


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

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Abstract

1. Generating actionable knowledge to meet current sustainability challenges requires unprecedented collaboration across scales, geographies, cultures and knowledges. Intergovernmental programmes and place-based knowledge–action networks have much potential to mobilize sustainability transformation. Although many research fields have benefited from research networks and comparative sites, the potential of site-based research networks for generating knowledge at the people–nature interface has yet to be fully explored.
2. This article presents the World Network of biosphere reserves (WNBR) of UNESCO's Man and Biosphere Programme, intentionally established for generating actionable knowledge through comparative sites envisioned as learning spaces for sustainable development. Drawing on experiences over five decades, and we offer six categories of insights. Our intent is to share the story of this network widely, distil the learnings from the network to enhance its potential to support both knowledge co-production and collaborative action for sustainability and inform wider efforts to establish place-based sustainability networks aimed at improving human–environment relations through knowledge and action.
3. The WNBR has generated insights on the challenges of creating and supporting an international and inter-governmental sustainability network to generate and mobilize place-based interdisciplinary knowledge in the long term. Despite the challenges, site- and place-based research facilitated by this network has been fundamental in creating space for sustainability science, knowledge co-production and transdisciplinary research at the human–nature interface.

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4. We share insights on pathways to the implementation of global sustainability agendas through local networks, and the role of research in supporting learning and experimentation in local sites as they work to adapt global sustainability goals. Research in the WNBR has generated deeper understanding on social-ecological complexity and resilience in place-based sustainability initiatives, and how collaborative platforms might facilitate collective action across landscapes. The network continues to offer a fundamental learning space on operationalizing pluralistic approaches to biodiversity conservation, for example, through its focus on biocultural diversity, offering a key opportunity for the implementation of the post-2020 Global Biodiversity Framework.
5. We conclude by arguing that WNBR, and similar place-based knowledge-action networks, can support interdisciplinary and transdisciplinary research related to human-nature relationships and provide opportunities for comparative research that may yield more explanatory power than individual case studies.

KEYWORDS

conservation, convention on biological diversity, human-nature nexus, living labs, Man and the Biosphere Programme, social-ecological systems, sustainability science, transdisciplinarity, UNESCO biosphere reserves

1 | INTRODUCTION

Human actions in the Anthropocene challenge the functioning of the ecosystems and the social foundations we depend upon (Fanning et al., 2022; IPBES, 2019). We must strengthen our collective understanding of how shared land- and seascapes can simultaneously meet people's needs and enhance biodiversity and resilience, contributing effectively to the 2030 Agenda (Sachs et al., 2019) and the Convention on Biological Diversity. International networks working for worldwide sustainability are vital to this task, with multilateral and intergovernmental organizations, like the United Nations Educational, Scientific and Cultural Organization (UNESCO), expected to play a key role (Morrison et al., 2020; Nature, 2020; Luo et al., 2022).

The research community has long called for international networks that provide platforms for interdisciplinary, longitudinal and comparative research on sustainability in social-ecological systems (Bai et al., 2019; Liu et al., 2007; Norström et al., 2022; Schneider et al., 2021). Site-based knowledge exchange networks can aid robust and action-oriented science to advance sustainability transformations. In this paper, we argue that an example of such a knowledge-action network for sustainability already exists: the World Network of biosphere reserves (WNBR) established under the Man and the Biosphere (MAB) Programme of UNESCO over the past five decades. This global network of sites (Figure 1, Box 1) has offered lessons about how to put people at the centre of sustainability and conservation actions within and across landscapes, and has helped to define and implement sustainability science, biocultural and rights-centred approaches to conservation and collective environmental action (Mace, 2014; Reed, 2016, 2019; Reed & Price, 2019).

To build on the experiences of this pioneering place-based knowledge-action network for sustainability, in this perspective we review the network's advancements and harness its learnings, offering six categories of fundamental insights from the experiences of the WNBR. We have three motivations. Firstly, we wish to share the story of WNBR with the wider research community, to increase its visibility and collectively reflect on its evolution and insights. Secondly, we wish to distil learnings from the WNBR, to enhance its potential to support both knowledge co-production related to human-environment relations and collaborative action for sustainability. Thirdly, we hope the insights we present here will inform broader research-action efforts at the people and nature interface, supporting the generation of actionable knowledge that will advance transformative thinking and doing for sustainability.

2 | SIX CATEGORIES OF INSIGHTS FROM WNBR

Over five decades, UNESCO's MAB Programme and the WNBR have generated collective understanding on the present and future economic, environmental, ethical and societal challenges of sustainable development, with an explicitly problem-solving approach at multiple scales (UNESCO, 2016). The network of sites has also offered key platforms at the landscape level that informed the evolution of sustainability science, defined here as research that advances understanding of social-ecological systems with a focus on actionable knowledge, gained by co-producing and weaving scientific, traditional and Indigenous knowledges in a transdisciplinary way (Miller et al., 2014). In the following section, we present and reflect

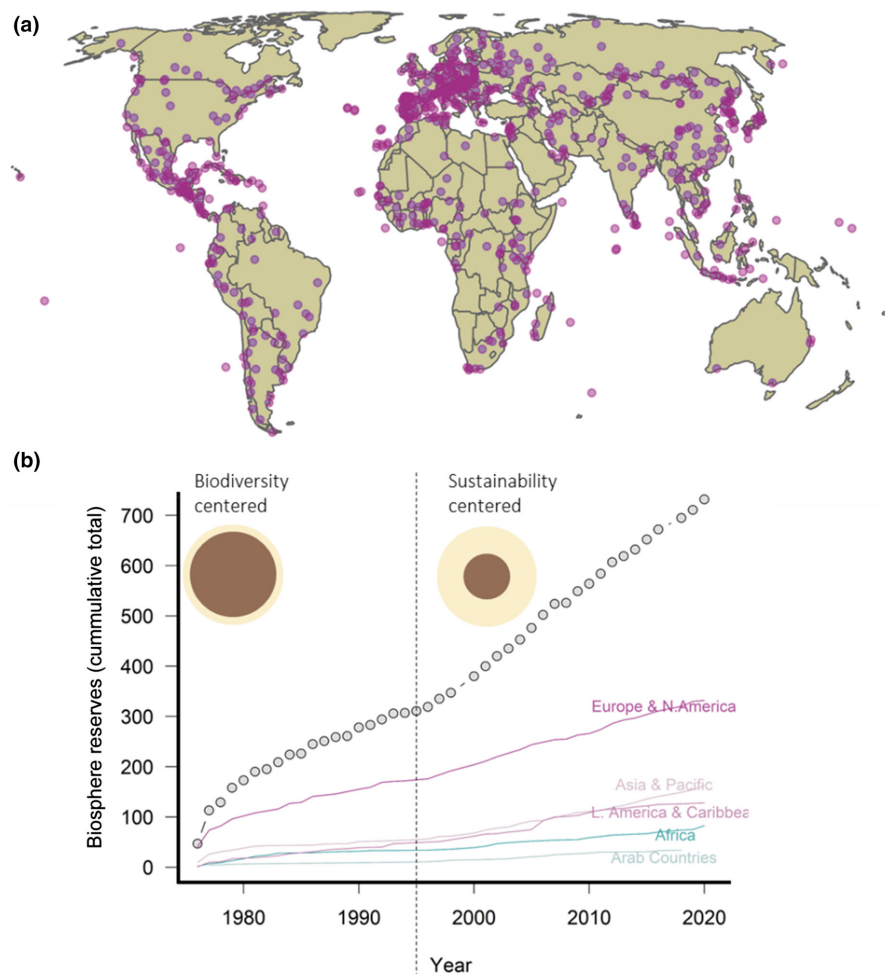


FIGURE 1 A network dedicated to sustainability, (a) map showing the extent of the World Network of biosphere reserves (2022), where (b) representation has steadily increased since the 1970s, and nomination has accelerated since the introduction of the Statutory Framework in 1995 which brought forward the focus on sustainability, where depicted circles represent the changing zonation model with more area (lighter colour transition areas and buffer zones) with sustainable development functions in addition to core protected areas (darker circles).

on key insights drawn from five decades of the programme under six themes. Each section begins with a short background on the programme itself and the WNBR, and then turns to key insights under each theme.

2.1 | Insights from creating and supporting an international sustainability knowledge-action network

2.1.1 | Background

The MAB Programme was first established to facilitate interdisciplinary, and problem-driven research on the interrelationships between people and nature. This was implemented through 14 project areas, which focused on major physiographical units (e.g. mountain regions, tropical forests) and on specific impacts or processes deemed to be of global significance, for example, human perceptions of the environment or the use of pesticides (Moreira-Muñoz et al., 2020). During these initial stages, scientists and UNESCO staff worked to develop an international network of representative ecosystems with different types and levels of human influence: Biosphere reserves (BRs). BRs were to serve as sites for research, biodiversity conservation, monitoring, education and training (UNESCO, 1970, 1971).

While most closely associated with the research area supporting biodiversity conservation, BRs were designed to support research across multiple themes and so host problem-oriented, interdisciplinary research and training (Reed & Price, 2019). A notable aspect was to encourage training of the 'next' generation of environmental researchers in the Global South. By the 1990s, the MAB research areas were disbanded, leaving the network of BRs as the central component of the MAB Programme (Reed & Price, 2019).

In 1995, the vision for BRs became more clearly articulated in the newly adopted Statutory Framework for the WNBR and the complementary 'Seville Strategy' (UNESCO, 1996; see Box 1). UNESCO argued that this marked the transition when the MAB Programme became more practice and management-focused, with a shift from a classical conservation science focus to a broader sustainability focus (UNESCO, 2007). Over time, the WNBR grew, and additional sites were designated because of the interest by local people to create a platform for sustainability at the landscape scale (Reed & Massie, 2013). Although coordinated international research activities decreased, this was a time when a new type of problem-focused sustainability researcher doing research in BRs emerged (Reed, 2019). These researchers worked across natural and social sciences on the sustainability of social-ecological systems; engaged in participatory and action research with BR practitioners, Indigenous and local peoples; and researched questions related

BOX 1 The MAB Programme and the World Network of biosphere reserves in a nutshell

The UNESCO established the Man and Biosphere (MAB) Programme in 1971. Its contours were first articulated at the 1968 intergovernmental and international 'Biosphere Conference' hosted by UNESCO and attended by multiple UN bodies. The purpose of the conference was to promote the establishment of an international and intergovernmental scientific programme that would help explain the effects of human activities on or in the biosphere. The designers of the MAB Programme were determined that it would be different from previous research programmes, which focused on ecological change while excluding human engagement (such as the International Biological Programme). The MAB Programme captured this intention by placing humanity at the forefront of the Programme's title.

Since MAB designated the first biosphere reserves (BRs) in 1976, the world network of these sites has grown to 738 BRs in 134 countries, including 22 transboundary sites as of 2022. The extent of the network is significant, making up almost 5% of global terrestrial area, covering all major biome types on Earth, with circa 270 million people living within them (Figure 1). Biosphere reserves are intended as model sites or 'learning places for sustainable development' (<https://en.unesco.org/biosphere/about>), where biodiversity conservation and human development are simultaneously pursued, and where social-ecological learning of about human-environment relations through collaboration and knowledge sharing is a central goal (Figure 1). The three formal functions of BRs were laid out in a key document, the 1995 Statutory Framework of the WNBR, which defines these functions as: *Biodiversity conservation, sustainable development and logistic support for research and capacity building*. In addition to making sustainability a key function of BRs, the Framework also defines the territorial spatial zonation structure of BRs (three zones with varying degrees of human use), and a requirement for periodic review. These amendments were made to ensure that human activity is a fundamental aspect of BRs, and the sites have the necessary management structures and processes to achieve their goals. For a more extensive historical and political background of BRs and the MAB Programme, readers are referred to Bridgewater 2015.

to environmental governance, civic participation and resilience of social-ecological systems. Sustainability priorities in the WNBR—such as addressing climate change, ecosystem services, urbanization and bringing local and Indigenous knowledge to bear on research and practice—continued to be reinforced in subsequent action plans (Madrid Action Plan 2008–2013 [UNESCO, 2007] and Lima Action Plan 2016–2025 [UNESCO, 2016]). However, despite growing interest by citizens in establishing BRs and the increased focus of the network on sustainability science and practice, the financial and logistical support for coordinated scientific research in BRs and the scientific networks promised with the establishment of the programme never truly materialized.

2.1.2 | Insights

Interdisciplinary site-based sustainability networks need consistent institutional support and collaboration across scales and sectors

The MAB Programme's evolution has exposed the challenges and opportunities of developing an international sustainability research and cooperation network. Unequal levels of governmental support of the Programme's different objectives at a national level across different countries and institutional biases within academia against interdisciplinary research (Heberlein, 1988) hindered the flourishing of problem-driven research. Developing theme-driven networks and undertaking comparative research within intergovernmental programmes are often costly, time-consuming and need leadership. Thus, maintaining research-action networks and removing barriers to problem-oriented and interdisciplinary research require strong coordination of academic, governmental and intergovernmental

institutions; appropriate recognition for this kind of research; and support by adequate resources and funding.

Sustainability knowledge-action networks need iterative and adaptive processes to synchronize their scope to current challenges, fed by both on-the-ground concerns and emerging high-level priorities

Although their impact has been limited, the MAB Programme has adapted its priorities at an institutional level through successive 'action plans' for the WNBR which set priorities for research and action. However, as in other large inter-governmental bodies, the process of priority setting continues to be cumbersome, lacks implementation at a national level and has not always been considered responsive. The process of priority setting has, nevertheless, been facilitated through transdisciplinary research which encourages a more agile co-production of knowledge and alignment of research agendas with local concerns. We propose that networks need agile, participatory and responsive priority setting across scales, and the ability to mobilize resources at all levels to ensure that priority areas are addressed in time.

Place-based research in sustainability sites has been fundamental in creating space for action-oriented sustainability science

Notwithstanding the challenges mentioned above, the 'sustainability turn' in the MAB Programme opened up space for a new kind of sustainability scholarship and mentored a new generation of budding sustainability scholars who became attracted to research in BRs. The evolution of the Programme demonstrated that research and practice sites can provide for both 'basic' research and 'use-inspired' research (Clark, 2007; Kates et al., 2001), and are appropriate spaces

for the evolution of transdisciplinary research. Indeed, BRs offered place-based spaces for knowledge co-production and helped scientists shift towards a deeper positioning of science for society (Miller et al., 2014; Wall et al., 2017), making fundamental contributions to the birth of sustainability science (Reed, 2019).

2.2 | Insights from long-term knowledge generation and mobilization in a sustainability knowledge–action network

2.2.1 | Background

Supporting knowledge generation and mobilization has been a central vision of WNBR since its inception. BRs aim to support scientific research and public education by engaging local citizens, managers, scientists and Indigenous Peoples (Bridgewater, 2015; Reed, 2016; Schultz et al., 2011). They are envisioned as 'learning sites' for sustainable development: sites where environmental change can be monitored, and practices or policies 'tested'. For example, BRs were proposed as key elements of a global network of 'geosphere-biosphere observatories' with a 'Biosphere Reserve Integrated Monitoring System' (BRIM), when international coordinated research on global change began in the 1980s (Drius et al., 2019; Dyer et al., 1988; Stoll-Kleemann et al., 2008). BRIM was largely ineffective. Similarly, proposals for BRs to become field sites within the Global Terrestrial Observing System (UNESCO, 1994) never materialized. However, in line with the programme's research objectives, BRs have still been the subject of wide-ranging scientific study, and published research on and in BRs has increased since the 1990s. A search in *Web of Science* reveals 5629 publication hits for the term 'Biosphere Reserve*', in contrast to 114 hits for 'Integrated Conservation and Development Project*' (All Fields; Search date December 2022). An online journal devoted specifically to research in and on BRs—the *International Journal of Biosphere Reserves*—was established in 2017, and the first comprehensive global and research-based book on BRs was published in 2020 (Reed & Price, 2019) with contributions from more than 65 authors. A bibliometric analysis (Kratzer, 2018) found a global coverage of BR publications, with the highest numbers of papers coming from Mexico, USA, India, Spain, China and Australia. The majority of studies used BRs as research sites, rather than as an object of study in themselves.

Despite the research surrounding BRs, challenges remain in establishing a visible and durable international science network working in and with BRs. While national scientific networks for the MAB Programme exist in a few countries (e.g. France, Japan, Sweden), as well as thematic networks such as those on islands and coasts, and on mountains (Clüsener Godt et al., 2022) or reference sites within the International Hydrological Programme (Bridgewater, 2021), coordinated international research on BRs is limited. This lack of visibility of the WNBR and its potential hampers opportunities for scaling up actionable knowledge generated by this network (Reed, 2016). In our opinion, this may be because in the last three decades, the

Secretariat and International Coordinating Council (ICC) of the MAB Programme and the national committees responsible for national level implementation have generally given a far greater emphasis to growing and maintaining the network of sites than on maintaining and strengthening networks of scientists working towards the goals of the MAB Programme. In many ways, it has become more of a 'sites' programme, comparable to those of UNESCO's other international site designations (e.g. World Heritage Sites and UNESCO Global Geoparks), which do not have a specific focus on research and monitoring (Carter et al., 2022). At the time of writing, there is still no shared public database which gathers unified data collected in and on the WNBR, although this is a current priority area within the MAB Programme (Bouamrane 2022, pers.comm.). Nevertheless, the Lima Action Plan (UNESCO, 2016) includes specific actions to establish an international, interdisciplinary and transdisciplinary scientific network within the MAB Programme, and to develop a research and knowledge exchange agenda and partnerships between BRs and research institutions. Recent efforts have been made to accelerate progress of these objectives by the international scientific community working in BRs, during the International Research Conference on biosphere reserves in 2022, which produced The Eberswalde Declaration (The Eberswalde Declaration 2022, https://en.unesco.org/sites/default/files/mab-icc-34-annex_natreprt_ger_eberswalde-declaration.pdf). The declaration called on all levels of governance, from international to national, as well as research institutions, to strengthen science, Indigenous and other knowledge systems, and research in, for and with BRs, emphasizing the innovative contributions of young people and Indigenous communities.

2.2.2 | Insights

Long-term reliable research infrastructure and support is required to facilitate continuity in the work of longitudinal and global knowledge–action networks for sustainability

Lack of coordinated research and appropriate infrastructure for long-term data storage and sharing has hampered the ability to extract long-term and large-scale learnings from the WNBR. This contrasts with other fields where long-term monitoring infrastructure, such as curated databases, has facilitated longitudinal studies of ecological or geophysical dynamics. Social–ecological systems research should improve standardization of longitudinal approaches as other fields have done, navigating the balance between capturing complexity and allowing for standardization (Reyers et al., 2022). Knowledge–action site-based sustainability networks also have the potential to capitalize on advances in Open Science and Big Data that can enable a fine-scale picture of the state of the biosphere (International Science Council, 2020). The big data revolution in site-based research could improve our capacity to harness knowledge on sustainability transformations, as well as facilitate novel approaches for local actors to engage with science, as both data collectors and knowledge co-producers, for example, through long-term citizen science projects (Carter et al., 2022; Nilsson et al., 2017).

Inter- and transdisciplinary projects raise additional challenges for long-term monitoring and data collection

Despite the power of longitudinal and big data approaches, the diversity of knowledges, interests and responsibilities resulting from inter- and transdisciplinary projects raises ethical, technical, financial and logistical challenges for storing, transferring and sharing data and information. The sense-making of the data and information collected by inter- and transdisciplinary actors across WNBR is embedded within the complex space of different disciplinary needs, understandings, contexts and biases—making long-term storage and usage complex. Data sharing is made complex by issues related to privacy and consent of human participants in social–ecological studies, intellectual property rights and local and Indigenous protocols (Carlson et al., 2017). There are no easy answers to ‘how’ such data should be collated and managed, but the need to co-create data policy guidelines for networks like the WNBR is clear. Nevertheless, we must navigate these challenges if we are to integrate big data approaches including both ecological and societal sustainability dimensions to foster holistic system understanding, and support more effective science–policy interfaces (Mastrángelo et al., 2019).

2.3 | Insights on knowledge co-production, interdisciplinary and transdisciplinary sustainability science

2.3.1 | Background

Biosphere reserves have been fundamental testing grounds for interdisciplinary and transdisciplinary knowledge co-production, exploring the potential of research and practice sites to mobilize knowledge across the science–policy–practice spectrum (Reed, 2016). Long before sustainability scientists adopted the terminology of ‘transdisciplinary’, scientists working in BRs were considering how to involve local people, rural and Indigenous communities in achieving conservation, development and research objectives (Reed, 2019). During its first decades, there was ample evidence of the MAB Programme’s success in catalysing innovative and interdisciplinary (and sometimes transdisciplinary) collaborative research and building research capacity around the world, with a series of 28 books published from 1989 to 2002, and numerous key publications (Hadley, 2006). The current MAB Strategy for 2015–2025 includes facilitation of participatory approaches to sustainability science in one of its four strategic objectives, declaring that ‘BRs, particularly through their coordinators, managers and scientists, have key roles to play in operationalizing and mainstreaming sustainability science’ (UNESCO, 2016). Clearly, contemporary architects of the MAB Programme support the practice of sustainability science and seek meaningful transdisciplinary research partnerships between sustainability practitioners and scientists.

In practice, research has shown that BRs provide platforms for mutual and collective learning through close cross-sectoral relationships (Schultz & Lundholm, 2010). However, the capacity to

share BR lessons for sustainability beyond their specific context is often limited, and challenges remain in drawing more generic lessons across sites. While researchers working with BR practitioners have developed novel and robust strategies of engagement for the production of knowledge (Reed & Massie, 2013), the history of involving Indigenous Peoples and local communities (IPLCs) in BR research and practice has been mixed (Barraclough, Schultz, et al., 2021; Batisse, 1986; Ferreira et al., 2020; Koy et al., 2019; Reed & Price, 2019). In addition, institutional and practical barriers remain to interdisciplinary and transdisciplinary scholarship and the establishment of long-term relationships between researchers and practitioners. Research programmes in BRs have exposed: the different timescales at which practitioners and researchers work; the scale mismatch of problems and solutions as experienced by local communities versus those researched by scientists; and challenges in defining roles, goals and processes in co-production processes (Malmberg et al., 2022).

2.3.2 | Insights

Knowledge–action networks need long-term inter- and transdisciplinary knowledge co-production partnerships and processes

The WNBR has shown the potential of long-term relationships between research institutions and BR sites to produce impactful transdisciplinary collaborations, for example, success stories of long-term collaboration between university UNESCO Chairs and local BRs experienced by the authors (Box 2). The development of trust through long-term partnerships is a challenging aspect to transdisciplinary processes (Roux et al., 2017), yet essential to facilitating participation and collaboration within sustainability projects, and building mutually reinforcing connections between partners and stakeholders, rights holders, scientists and the population at large. Research in BRs has shown that, for the full potential of learning sites for sustainability to be realized, these relationships must be supported with work capacity and incentives for evaluation and communication of lessons learned.

Engaging local and Indigenous peoples responsibly and ethically raises serious methodological questions for sustainability scientists

Research efforts to avoid the ‘bad Anthropocene’ suggest a need to include and value Indigenous and local peoples and knowledges within all aspects of the science–policy interface (Dryzek & Pickering, 2018; Tengö et al., 2017; Wehi et al., 2021). This issue was raised when the MAB Programme was first conceived and remains a challenge. Engaging with Indigenous knowledge and epistemologies is challenging, requiring a transformation in how science is conceived, executed and evaluated. This will require fundamental changes in how we organize our research (Kealiikanakaolehailani & Giardina, 2016; Smith, 2019; Tengö et al., 2014), including: decolonizing research practices in ecology and concepts of nature stewardship more broadly; ensuring more inclusive research practice

BOX 2 Learning spaces for sustainability

The interdisciplinary graduate School of Environment and Sustainability at the University of Saskatchewan officially partnered with Redberry Lake Biosphere Region in 2012 to support their mutual interests in biodiversity conservation, sustainable development and capacity enhancement. Since then, students, faculty and practitioners have supported 12 student projects (topics include collaborative management/governance, sustainable agriculture, biodiversity protection in 'working' landscapes and sustainability education), over 20 publications and presentations and 10 videos or mass media that promote their work. Additionally, between 2011 and 2019, a collaborative field school introduced 186 students to the region and the purpose and efforts of Biosphere Regions. Some students have since been hired on for short or longer term projects with the Biosphere Region or other similar sustainability organizations.



that supports Indigenous self-determination; meaningful dialogue of knowledges between stakeholders and rights holders with different worldviews and dissimilar access to power and decision-making (Leff, 2004; McElwee et al., 2020; Reed et al., 2020; Trisos et al., 2021). Engaging in new practices might also come into conflict with the desire to support solutions based on large-scale synthesis and 'big data' as Indigenous and local peoples express their rights to determine the terms of knowledge sharing (Wiegleb & Bruns, 2022).

2.4 | Insights on implementing global sustainability agendas through local networks

2.4.1 | Background

The MAB Programme is not prescriptive in the governance model to be applied in individual BRs, allowing for flexibility and, potentially, learning-by-doing, in view of specific socio-economic and political circumstances (Pool-Stanvliet & Coetzer, 2020a, 2020b). Consequently, a diversity of governance approaches exists both within and across countries in the WNBR, with variable

operational successes (Barraclough, Schultz, & Måren, 2021; Van Cuong et al., 2017). Interviews with people engaged in BR implementation indicate that the concept holds a range of local meanings, and that BRs help people navigate the real-world messiness of pursuing sustainability (Schultz et al., 2018). The diversity of governance approaches across the WNBR has been considered a major 'asset [of] the MAB Programme' (UNESCO, 2021). However, challenges in implementing the BR concept reflect the complex realities of implementing cross-scale and cross-sector sustainability projects, such as the difficulties practitioners face in adapting global policy frameworks to diverse local contexts and the long time required to establish a multi-use region in which diverse stakeholders work together (Price, 2002). Thus, BRs have exposed the difficulties in implementing multifaceted projects requiring the collaboration of multiple, sometimes overlapping, institutions (Barraclough, Schultz, et al., 2021), particularly where development pressures persist (Coetzer et al., 2014), local governments are antagonistic (Mercer & Hyman, 2009), local citizens do not buy-in (Yuan et al., 2008) and governance arrangements lack sufficient funding or capacity (Schliep & Stoll-Kleemann, 2010). In addition, BRs must move to implement global and national sustainability agendas while grappling with the same environmental conflicts found globally, such as overexploitation of forests, land use changes, extensive wildfires, urban sprawl, corruption and illicit economies (Gonzalez-Duarte, 2021; Moreira-Muñoz et al., 2020).

The periodic review process established in the 1995 Statutory Framework aims to ensure that all members of the WNBR, particularly older sites, fulfil the three complementary and mutually reinforcing functions of BRs (conservation, sustainable development and logistics; Bouamrane et al., 2019; Price, 2002). However, translating the diversity of BR meanings, visions and agendas into standardized systems that assess the achievements of BR organizations, monitor their success and foster learning for future practice across the three functions has been a fundamental challenge in the MAB Programme (Reed & Egunyu, 2013). However, progress is being made, with many countries and regions experimenting with specific selection and evaluation criteria for improving the performance of their national BR networks (Pool-Stanvliet et al., 2018; UNESCO, 2021), encouraging network members to become more *intentional* and *systematic* in both the designation and the contextual interpretation of MAB ambitions for local implementation.

2.4.2 | Insights

Multilateral initiatives must outline some basic principles supported by legal and institutional frameworks while allowing for context-specific actions at local and national levels

The absence of a governance 'blueprint' in BRs provides lessons on navigating the complexity of localizing global sustainability ambitions (Plummer et al., 2017). State-sponsored ('top-down') governance models may offer considerable operational security to local governance initiatives by providing access to financial, logistical

and legal resources, particularly in contexts where stronger legal or institutional support is required. However, challenges arise for operational autonomy when tensions exist between the needs of local experimentation and the requirements of governing legislation (Reed & Price, 2019). These limitations can become particularly problematic in contexts where there is local distrust linked to social-political memory of land dispossession, neo-colonial fears and perceptions of top-down restrictions on land access and use. Community-led ('bottom-up') governance models and their initiatives can be advantageous by strengthening local participation and trusting relationships. However, these governance models may lack implementation authority and consequently, depend on other institutions to implement actions (UNESCO, 2021). More research is needed to develop governance theories and practices that inform experimentation in institutional and legal flexibility across scales, to find models which simultaneously enable local experimentation while ensuring basic standards of sustainability practice.

Balancing compliance monitoring with experimentation and learning is fundamental to localizing global sustainability agendas

The intentional flexibility around governance within the MAB Programme has demonstrated opportunities for cross-cultural learning, institutional experimentation, innovation and agility, hence fostering resilience and adaptive capacity (Edge & McAllister, 2009). The periodic review process in BRs has shown the importance of supporting models that enable continued learning and experimentation to help adapt and change the form of local sustainability initiatives (Reed & Egunyu, 2013). Balancing compliance monitoring with learning can help national and regional networks become more effective and responsive to the demands of a transforming world. Responsive review processes which encourage mutual learning can increase project relevance and longevity, with continued 'support from responsible partners for the maintenance and development of these sites' (Pool-Stanvliet et al., 2018). Thus, sustainability initiatives should support compliance monitoring, while simultaneously encouraging systematic efforts to evaluate practices, and reflect, and share lessons learned (Reed & Egunyu, 2013).

2.5 | Insights on social-ecological complexity and resilience in place-based sustainability initiatives

2.5.1 | Background

Research about BRs, with and by BR practitioners, has made limited but important contributions to the development of fundamental concepts within the sustainability science and social-ecological systems literature. Biosphere reserves have helped develop our understanding of resilience in social-ecological systems, such as the role of participation in environmental governance (Herrero, 2017; Ishwaran et al., 2008; Schultz et al., 2015; Schultz & Lundholm, 2010; Van Cuong et al., 2017), adaptive approaches to co-management (Plummer et al., 2017; Schultz et al., 2011) and social and place-based

learning (Reed & Massie, 2013). For example, a case study of Kristianstads Vattenrike BR in Sweden as part of the Millennium Ecosystem Assessment highlighted the role of local stewards in the generation of ecosystem services (Schultz et al., 2007) and identified the importance of bridging organizations for initiating, coordinating and maintaining adaptive co-management and adaptive governance (Hahn et al., 2006; Olsson et al., 2007). Two global surveys of BR coordinators enabled unique quantifications of the relationships between adaptive co-management, stakeholder participation and management success (Schultz et al., 2011; Stoll-Kleemann et al., 2010). The studies found, for example, that involvement of local communities increases the likelihood that BRs meet development goals, without compromising conservation success. One of the surveys also identified the different ways in which BRs can act as learning sites for sustainable development (Schultz & Lundholm, 2010), a study that was later deepened in a comparison of learning accounts from 177 participants in 11 BRs (Schultz et al., 2018). Research has also used BRs as case studies of landscape-scale initiatives where networks of collaborating actors establish bridging and bonding structures to achieve sustainability outcomes (Bodin, Baird, et al., 2020), contributing to our understanding of conflict and cooperation in environmental management (Bodin, García, et al., 2020).

2.5.2 | Insights

Adaptive governance and management are facilitated by bridging institutions that facilitate participatory processes and increase social-ecological resilience across landscapes

Research in BRs has shown the importance of adaptive co-management and governance for increasing social-ecological resilience through ongoing cycles of action and reflection, enabled through participation, long-term collaborations and learning feedback loops. Participatory processes in environmental governance open the possibility to explore and increase the synergies between social and environmental sustainability while navigating trade-offs. These insights offered by BRs are essential for moving towards more pluralistic, dynamic and rights-based approaches to biodiversity conservation (see Section 6).

Landscape-scale sustainability institutions can be fundamental global instruments to promote collective action across administrative and political boundaries, and stakeholder networks

BRs have been explicitly formulated with land-use multifunctionality in mind, enabling collaboration through diverse actor networks engaged in landscape management (Hedden-Dunkhorst & Schmitt, 2020; Malmberg et al., 2021; Pool-Stanvliet & Coetzer, 2020a, 2020b). Key landscape-scale institutions, operating as 'relational hubs', where local citizens, researchers and public and private organizations work together, have been found to be critical in shaping collective action (Cockburn et al., 2020). Relational hubs also offer platforms for complementarity and harmonization of sustainability policies,

and initiatives within a defined landscape space (Pool-Stanvliet & Coetzer, 2020a, 2020b). Yet, such multifunctional landscapes present opportunities for both collaboration *and* contestation owing to a plurality of stakeholder values, goals, power imbalances and divergent land-use needs (Barraclough et al., 2022; Cusens et al., 2022). In this respect, sites like BRs can have key relational roles that help shape the context of collaboration and the potential of collaborative outcomes that generate social-ecological learning (Schoon et al., 2021).

2.6 | Insights on operationalizing new conservation narratives for the post-2020 Global Biodiversity Framework and beyond

2.6.1 | Background

How to incorporate BRs into international biodiversity policy has been a longstanding debate between International Union for the Conservation of Nature (IUCN), UNESCO and the scientific and practitioner community at the nexus of sustainability and conservation (Barraclough, Reed, et al., 2021; Bridgewater et al., 1996; Price, 2017). We argue that the BR vision sits at the heart of the debate between different approaches to biodiversity conservation (Gavin et al., 2018; Kareiva & Marvier, 2012; Sutherland & Woodroof, 2009), and of calls for 'new conservation narratives' that address the failure of conservation agendas to achieve their targets (Louder & Wyborn, 2020). The debate between different, and sometimes opposed, conservation narratives is ongoing, for example, the 'Half Earth' initiative provides a current example of an 'ecocentric narrative' (Louder & Wyborn, 2020). Such ecocentric narratives have received criticism for not explicitly accounting for the impacts of protected areas on the rights of local and Indigenous peoples (Schleicher et al., 2019); promoting an essentialized and westernized version of nature, and the tacit dualistic view of humans and nature (Ellis, 2019; Mace, 2014). Further evidence shows that strictly protected areas are not necessarily more effective in conserving biodiversity than areas in which multiple human uses are permitted (Coetzer et al., 2014), and can displace pressure to areas outside the protected area, disrupt traditional management systems and result in the displacement of traditional custodians and opening up of land for proliferation (Gonzalez-Duarte, 2021). In addition, protected areas have been criticized for their failure to address underlying drivers of biodiversity loss, such as global capitalism (Brockington et al., 2008) and to acknowledge the contribution of Indigenous Peoples to biodiversity conservation (Garnett et al., 2018). This debate characterized the negotiations of the new Global Biodiversity Framework's proposed target of 30% of terrestrial areas formally protected (CBD, 2021) raising concerns on the risks of area-based targets particularly for the recognition of the rights of IPLCs (Kubiak, 2020; Tauli, 2022).

The MAB Programme anticipated the essence of this debate with its vision of 'Breaking the Glass: Opening Conservation to Man' presented during its 10th anniversary in 1981 (see [Supplementary Material](#)), establishing a model of conservation which moved beyond a 'fortress conservation' model and considered sustainable resource

use by local communities. Biosphere reserves have been explicitly implementing this vision since 1996, more recently through an enhanced focus on *biocultural conservation*, in tandem with a wider involvement of UNESCO with this topic through UNESCO-SCBD Joint Program on the linkages between cultural and biological diversity (CBD and UNESCO, 2014). Biocultural approaches address the loss of both biological and cultural diversity, and emphasize their interdependence via coevolution processes, common threats and geographic overlap (Gavin et al., 2015), and these approaches have developed and matured in the BR network (Bridgewater & Rotherham, 2019; Reed & Price, 2019). Despite these advances, incorporating multifunctional landscapes and biocultural diversity into biodiversity policy remains a challenge. For example, IUCN and the World Conservation Monitoring Centre specifically exclude BRs from lists and databases (Bridgewater et al., 1996; IUCN, 1994; Price, 2017). Although there are advances in the recognition of diverse landscapes, such as IUCN type VI (protected areas with sustainable use of natural resources) and recently defined 'Other Effective Area-Based Conservation Measures' (OECMs; Gurney et al., 2021), challenges in integrating approaches which acknowledge human use of landscapes remain (Barraclough, Reed, et al., 2021). This challenge is shared, not just by BRs but also by other designations with a focus on local and Indigenous community stewardship and sustainable use, such as Territories of Life, Indigenous Conserved and Protected Areas (ICPAs) and Indigenous and Community Conserved Areas (ICCAs; Smyth, 2015). Including these areas in international biodiversity policy and nature accounting seems a vital step towards broadening our understanding and pathways towards biodiversity conservation (Garnett et al., 2018; Gurney et al., 2021).

2.6.2 | Insights

Pluralistic approaches are required to solve nature loss, which go beyond protected area coverage to acknowledge human populations living within and with multifunctional landscapes

With a half century of research and action in biodiversity conservation with people, BRs can contribute to understanding the science and governance of multifunctional landscapes. However, despite the importance of land management approaches like BRs to reach global biodiversity goals, protected area coverage remains one of the main flagship targets in the global biodiversity framework (CBD, 2022). Thus, expanding conservation categories and designations in biodiversity policy is a key step in aiding implementation, follow-up and compliance monitoring of the contributions of multifunctional landscapes to biodiversity conservation (Raymond et al., 2022).

The emphasis on biocultural diversity is crucial in the search for new conservation narratives and solutions to the nature loss

Biocultural approaches can prove essential to expanding our relational understanding of sustainability challenges, weaving Indigenous principles and worldviews with scientific understanding requiring active decolonization of research ontologies,

epistemologies and practices. Biocultural approaches are linked to pleas against technocentric solutions to the global change crisis and the generation of a new social contract between humans, and between humanity and the more-than-human life: a new eco-social contract for all Earth denizens (Marsden, 2017; Moreira-Muñoz et al., 2020). Biocultural approaches also call for the explicit recognition of socio-environmental conflicts in BRs and beyond, including concrete actions against the risks taken by environmental activists (Gómez et al., 2021; Scheidel et al., 2020).

The nature crisis requires institutions that address the scale disconnect between ecological issues and the jurisdictions of social and political processes

BRs have demonstrated the potential for collaboration in multifunctional landscapes which link actors across scales and interests (Reed & Abernethy, 2019) and thus offer opportunities for the cross-sectoral collaboration. These lessons are essential as we move to implement the next generation of targets under the global biodiversity framework, which will require action beyond the administrative boundaries of protected areas, enlisting the assistance of actors beyond State 'environmental' authorities (CBD, 2021). To aid implementation and monitoring, we need research to evaluate how multifunctional landscapes and sustainable resource use contribute to biodiversity enhancement, and how collaborative sustainability platforms can help improve the social-ecological fit required to address global challenges across scales and jurisdictions (Reed & Price, 2019).

3 | TOWARDS A VISIONARY FUTURE: BIOSPHERE RESERVES AT THE LEARNING FRONTIER OF BIOCULTURAL APPROACHES TO GLOBAL BIOSPHERE STEWARDSHIP

Working towards a sustainable future requires active planetary stewardship for regenerating and strengthening the resilience of the biosphere (Folke et al., 2021). We propose that BRs, and similar initiatives, can be learning grounds for sustainability paradigm shifts, such as the shift towards 'biosphere stewardship' (Chapin et al., 2010; Cooke et al., 2016; Peçanha Enqvist et al., 2018). As a large global network of sites that engage in visioning exercises for sustainability transformation through their nomination and periodic review processes, the WNBR provides an opportunity to gather and share diverse future visions of sustainability and biosphere stewardship (Pereira et al., 2020). Importantly, these networks have the potential to build robust scientist-practitioner collaborations that provide for knowledge sharing for both theory and action related to sustainability transformation. Stewardship focused networks, like WNBR, can help build a shared language and understanding of sustainability grounded both in theory and practice and will be instrumental to facilitating collaborations and partnerships across scales, sectors and academic disciplines.

Earth stewardship initiatives should create space for a multiplicity of human-nature connections (Cooke et al., 2016). Thanks

to the emphasis of the MAB Programme and BRs on biocultural diversity and the relationships between people and their environments, much knowledge has already been generated, although not always synthesized, on navigating pluralistic understandings of biodiversity and people and nature relationships (Pascual et al., 2021). Biocultural research in BRs and beyond involves the decolonization of our scientific paradigm (Trisos et al., 2021), encompassing multiple worldviews and values of nature, and the dialogue of knowledges. UNESCO and the MAB Programme could further lead in the integration of cultural and spiritual values with biodiversity conservation, for example, by linking the UNESCO programmes of BRs, World Heritage Sites and Intangible Cultural Heritage of Humanity (Carter et al., 2022) and testing novel frameworks on the multiple values of natures (IPBES, 2022). Biosphere reserves are thus fundamental spaces at the frontlines of practice and learning for integrating the SDGs with, for example, the solidarity economy, circular economy, decarbonization and social justice (Schröder, 2020), as well as and having context-appropriate biocultural approaches to sustainability indicators across scales (Sterling et al., 2017). Biosphere reserves have also been signalled as placed to explore visionary concepts such as regenerative development (Moreno-Ramos & Müller, 2019), eco-social peace (Moreira-Muñoz et al., 2020) and visions to build an eco-welfare governance network seeking to redistribute carbon emissions, work, leisure time, income and wealth (Büchs & Koch, 2017; Moreira-Muñoz et al., 2020).

4 | CONCLUSION

Transformations towards sustainable and just futures require strategies that ground them in place-based transformative knowledge on the complex dynamics of social-ecological systems, while fostering collective reflexive capacity to guide future pathways (Knaggård et al., 2018; Liu et al., 2015; Sachs et al., 2019). In this paper, we reflect on five decades of experiences of the world's first network of sites aiming to be 'testing grounds' for sustainability strategies which generate actionable knowledge on human-nature relations. We learn both from the successes and the limitations of these efforts and offer these reflections to the wider research community, in order to increase the visibility of this network, enhance its potential to contribute to sustainability transformation and use its insights to enhance collective efforts for global coordinated place-based sustainability research and action.

Despite the challenges faced in fulfilling the potential and vision of this network, the WNBR offers an important asset for our times: a readymade network for sustainability research and action. Biosphere reserves and the knowledge emerging from them put the focus on *solutions and actions in pursuit of sustainability*, at the forefront of collective experimentation to shift societies towards sustainable and resilient pathways. Biosphere reserves and their network provide places to practice, test, refine and implement new sustainability research frameworks, methodologies and policies, with the capacity to speed

up synthesis and learning processes on a global scale. In addition, by working cross-culturally, practitioners and scientists working in BRs and similar sites are at the frontlines of transdisciplinary learning, weaving of knowledges and rights-based approaches to conservation, holding equity as a cross-cutting imperative and generating spaces for intergenerational learning and reconciliation with Indigenous Peoples. Such landscapes also offer researchers and practitioners with opportunities to try and adapt new forms of scientific practice that support transformative learning and action for sustainability.

If we are to leverage the power of place-based learning for sustainability to meet global challenges, 'individual sites' are not sufficient: Regional and global networks are needed, to develop middle-range theories which account for context specificities but are generalizable (Meyfroidt et al., 2018). We hope the insights generated from the challenges and successes of WNBR will help further inter- and transdisciplinary intergovernmental and intercultural scientific approaches that can generate actionable knowledge (Mach et al., 2020) 'just in time' to advance much-needed sustainability transformations.

AUTHOR CONTRIBUTIONS

Alicia D. Barraclough led the writing of the manuscript. All authors contributed with writing, critically revised the drafts and gave final approval for publication.

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No conflict of interest declared.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Figure S1. “Breaking the glass” image from of “Breaking the Glass: Opening Conservation to Man” presented during MAB 10th anniversary in 1981 at a UNESCO General Conference. Copyright UNESCO.

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