmap for the MAB Programme for the period of 2025–2035 can constitute a unique opportunity to integrate such principles for transdisciplinary sustainability research in the MAB Programme and in the work of Biosphere Reserves worldwide. This would be essential to transform research *in* Biosphere Reserves towards research *about* and *with* Biosphere Reserves and thereby to highlight them as model regions for sustainability transformations.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11625-024-01542-1.

Acknowledgements We thank Martin Balas for contributing to initial concept development and publication selection trials at an earlier stage of this paper. We thank Jahia Ifill Knobloch and Parker Myers for contributing to the coding of publications. We are grateful for the useful comments of the two anonymous reviewers.

Author contributions Conceptualization: C.H.D, C.G., F.W., H.v.W., A.F.F., J.H., C.M., P.L.I, V.L. Investigation: C.H.D, C.G., F.W., J.H., C.M., F.N., S.H., B.d.F.A. Data curation: C.H.D, C.G., F.W., H.v.W., A.F.F., J.J. Formal analysis: C.G., F.W., H.v.W. Methodology: C.H.D, C.G., F.W., H.v.W., A.F.F. Visualization: C.G., F.W., H.v.W. Funding acquisition: P.L.I., V.L., J.H., C.H.D., C.G., A.F.F. Project administration: C.H.D, C.G., A.F.F. Supervision: C.H.D, C.G., H.v.W., A.F.F. Writing—original draft: C.H.D, C.G., H.v.W., J.J., F.N., S.H., B.d.F.A. Writing—review and editing: C.H.D, C.G., F.W., H.v.W., A.F.F., P.L.I., C.M., J.J., J.H., V.L.

Funding Open Access funding enabled and organized by Projekt DEAL. All authors except P.L.I., V.L. and H.v.W. were funded through the Biosphere Reserves Institute and the Innovation and Career Center "ProBio-LaB" by the Ministry of Science, Research and Culture of the federal state of Brandenburg.

Data availability Data can be made available upon request.

Declarations

Conflict of interests The authors have no relevant financial or non-financial interests to disclose.

References

Abson DJ, von Wehrden H, Baumgärtner S, Fischer J, Hanspach J, Härdtle W, Heinrichs H, Klein AM, Lang DJ, Martens P, Walmsley D (2014) Ecosystem services as a boundary object for sustainability. Ecol Econ 103:29–37

Abson DJ, Fischer J, Leventon J, Newig J, Schomerus T, Vilsmaier U, von Wehrden H, Abernethy P, Ives CD, Jager NW, Lang DJ (2017) Leverage points for sustainability transformation. Ambio 46(1):30–39

Aschenbrand E, Gräbener U, Ibisch PL, Luthardt V, Matias DM, Mutschler LM (2023) Science and research in, for, and with UNESCO biosphere reserves. In: Conference proceedings, including the Eberswalde declaration. Biosphere Reserves Institute, Eberswalde University for Sustainable Development. Eberswalde, Germany

Barraclough AD, Schultz L, Måren IE (2021) Voices of young biosphere stewards on the strengths, weaknesses, and ways forward for 74 UNESCO biosphere reserves across 83 countries. Glob Environ Chang 68:102273

Barraclough AD, Reed MG, Coetzer K, Price MF, Schultz L, Moreira-Muñoz A, Måren I (2023) Global knowledge–action networks at the frontlines of sustainability: insights from five decades of science for action in UNESCO's World Network of biosphere reserves. People Nat 5(5):1430–1444

Bartlett C, Marshall M, Marshall A (2012) Two-eyed seeing and other lessons learned within a co-learning journey of bringing together indigenous and mainstream knowledges and ways of knowing. J Environ Stud Sci 2(4):331–340

Brandt P, Ernst A, Gralla F, Luederitz C, Lang DJ, Newig J, Reinert F, Abson DJ, von Wehrden H (2013) A review of transdisciplinary research in sustainability science. Ecol Econ 92:1–15

Caniglia G, Vogel C (2023) On being oriented: strengthening transgressive orientations in transdisciplinary sustainability research through queer theory. GAIA Ecol Perspect Sci Soc 32(1):167–171

Cardel MI, Dean N, Montoya-Williams D (2020) Preventing a secondary epidemic of lost early career scientists. Effects of COVID-19 pandemic on women with children. Ann ATS 17(11):1366–1370

Chambers JM, Wyborn C, Ryan ME, Reid RS, Riechers M, Serban A, Bennett NJ, Cvitanovic C, Fernández-Giménez ME, Galvin KA, Goldstein BE, Klenk NL, Tengö M, Brennan R, Cockburn JJ, Hill R, Munera C, Nel JL, Österblom H, Bednarek AT, Bennett EM, Brandeis A, Charli-Joseph L, Chatterton P, Curran K, Dumrongrojwatthana P, Durán AP, Fada SJ, Gerber J-D, Green JMH, Guerrero AM, Haller T, Horcea-Milcu A-I, Leimona B, Montana J, Rondeau R, Spierenburg M, Steyaert P, Zaehringer JG, Gruby R, Hutton J, Pickering T (2021) Six modes of co-production for sustainability. Nat Sustain 4(11):983–996

Chilisa B (2017) Decolonising transdisciplinary research approaches: an African perspective for enhancing knowledge integration in sustainability science. Sustain Sci 12(5):813–827

Choudhary CK, Fakana Selemon T, Mengist AB (2021) Conservation of Majang forest biosphere reserve: an opportunity conservation of Majang forest biosphere reserve: south west Ethiopia. Asian J Conserv Biol 10(2):280–296

Coetzer KL, Witkowski ETF, Erasmus BFN (2014) Reviewing biosphere reserves globally: effective conservation action or bureaucratic label? Biol Rev Camb Philos Soc 89(1):82–104

Dahdouh-Guebas F, Ahimbisibwe J, van Moll R, Koedam N (2003) Neo-colonial science by the most industrialised upon the least developed countries in peer-reviewed publishing. Scientometrics 56(3):329–343

Dorninger C, Abson DJ, Apetrei CI, Derwort P, Ives CD, Klaniecki K, Lam DP, Langsenlehner M, Riechers M, Spittler N, von Wehrden H (2020) Leverage points for sustainability

transformation: a review on interventions in food and energy systems. Ecol Econ 171:106570
Dufrene M, Legendre P (1997) Species assemblages and indicator species: the need for a flexible asymmetrical approach. Ecol Monogr 67(3):345
Ferreira AF, Zimmermann H, Santos R, von Wehrden H (2020) Biosphere reserves' management effectiveness—a systematic literature review and a research agenda. Sustainability 12(14):5497
Fire M, Guestrin C (2019) Over-optimization of academic publishing metrics: observing Goodhart's Law in action. GigaScience. https://doi.org/10.1093/gigascience/giz053
Fischer J, Riechers M (2019) A leverage points perspective on sustainability. People Nat 1(1):115–120
Fox CW, Duffy MA, Fairbairn DJ, Meyer JA (2019) Gender diversity of editorial boards and gender differences in the peer review process at six journals of ecology and evolution. Ecol Evol 9(24):13636–13649
Fritz L, Binder CR (2020) Whose knowledge, whose values An empirical analysis of power in transdisciplinary sustainability research. Eur J Futures Res. https://doi.org/10.1186/s40309-020-0161-4
George C, Reed MG (2017) Operationalising just sustainability: towards a model for place-based governance. Local Environ 22(9):1105–1123
Ghodsvali M, Krishnamurthy S, de Vries B (2019) Review of transdisciplinary approaches to food-water-energy nexus: a guide towards sustainable development. Environ Sci Policy 101:266–278
Ghosh A (2020) Deconstructing a 2-year long transdisciplinary sustainability project in Northern universities: is rhetorical nobility obscuring procedural and political discords? Sustain Sci 15(4):1111–1127
Hirsch Hadorn G, Bradley D, Pohl C, Rist S, Wiesmann U (2006) Implications of transdisciplinarity for sustainability research. Ecol Econ 60(1):119–128
Hofstra B, Kulkarni VV, Munoz-Najar Galvez S, He B, Jurafsky D, McFarland DA (2020) The diversity-innovation paradox in science. Proc Natl Acad Sci USA 117(17):9284–9291
Holman L, Stuart-Fox D, Hauser CE (2018) The gender gap in science: how long until women are equally represented? PLoS Biol 16(4):e2004956
Huang J, Gates AJ, Sinatra R, Barabási A-L (2020) Historical comparison of gender inequality in scientific careers across countries and disciplines. Proc Natl Acad Sci USA 117(9):4609–4616
Ishwaran N, Persic A, Tri NH (2008) Concept and practice. The case of UNESCO biosphere reserves. IJESD 7(2):118
Jahn S, Newig J, Lang DJ, Kahle J, Bergmann M (2021) Demarcating transdisciplinary research in sustainability science—five clusters of research modes based on evidence from 59 research projects. Sustain Dev 30(2):343–357
Kates RW, Clark WC, Corell R, Hall JM, Jaeger CC, Lowe I, McCarthy JJ, Schellnhuber HJ, Bolin B, Dickson NM, Faucheux S, Gallopin GC, Grübler A, Huntley B, Jäger J, Jodha NS, Kasperson RE, Mabogunje A, Matson P, Mooney H, Moore B, O'Riordan T, Svedlin U (2001) Environment and development. Sustainability science. Science 292(5517):641–642
Knapp CN, Reid RS, Fernández-Giménez ME, Klein JA, Galvin KA (2019) Placing transdisciplinarity in context: a review of approaches to connect scholars. Soc Action Sustain 11(18):4899
Kratzer A (2018) Biosphere Reserves research: a bibliometric analysis. Ecomont 10(2):36–49
Lang DJ, Wiek A, Bergmann M, Stauffacher M, Martens P, Moll P, Swilling M, Thomas CJ (2012) Transdisciplinary research in sustainability science: practice, principles, and challenges. Sustain Sci 7(S1):25–43
Lawrence MG, Williams S, Nanz P, Renn O (2022) Characteristics, potentials, and challenges of transdisciplinary research. One Earth 5(1):44–61
Leventon J, Roelich K, Middlemiss L (2019) An academic mother's wish list: 12 things universities need. Nature. https://doi.org/10.1038/d41586-019-00019-x
Malmborg K, Wallin I, Brukas V, Do T, Lodin I, Neset T-S, Norström AV, Powell N, Tonderski K (2022) Knowledge co-production in the Helge å catchment: a comparative analysis. Ecosyst People 18(1):565–582
Meadows D (1999) Leverage points: places to intervene in a system. The Sustainability Institute, Hartland, USA
Meadows DH (2012) Thinking in systems. A primer. Taylor and Francis, Hoboken
Miller DC, Agrawal A, Roberts JT (2013) Biodiversity, governance, and the allocation of international aid for conservation. Conserv Lett 6(1):12–20
Mountz A, Bonds A, Mansfield B, Loyd J, Hyndman J, Walton-Roberts M, Basu R, Whitson R, Hawkins R, Hamilton T, Curran W (2015) For slow scholarship: a feminist politics of resistance through collective action in the neoliberal university. ACME 14(4):1235–1259
Nakagawa S, Ivimey-Cook ER, Grainger MJ, O'Dea RE, Burke S, Drobniak SM, Gould E, Macartney EL, Martinig AR, Morrison K, Paquet M, Pick JL, Pottier P, Ricolfi L, Wilkinson DP, Willcox A, Williams C, Wilson LAB, Windecker SM, Yang Y, Lagisz M (2023) Method reporting with initials for transparency (MeRIT) promotes more granularity and accountability for author contributions. Nat Commun 14(1):1788
Newig J, Jahn S, Lang DJ, Kahle J, Bergmann M (2019) Linking modes of research to their scientific and societal outcomes. evidence from 81 sustainability-oriented research projects. Environ Sci Policy 101:147–155
Norström AV, Cvitanovic C, Löf MF, West S, Wyborn C, Balvanera P, Bednarek AT, Bennett EM, Biggs R, de Bremond A, Campbell BM, Canadell JG, Carpenter SR, Folke C, Fulton EA, Gaffney O, Gelcich S, Jouffray J-B, Leach M, Le Tissier M, Martín-López B, Louder E, Loutre M-F, Meadow AM, Nagendra H, Payne D, Peterson GD, Reyers B, Scholes R, Speranza CI, Spierenburg M, Stafford-Smith M, Tengö M, van der Hel S, van Putten I, Österblom H (2020) Principles for knowledge co-production in sustainability research. Nat Sustain 3(3):182–190
Olson DM, Dinerstein E (2002) The Global 200: priority ecoregions for global conservation. Ann Mo Bot Gard 89(2):199
Olsson P, Folke C, Galaz V, Hahn T, Schultz L (2007) Enhancing the fit through adaptive co-management: creating and maintaining bridging functions for matching scales in the Kristianstads Vattenrike Biosphere Reserve, Sweden. E&S. https://doi.org/10.5751/ES-01976-120128
Pereira L, Frantzeskaki N, Hebinck A, Charli-Joseph L, Drimie S, Dyer M, Eakin H, Galafassi D, Karpouzoglou T, Marshall F, Moore M-L, Olsson P, Siqueiros-García JM, van Zwanenberg P, Vervoort JM (2020) Transformative spaces in the making: key lessons from nine cases in the Global South. Sustain Sci 15(1):161–178
Plummer R, Baird J, Dzyundzyak A, Armitage D, Bodin Ö, Schultz L (2017) Is adaptive co-management delivering? Examining relationships between collaboration, learning and outcomes in UNESCO biosphere reserves. Ecol Econ 140:79–88
Pohl C, Hirsch Hadorn G (2008) Methodological challenges of transdisciplinary research. Nat Sci Soc 16(2):111–121
Pool-Stanvliet R, Coetzer K (2020) The scientific value of UNESCO biosphere reserves. S Afr J Sci. https://doi.org/10.17159/sajs.2020/7432
Pool-Stanvliet R, Stoll-Kleemann S, Giliomee JH (2018) Criteria for selection and evaluation of biosphere reserves in support of the UNESCO MAB programme in South Africa. Land Use Policy 76:654–663

Reed MG (2016) Conservation (in)action: renewing the relevance of UNESCO biosphere reserves. Conserv Lett 9(6):448–456
Reed MG, Abernathy P (2018) Facilitating co-production of transdisciplinary knowledge for sustainability: working with Canadian biosphere reserve practitioners. Soc Nat Resour 31(1):39–56
Reed MG, Godmaire H, Abernethy P, Guertin M-A (2014) Building a community of practice for sustainability: strengthening learning and collective action of Canadian biosphere reserves through a national partnership. J Environ Manage 145:230–239
Reed MG, Robson JP, Campos Rivera M, Chapela F, Davidson-Hunt I, Friedrichsen P, Haine E, Johnston ABD, Lichtenstein G, Lynes LS, Oloko M, Sánchez Luja M, Shackleton S, Soriano M, Sosa Peréz F, Vasseur L (2023) Guiding principles for transdisciplinary sustainability research and practice. People Nat 5(4):1094–1109
Riechers M, Brunner BP, Dajka J-C, Duşe IA, Lübker HM, Manlosa AO, Sala JE, Schaal T, Weidlich S (2021a) Leverage points for addressing marine and coastal pollution: a review. Mar Pollut Bull 167:112263
Riechers M, Loos J, Balázsi Á, García-Llorente M, Bieling C, Burgos-Ayala A, Chakroun L, Mattijssen TJ, Muhr MM, Pérez-Ramírez I, Raatikainen KJ, Rana S, Richardson M, Rosengren L, West S (2021b) Key advantages of the leverage points perspective to shape human–nature relations. Ecosyst People 17(1):205–214
Riechers M, Fischer J, Manlosa AO, Ortiz-Przychodzka S, Sala JE (2022) Operationalising the leverage points perspective for empirical research. Curr Opin Environ Sustain 57:101206
Rivera-Arriaga E, Williams-Beck L, Vidal Hernández LE, García Arjona ME (2021) Crafting grassroots' socio-environmental governance for a coastal biosphere rural community in Campeche, Mexico. Ocean Coast Manage 204:105518
Ross MB, Glennon BM, Murciano-Goroff R, Berkes EG, Weinberg BA, Lane JI (2022) Women are credited less in science than men. Nature 608(7921):135–145
Schäfer M, Bergmann M, Theiler L (2021) Systematizing societal effects of transdisciplinary research. Res Eval. https://doi.org/10.1093/reseval/rvab019
Schultz L, Lundholm C (2010) Learning for resilience? Exploring learning opportunities in biosphere reserves. Environ Educ Res 16(5–6):645–663
Schultz L, Duit A, Folke C (2011) Participation, adaptive co-management, and management performance in the world network of biosphere reserves. World Dev 39(4):662–671
Sharip Z, Majizat A, Suratman S (2018) Socio-economic and institutional assessment of Malaysia's first biosphere reserve: Chini Lake. Lakes Reservoirs 23(2):104–116
Staffa RK, Riechers M, Martín-López B (2022) A feminist ethos for caring knowledge production in transdisciplinary sustainability science. Sustain Sci 17(1):45–63
Stanvliet R, Jackson J, Davis G, de Swardt C, Mokhoele J, Thom Q, Lane BD (2004) The UNESCO biosphere reserve concept as a tool for urban sustainability: the CUBES Cape Town case study. Ann N Y Acad Sci 1023:80–104
Stoll-Kleeman S, de La Vega-Leinert AC, Schultz L (2010) The role of community participation in the effectiveness of UNESCO biosphere reserve management: evidence and reflections from two parallel global surveys. Environ Conserv 37(3):227–238
Sultana F (2022) The unbearable heaviness of climate coloniality. Polit Geogr 99:102638
Sultana F (2023) Whose growth in whose planetary boundaries? Decolonising planetary justice in the Anthropocene. Geogr Environ. https://doi.org/10.1002/geo2.128
Talwar S, Wiek A, Robinson J (2011) User engagement in sustainability research. Sci Pub Policy 38(5):379–390
Thambinathan V, Kinsella EA (2021) Decolonizing methodologies in qualitative research: creating spaces for transformative praxis. Int J Qual Methods 20:160940692110147
Turnhout E, Metze T, Wyborn C, Klenk N, Louder E (2020) The politics of co-production: participation, power, and transformation. Curr Opin Environ Sustain 42:15–21
UNESCO (1996) Biosphere reserves: the Seville Strategy and the statutory framework of the world network. UNESCO, Paris, France
UNESCO (2017) A new roadmap for the man and biosphere (MAB) programme and its world network of biosphere reserves. MAB strategy (2015–2025), Lima action plan (2016–2025). Lima Declaration, Paris, France
UNESCO (2024) Designation and review process. https://www.unesco.org/en/mab/wnbr/designation?hub=66369. Last Accessed April 24, 2024
van Cuong C, Dart P, Hockings M (2017) Biosphere reserves: attributes for success. J Environ Manage 188:9–17
Vogel C, O'Brien K (2022) Getting to the heart of transformation. Sustain Sci 17(2):653–659
Walk H, Luthardt V, Nölting B (2020) Participatory learning for transdisciplinary science in biosphere reserves. In: Reed MG, Price MF (eds) UNESCO biosphere reserves. Supporting biocultural diversity, sustainability and society. Routledge, Abingdon, Oxon, New York, NY, pp 297–308
Zimmermann S, Dermody BJ, Theunissen B, Wassen MJ, Divine LM, Padula VM, von Wehrden H, Dorresteijn I (2023) A leverage points perspective on Arctic indigenous food systems research: a systematic review. Sustain Sci 18(3):1481–1500
Zonta AL, Jacobi J, Mukhovi SM, Birachi E, von Groote P, Abad CR (2023) The role of transdisciplinarity in building a decolonial bridge between science, policy, and practice. GAIA Ecol Perspect Sci Soc 32(1):107–114
Zscheischler J, Rogga S (2015) Transdisciplinarity in land use science—a review of concepts, empirical findings and current practices. Futures 65:28–44