Leverage points to foster human-nature relations for sustainability transformation

Kumulative Habilitationsschrift

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To all those who supported me and my work, thank you.

Abstract

Despite warnings from scientists and from society starting in the 1970s, we have long overshot our planetary boundaries – eroding biodiversity, changing our landscapes, and polluting our soil and atmosphere. Yes, efforts to change the unsustainable trajectories of our Earth system have increased through, for example, the Millennium Goals, the Sustainable Development Goals, or the Aichi Targets, but to no avail. The interventions to increase sustainability are conflicting on local, national and global levels, and often prioritise quick-fixes and short-term solutions instead of tackling the root causes of the "sustainability gap". We, hence, need to find "places to intervene in complex systems that bring about transformative change" (Meadows 1999) – a premise and concept that Donella Meadows calls "leverage points". Based on her seminal work, a team from the Leuphana University has identified three "realms of leverage" in which changes may lead to system transformation (Abson et al. 2017). One of these realms is the reconnection of humans to nature. In this habilitation, I focus on this realm of leverage and aim to (1) enhance the understanding of the influence of landscape change on human-nature relations through empirical, place-based research and comparisons across landscapes in different countries and continents; (2) identify and clarify the new concepts of relational values and leverage points; and (3) highlight empirical evidence on leverage points to foster human-nature relations for sustainability transformation, building mainly on empirical work done in six landscapes in Transylvania, Romania and Lower Saxony, Germany, but also including case studies from Ethiopia and India, systematic literature reviews and conceptual pieces. This thesis showed that cultural landscapes are changing with astonishingly comparable trajectories toward unsustainable futures. Our earth's current environmental and climate crisis will continue to erode the fundaments of sustainability, hence, re-connecting humans to nature is of outstanding significance for transformative change. Identifying leverage points and implementing an intervention to strengthen human–nature relations will be a great challenge in the coming years. One possible leverage point can be strengthening experiential and emotional dimensions, as they specifically shape the connections people have with cultural landscapes. Further, this thesis highlighted the importance of the interlinkages between shallow and deep leverage points. Our results show that structurally complex landscapes and structurally rich social relations mediated by nature are interlinked and strengthening one, may strengthen the other. Moreover, strengthening sense of place and a sense of agency may enable self- and re-organization of cultural landscapes by opening the possibility to renegotiate people's values for values and the goals of the social-ecological system, which, in turn, may enhance the structural diversity of landscapes and small-scale agriculture. Our results presented in this thesis also lay the ground for the hypothesis that degrading landscapes might also degrade social relations, which, in turn, can lead to contrasts and conflicts between actors and social groups. Although much work is still necessary to foster transformative change, this thesis offers innovative approaches. This thesis created and popularised the "Leverage points perspective", including "chains of leverage", as well as producing novel insights on human-nature relations – such as the distinction of human-nature connectedness and relational values, classifying relational value groups and empirically assessing dimensions of human-nature connectedness and relational values concerning landscape change and landscape features. These novel contributions can have wide-ranging impacts on the scientific discussions and societal implementation of interventions for sustainability.

Zusammenfassung

Trotz Warnungen von Wissenschaftler*innen und der Gesellschaft seit den 1970er Jahren haben wir unsere planetarischen Grenzen längst überschritten, mit der Konsequenz von sinkender Biodiversität, rapiden Landschaftsveränderungen und steigenden Treibhausgasemissionen. Die Bemühungen, diese nicht-nachhaltige Laufbahn unseres Erdsystems zu ändern, haben zwar zugenommen, z. B. durch die Millenniumsziele, die Ziele für nachhaltige Entwicklung oder das Übereinkommen über die biologische Vielfalt, aber ohne jeden Erfolg. Die Maßnahmen zur Verbesserung der Nachhaltigkeit sind auf lokaler, nationaler und globaler Ebene widersprüchlich und geben oft schnellen und kurzfristigen Lösungen den Vorrang. Wir müssen daher "Orte [finden], an denen in komplexe Systeme eingegriffen wird, um einen transformativen Wandel herbeizuführen" (Meadows 1999) – eine Prämisse und ein Konzept, das Donella Meadows „Leverage Points“ (Interventionspunkte) nennt. Basierend auf ihrer bahnbrechenden Arbeit hat ein Team der Leuphana Universität drei Bereiche identifiziert, in denen Veränderungen zu einer Systemtransformation führen können (Abson *et al.* 2017). Einer dieser Bereiche ist die Rückverbindung zwischen Mensch und Natur. In dieser Habilitation konzentriere ich mich darauf Interventionspunkte zu identifizieren, um Menschen wieder stärker mit der Natur zu verbinden. Diese Habilitation zielt darauf ab, (1) das Verständnis des Einflusses des Landschaftswandels auf die Mensch-Natur-Beziehungen durch empirische, ortsbezogene Forschung und Vergleiche zwischen Landschaften in verschiedenen Ländern und Kontinenten zu verbessern; (2) die neuen Konzepte der relationalen Werte und der „Leverage Points“ zu identifizieren und zu klären; und (3) empirische Belege für Interventionspunkte zur Förderung der Mensch-Natur-Beziehungen für die Nachhaltigkeitstransformation hervorzuheben. Diese Analysen basieren hauptsächlich auf empirischen Studien in sechs Studienstandorten/Landschaften in Siebenbürgen, Rumänien und Niedersachsen, Deutschland. Meine Arbeit hat gezeigt, dass sich die Kulturlandschaften in Europa und überall auf der Welt verändern, mit erstaunlich vergleichbaren Entwicklungen in Richtung einer nicht nachhaltigen Zukunft. Daher ist es für einen transformativen Wandel von herausragender Bedeutung, die Abwärtsspirale der zunehmenden Entkopplung von der Natur zu durchbrechen. Die Identifizierung von Interventionspunkten zur Stärkung der Mensch-Natur-Beziehungen wird in den kommenden Jahren eine große Herausforderung darstellen. Ein Interventionspunkt ist die Stärkung der Erlebnis- und Gefühlsdimensionen, die die Beziehungen der Menschen zur Kulturlandschaft besonders prägen. Darüber hinaus zeigen unsere Ergebnisse, dass strukturell komplexe Landschaften und strukturell reichhaltige, durch die Natur vermittelte soziale Beziehungen miteinander verknüpft sind und die Stärkung des einen auch das andere stärken kann. Darüber hinaus kann die Stärkung des Ortssinns und des Handlungssinns eine Selbst- und Reorganisation von Kulturlandschaften ermöglichen, indem sie die Möglichkeit eröffnet, die Werte der Menschen für die Werte und Ziele des sozial-ökologischen Systems neu zu verhandeln. Die in dieser Arbeit vorgestellten Ergebnisse legen den Grundstein für die Hypothese, dass die Degradierung von Landschaften auch zu einer Degradierung der sozialen Beziehungen, was wiederum zu Gegensätzen und Konflikten zwischen sozialen Gruppen führen kann. Die innovativen Ansätze dieser Habilitation beinhalten die „Leverage Points Perspektive“, „Chains of Leverage“, und einen Weg zur Standardisierung der Identifizierung von Leverage Points. Zusätzliche innovative Erkenntnisse über Mensch-Natur-Beziehungen betreffen die Unterscheidung von Mensch-Natur-Verbundenheit und relationalen Werten, die Klassifizierung von relationalen Werten und deren empirische Bewertung in Bezug auf Landschaftswandel und -merkmale.

Synopsis

Contents of the synopsis

1. Introduction

1.1. The need for sustainability transformation

Due to humanities rapidly and constantly growing reliance on fossil fuels and industrialised forms of agriculture, we have exceeded the safe operating space for humanity (Rockström *et al.* 2009b; Steffen *et al.* 2015). By crossing these safe operating spaces, also called 'planetary boundaries', the risks for non-linear, abrupt changes in the complex Earth system is increasing. Rockström *et al.* (2009a, b) identified nine Earth-system processes and associated thresholds that, when crossed, would cause grave environmental, social and economic change and would lead to a worsening of the overall Earth system. Of these nine identified processes, climate change, the rate of biodiversity loss, and the nitrogen cycle have been crossed (Rockström *et al.* 2009a, b). An updated assessment in relation to environmental pollutants added, amongst others, land use and land-system change to the processes in which we have exceeded planetary boundaries (Persson *et al.* 2022).

Although the information and knowledge on humanities growing unsustainable trajectory is increasing, the general trajectory has been made aware already in the 1970s (Meadows et al 1972). The unprecedented anthropogenic impacts on the climate and natural habitats of this earth (IPCC 2014, 2018) have even lead to the announcement of a new geological epoch: the Anthropocene (Steffen *et al.* 2007). The Anthropocene is characterized by a sixth mass extinction event (Millennium Ecosystem Assessment 2005; Barnosky *et al.* 2011; Hughes *et al.* 2017) impairing the functioning and resilience of ecosystems (Carpenter *et al.* 2005; Biggs *et al.* 2012), by increased natural hazards (Steffen *et al.* 2018) and a general insecure future (Folke 2020).

Since the first warnings in the 1970s, actors in science and society have intensified efforts to steer away from the unsustainable trajectories of global environmental and landscape changes. Such efforts include various agreements towards a range of environmental and sustainability goals (e.g., the Millennium Goals, the Sustainable Development Goals, the Aichi Targets). Yet to no avail: numerous social and biophysical indicators of sustainability continue to worsen exponentially (Ripple *et al.* 2017), as local, national and global intents of achieving sustainability goals are conflicting. Distal drivers for this unsustainable trajectory can be seen in the increasing telecoupling through global economic trade, changing diets of broad sections of the global populations, and a capitalistic paradigm of economic growth (e.g., Foley *et al.* 2011). One key direct driver of the decline of biodiversity and climate change is the deterioration, fragmentation and loss of terrestrial habitat, especially through the ever industrialising and intensifying agricultural sector. Through landscape and land use change – be it rapid and disruptive or steady and gradually over time – the health of the soil, water, and air are eroded, leading to a rapid decrease of wild, farmland, and crop diversity all across the globe (Green *et al.* 2005; Tscharntke *et al.* 2005; FAO 2011).

Especially, traditional cultural landscapes[1] provide a balance of provisioning, regulating, and cultural ecosystem services upon which human well-being depends (Young *et al.* 2005; Bürgi *et al.* 2017). Yet, cultural landscapes across the world are threatened by a broad range of interacting drivers (Bürgi *et al.* 2005) leading, for example, to the non-viability of extensive, traditional management practices, in turn followed by land intensification or land abandonment (e.g., Zscheischler *et al.* 2019). Instead of a balanced support for human well-being, the newly created, simplified agricultural landscapes tend to focus on providing crops mostly for economic benefits instead of for local livelihoods (Foley *et al.* 2005). Cultural landscapes increasingly serve consumers in distant locations – impacting local food security (Fischer *et al.* 2017; Jiren *et al.* 2020) and contributing to a disconnection of local people from their landscape (Khoury *et al.* 2014). Changing cultural landscape can negatively impact, for example, inhabitants tangible and intangible local heritage (Pătru-Stupariu *et al.* 2019), or sense of place and a feeling of home (Fernández-Giménez 2015), all of which could come with a time gap between the actual ecological degradation and the loss of such shared and individual values (Horcea-Milcu *et al.* 2017).

Global developments, hence, show an ever-growing, rather than shrinking, "sustainability gap" (Fischer *et al.* 2007) for many social and biophysical indicators. Instead of coming closer to internationally agreed sustainability goals, we experience a growing discrepancy between the ideal – sustainable – and the actual state of the world (Steffen *et al.* 2018). It is therefore getting clear that conventional and one-dimensional ways to solve these problems are insufficient to foster sustainability (Santos-Martín *et al.* 2013). To overcome this discrepancy, new ways of thinking and acting are necessary. Hence, a sustainability transformation entails radical "systemic shifts in values and beliefs, patterns of social behaviour, and multilevel governance and management regimes" (Olsson *et al.* 2014). One of such way of thinking to foster sustainability transformation is systems thinking which allows developing more holistic pathways toward sustainability. Such an holistic approach is necessary, because a transformation of the entire system is needed to halt the degradation of the natural resources on which human well-being depends (Griggs 2015). Yet, this is easier said than done, as transformations of systems are difficult to induce (Meadows 1999). Knowledge of where to intervene in a system and what consequences and ripple effects these interventions might bring about is required to enable a sustainability transformation.

1.2. Human-nature relations as realm of leverage

To create knowledge on where to intervene in a system, this thesis uses Donella Meadows' seminal work on "places to intervene in complex systems that bring about transformative change" (i.e., 'leverage points') (Meadows 1999). Leverage points are parts of a complex, social-ecological system which can be acted upon to induce change (i.e. create interventions for sustainability transformation).

[1] In this habilitation, we build on a moderate social constructivist approach on cultural landscapes. We consider landscape a social construction, which is based on the physical and/or material elements of the environment. However, the interpretation of these elements, their meaning and relationships differs between different people or groups (Gailing and Leibenath 2015; Köpsel *et al.* 2017). The materialities of landscape, e.g., landscape elements, thus provide the 'raw material' to which meanings are ascribed (Stedman 2016). We acknowledge, the vast disciplinary and national differences between the notion of 'landscape' and 'cultural landscape' (Jones 2003).

Leverage points can be classified into deep and fundamental, and shallow, superficial ones with hierarchical order. The distinction between shallow and deep leverage points describes the extent to which they can alter the trajectory of a system to foster sustainability transformation, that is interventions at deep leverage points have greater potential to change a system than those interventions targeting shallow leverage points. Following Abson *et al.*'s classification (2017), "shallow places" to intervene include system parameters and feedbacks, whereas "deeper places" to intervene include system design and intent. These four system characteristics (parameters, feedbacks, design and intent of a system, see Figure 1) are nested and linked, because changing the system design and intent automatically influences the systems feedbacks and parameters (Meadows 1999; Abson *et al.* 2017). Yet, were and how to intervene in a system to induce sustainability transformations?

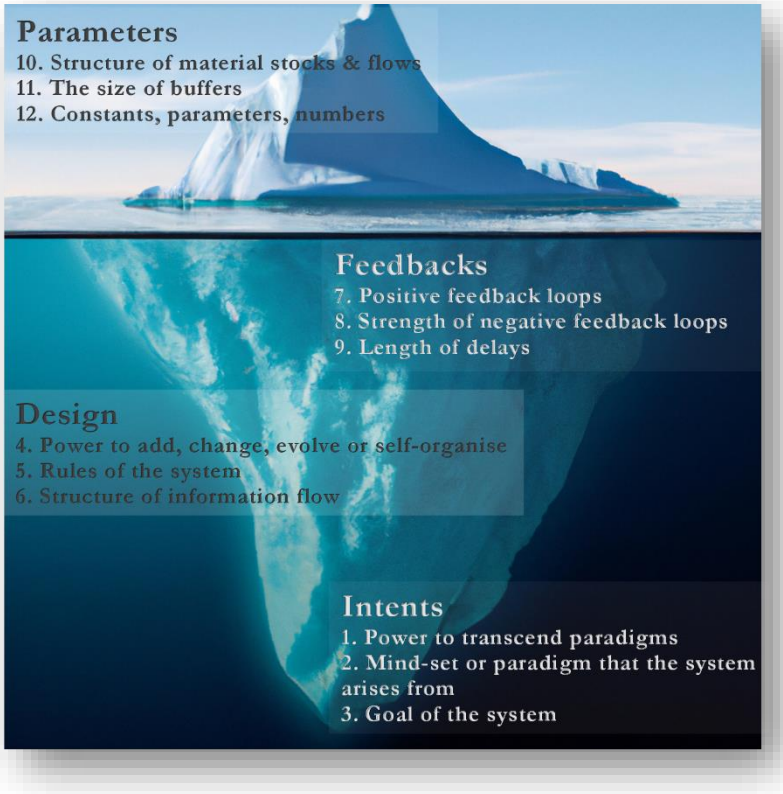

Figure 1: Abson *et al.*'s classification (2017) of the nested four system characteristics (parameters, feedbacks, design and intent of a system) and their related 12 leverage points by Donella Meadows (1999). Own design based on Open AI, Dall E (openai.com/blog/dall-e/).

Abson *et al*. (2017) suggests, three "realms of leverage" in which changes may lead to system transformation: Restructuring institutions, reconnecting humans to nature, and rethinking paradigms (Figure 2).

1. *Re-Structure* is concerned with institutional reform and collapse, including measures targeting systemic and structural changes. Institutions (including lack of them) (according to Young, 2002) can restrict local populations in their, possibly sustainable, customs, even if they have a long tradition (Gilbert, 2011). As a result, benefits (e.g., aesthetic benefits of a structurally rich agricultural landscape for tourism) and costs (keeping structural diversity in landscapes despite

pressures to intensify farming) are not equally distributed and disadvantage processes are systematically institutionalised (e.g., Berbés-Blázquez et al., 2016; Ceauşu et al., 2019).

2. *Re-Think* emphasises the need for knowledge co-production, especially through transdisciplinary processes. Western knowledge systems, which often form the basis of (inter-)national top-down interventions, can reproduce systemic problems instead of resolving them. Prioritising technical knowledge, for example, can disregard local, traditional knowledge systems (Iniesta-Arandia et al., 2015; Loch and Riechers 2021), although community and place-based knowledge can open up new ways for sustainability transformation (Bodorkós & Pataki, 2009; Lemahieu et al., 2018; Molnár et al., 2015).
3. *Re-Connect* focuses on fostering material and non-material interlinkages between humans and nature as well as strengthening human values for nature or nature's contribution to people (Díaz *et al.* 2018; Garcia Rodrigues *et al.* 2021). Human-nature connections can span multiple dimensions (material, experiential, cognitive, emotional and philosophical) which are often linked to and create the values that people hold towards nature because of a relation to nature people's (e.g., relational values). The positive effects of human-nature relations include strengthening health and recovery (Maller *et al.* 2006; Shanahan *et al.* 2016), the cognitive development of children (cf. Taniguchi *et al.* 2005), and overall happiness and well-being (Capaldi *et al.* 2014).

Figure 2: Graphical representation of the three realms of leverage, Re-Connect, Re-Think and Re-Structure. Own design based on Open AI, Dall E (openai.com/blog/dall-e/).

Material and non-material interlinkages between humans and nature covered in the realm of "Re-Connect" seem to be specially locked in a downward spiral with unsustainable (system) behaviour patterns. Ever-increasing disconnections of humans from nature increases unsustainable (system) behaviour, which increases disconnections from nature and so forth (Rockström *et al.* 2009a; Nisbet *et al.* 2009; Steffen *et al.* 2018). Scholars state that reconnecting human with nature may halt this downward spiral and, in turn, unsustainable (system) behaviour (Folke *et al.* 2011; Zylstra *et al.* 2014), yet calls for such "reconnection" lack concrete insights about what human-nature relations actually means and how they might be leveraged.

In this habilitation, I will focus on the realm of leverage of "Re-Connect" by analysing human's relations concerning changing landscapes and how to identify leverage points to foster human-nature relations for sustainability transformation. I will show how the realm of re-connect can address all four system characteristics, therewith having great potential for fostering sustainability transformation.

2. Outline

2.1. Aims and scope

To identify leverage points to foster human-nature relations for sustainability transformation, in this thesis, I investigate and synthesize three novel frameworks (Figure 3):

1. a comprehensive approach of understanding and assessing the dimensions of human-nature connectedness (Ives *et al.* 2017, 2018),
2. the idea of valuing human relationships to nature through relational values (Muraca 2011),
3. and the, here newly developed leverage points perspective (publication X, Fischer and Riechers 2019; publication XI, Riechers *et al.* 2022b).

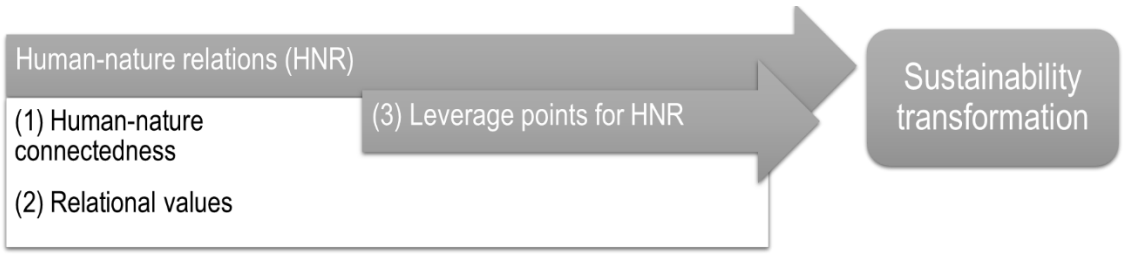

Figure 3: Graphical representation of the novel concepts used in this thesis: human-nature relations, consisting of human-nature connectedness and relational values; as well as leverage points to foster human-nature relations for sustainability transformation.

This thesis aims to identify leverage points to enhance how human-nature relations (i.e., human-nature connectedness and relational values) for sustainability transformation adapted from (publications XII and XIII, Riechers *et al.* 2021e, g). Therefore, empirical evidence is needed to highlight the place-based specificity (publications II and III, Riechers *et al.* 2019; Balázsi *et al.* 2019), as well as the cross-country comparability of the concepts (Publications VIII and XIII, Riechers *et al.* 2020b, 2021e). With this, I also seek to provide information on potential motivations for inhabitants of the landscapes and decision-makers to engage in pro-environmental behaviour and sustainable management as related to landscape change and land use practices (publications I and IV, Riechers *et al.* 2021g; Lübker *et al.* 2021). Moreover, in this thesis, I strive for establishing the leverage points perspective, thus setting the scene for future empirical research (publications IX, X and XI, Fischer and Riechers 2019; Riechers *et al.* 2021c, 2022b). Specifically, the objectives are to:

1. Enhance the understanding of the influence of landscape change on human-nature relations through empirical, place-based research and comparisons across landscapes in different countries and continents;
2. Identify and clarify the new concepts of relational values and the leverage points perspective;

3. Highlight empirical evidence on leverage points to foster human-nature relations for sustainability transformation.

The individual studies in this thesis are rooted in social sciences, but are social-ecological since they were carried out in the inter- and transdisciplinary contexts of the project "Leverage Points for Sustainability Transformation", funded by the German federal state of Lower Saxony and the Volkswagen Stiftung (Grant Nr. A112269). As it is inherent in a cumulative habilitations, the articles this synopsis have been published achronically to my outlined narrative.

2.2. Study sites

The core empirical work of this thesis builds on six study sites within Romania and Germany (seven of the 13 articles included in this thesis). One comparison paper builds on this empirical work relates the findings to other case studies in Ethiopia and India. Two further articles are systematic literature reviews and three are conceptual pieces build on the established empirical knowledge on working with human-nature relations and the concept of leverage points.

The cores six study sites include a landscape gradient from minor and gradual to relatively major and rapid landscape change between three landscapes in Transylvania, Romania and three in Lower Saxony, Germany (Figure 4).

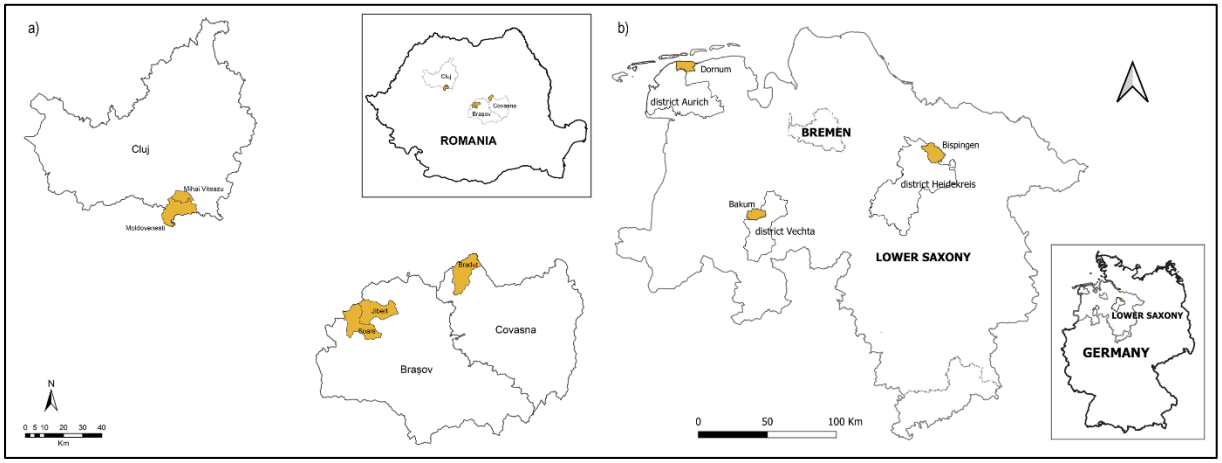

Figure 4: Study sites, a) Romania, with the three study sites in Transylvania (from west to east). Turda area (Mihai Viteazu and Moldovenești Communes, Cluj County), Rupea area (Șoarș and Jibert Communes, Brașov County), Baraolt area (Brăduț Commune, Covasna County); b) Germany with the three focal areas in Lower Saxony (from west to east) Dornum (district Aurich), Bakum (district Vechta), Bispingen (district Heidekreis). Source: publication VII, Riechers *et al.* 2021a

The study sites can be characterised as follows:
Transylvania, Romania

1. Baraolt area (Brăduț Commune in Covasna County): smallholder-dominated cultural landscape with large patches of forests, grasslands, and abundant wildlife; Driven by socioeconomic and

institutional change, both land abandonment and intensification have increased slowly over the last decades.

2. Turda area (Mihai Viteazu and Moldovenești Communes in Cluj County): flat, crop-dominated and subject to strong urban influences due to its proximity to the cities of Cluj-Napoca, Turda, Câmpia Turzii, and Aiud. Following the accession of Romania into the EU in 2007, the intensity of land use has increased; small-holder vegetable cultivation has been increasingly replaced by industrial crops.
3. Rupea area (Șoarș and Jibert Communes in Brașov County): small-holder-dominated cultural landscape with croplands close to villages; Large areas of high natural value farmlands in remote areas; Due to socio-political influences during socialism (1947-1989), the local Saxon community emigrated and the area was repopulated by Roma and Romanian citizens.

Lower Saxony, Germany

1. Gemeinde Bispingen (district Heidekreis): east of Lower Saxony; partly inside the Lueneburger heath nature park (protected under Germany's federal nature conservation act); The nature park has slowed down landscape change because of restrictions on agricultural intensification and large-scale infrastructure projects.
2. Gemeinde Bakum (district Vechta): located in the middle of Lower Saxony; has changed substantially over the last 20 years due to agricultural intensification; known for the highest density mass husbandry in Germany.
3. Gemeinde Dornum (district Aurich): northeast of Lower Saxony in the landscape region of Eastern Frisia; coastal landscape at the North Sea; flat, dominated by often intensively used grasslands and a relatively high amount of wind parks to generate renewable energy.

2.3. Overview

2.3.1. Thesis components

In addition to this synopsis, my thesis comprises 13 separate publications, of which 12 have been published in high-ranking peer-reviewed journals and one additional article is accepted and in proof. Table 1 provides an overview of the publications, my contribution and their current publication status. Of these articles, 10 were written by me as the first author, three as a second/last author. All articles are/will be published between 2019 and 2022.

Our result of the work forming this thesis refers to the empirical application of the framings of human-nature connectedness, relational values, and leverage points and includes conceptual and method-based advancements, as well as evidence of the influence of landscape change on these connections and values, as well as potential leverage points to foster sustainability transformation. As is shown in table 1, four publications address human-nature connectedness, four publications link and highlight relational values and five publications focus on leverage points, including the newly developed leverage points perspective.

Table 1 Overview of publications

No.	Publication & contribution	Status
Human-nature connectedness		
I	**Riechers**, M., Á. Balázsi, D. J. Abson, and J. Fischer. 2020. The influence of landscape change on multiple dimensions of human–nature connectedness. *Ecology & Society* 25(3). Contribution: M.R. designed the study, collected and analysed data, and wrote, edited, and revised the largest part of the manuscript (80%).	Published
II	Balázsi, Á., M. **Riechers**, T. Hartel, J. Leventon, and J. Fischer. 2019. The impacts of social-ecological system change on human-nature connectedness: A case study from Transylvania, Romania. *Land Use Policy* 89:104232. Contribution: M.R. designed the study, helped analyse the data, and edited, and revised the manuscript (60%).	Published
III	**Riechers**, M., W. Henkel, M. Engbers, and J. Fischer. 2019. Stories of favourite places in public spaces: emotional responses to landscape change. *Sustainability* 11(14):3851. Contribution: M.R. designed the study, collected and analysed data, and wrote, edited, and revised most of the manuscript (90%).	Published
IV	Lübker, H.M., Abson D.J., and M. **Riechers**. 2021. Discourses for deep transformation: perceptions of economic growth in two rural communities in Lower Saxony, Germany. *Sustainability Science* 16 1827–1840. Contribution: M.R. designed the study and collected the data, supervision of the bachelor thesis on which this article is based, wrote parts of the article, and edited and revised most of the manuscript (50%).	Published
Relational values		
V	**Riechers**, M., B. Martín-López, and J. Fischer. 2021. Human–nature connectedness and other relational values are negatively affected by landscape simplification: insights from Lower Saxony, Germany. *Sustainability Science*. Contribution: M.R. designed the study, collected and analysed data, and wrote, edited, and revised the largest part of the manuscript (80%).	Published
VI	**Riechers**, M., Betz, L., Gould, R., Loch, T.K., Lam, D.P.M., Lazzari, N., Martín-Lopéz, B., Sala, J.E. (in proof by Ecology and Society). Reviewing relational values for future research: insights from the coast. Contribution: M.R. designed the study, collected and analysed 60% of the data, and wrote, edited, and revised the greatest part of the manuscript (90%).	Accepted/ in proof
VII	**Riechers**, M., Á. Balázsi, J. Engler, G. Shumi, and J. Fischer. 2021. Understanding relational values in cultural landscapes in Romania and Germany. *People and Nature*. Contribution: M.R. designed the study, collected and analysed data, and wrote, edited, and revised the largest part of the manuscript (80%).	Published
VIII	**Riechers**, M., Á. Balázsi, L. Betz, T. S. Jiren, and J. Fischer. 2020. The erosion of relational values resulting from landscape simplification. *Landscape Ecology*. Contribution: M.R. co-designed the study, collected and analysed data for the German case study, and wrote, edited, and revised the part of the manuscript (50%).	Published

Table 1: continued

No.	Publication & contribution	Status
The leverage points perspective		
IX	Fischer, J., and M. **Riechers**. 2019. A leverage points perspective on sustainability. *People and Nature*. Contribution: M.R. edited and revised parts of the manuscript (20%).	Published
X	**Riechers**, M., Fischer, J., Manlosa, A.O., Ortiz-Przychodzka, S., Sala, J.E. (2022). Operationalising the leverage points perspective for empirical research. *COSUST*. Contribution: M.R. designed the study, wrote, edited, and revised the majority of the manuscript (80%).	Published
XI	**Riechers**, M., B. P. Brunner, J.-C. Dajka, I. A. Duşe, H. M. Lübker, A. O. Manlosa, J. E. Sala, T. Schaal, and S. Weidlich. 2021. Leverage points for addressing marine and coastal pollution: A review. *Marine Pollution Bulletin* 167:112263. Contribution: M.R. designed the study, collected and analysed 90% of the data, and wrote, edited, and revised the greatest part of the manuscript (90%).	Published
XII	**Riechers**, M., I. A. Pătru-Duşe, and Á. Balázsi. 2021. Leverage points to fostering human-nature connectedness in cultural landscapes. *Ambio*. Contribution: M.R. designed the study, wrote, edited and revised most of the manuscript (90%).	Published
XIII	**Riechers**, M., J. Loos, Á. Balázsi, M. García-Llorente, C. Bieling, A. Burgos-Ayala, L. Chakroun, T. J. M. Mattijssen, M. M. Muhr, I. Pérez-Ramírez, K. J. Raatikainen, S. Rana, M. Richardson, L. Rosengren, and S. West. 2021. Key advantages of the leverage points perspective to shape human-nature relations. *Ecosystems and People* 17(1):205–214. Contribution: M.R. designed the study, wrote, edited, and revised the majority of the manuscript (80%).	Published

Additionally, during the four your publication period for the habilitation, I have published an additional 13 papers related to the topics of:

- leverage points (Dorninger *et al.* 2020; Dajka *et al.* 2020; Fischer *et al.* 2021; Jiren *et al.* 2021a; Fanini *et al.* 2021),
- human-nature relations (Riechers *et al.* 2021b; Loch and Riechers 2021),
- values (Horcea-Milcu *et al.* 2019), and
- methods of co-producing knowledge that may advance understanding of human-nature relations (Jiren *et al.* 2021b; Riechers *et al.* 2021d; Chambers *et al.* 2021, 2022; Staffa *et al.* 2021).

Two of those publications will be highlighted in this synopsis: Dorninger *et al.* (2020) review of the literature on energy and food systems that uses leverage points as an analytical tool, and Jiren *et al.* (2021a) study on the links between deep and shallow leverage points to transform agricultural institutions. The latter lays the groundwork for advancing the leverage points perspective about the novel idea of 'chains of leverage' as seen in publication X. Although these publications provide insights

related to the topic of leverage points and human-nature connectedness addressed here, they have not been included to keep the length of the thesis to a reasonable limit.

3. Human- nature relations influenced by landscape change

Creating a comprehensive understanding of human-nature relations is crucial for sustainability transformation. Hence, this thesis works with the overarching approach of 'human-nature relations' which includes two novel conceptual frameworks:

1. dimensions of human-nature connectedness (i.e., material, experiential, cognitive, emotional and philosophical dimensions), and
2. relational values (i.e., the values that people hold towards nature because of a relation to nature or specific entities, often based on and linked to their human-nature connectedness).

This section of the synopsis discusses the potentials and challenges of both frameworks while highlighting conceptual and methodological advancement in their scientific application to which this habilitation contributed. The impact of landscape change on these concepts is highlighted.

3.1. The concept of human-nature connectedness

Many researchers argue, that a disconnection of people and societies from nature may exacerbate the global environmental crisis by enhancing unsustainable behaviour patterns (Pyle 2003; Folke *et al.* 2011; Abson *et al.* 2017). Changes in the broader historical social-ecological system (publication II, Balázsi *et al.* 2019), rapid landscape change (publications I and VIII, Riechers *et al.* 2020a, b) or urbanisation (Miller 2005) are just a few factors that can decrease and alter human-nature connectedness. Yet, beneficial effects of connections between humans and nature are widely recognised for sustainability (Folke *et al.* 2011; Zylstra *et al.* 2014).

To better understand the diverse ways, humans can be connected with nature, this thesis uses the newly developed concept of "human-nature connectedness" based on Ives *et al.* (2017, 2018). This concept recognises human-nature connectedness as encompassing five dimensions:

1. A *material* dimension, including food, fuel, or other goods, with research focusing largely on biophysical flows (Wackernagel *et al.* 1999; Haberl *et al.* 2004; Dorninger *et al.* 2017);
2. An *experiential* dimension, covering activities in nature, such as highlighted in the works by Soga and Gaston (2016) or Keniger et al. (2013);
3. An *emotional* dimension, often focussing on aspects such as spirituality, aesthetics and sense of place (Kals *et al.* 1999; Stedman 2003; Brown and Raymond 2007);
4. A *cognitive* dimension consisting often of awareness and knowledge about natural systems (e.g., Bradley *et al.* 1999; Schultz 2001, 2002) as well as psychological aspects (e.g. Stedman 2002; Collado *et al.* 2013); and

5. A *philosophical* dimension, related to conceptions of humanity's place in nature (e.g. van den Born 2008; Raymond *et al.* 2013).

Those dimensions span a multitude of academic disciplines and conceptual framings that cover decades of research in their respective fields. Although this literature is rich and vast, many calls for "reconnection" with nature have remained vague and abstract. So far, a comprehensive assessment of human-nature connectedness and how to foster it at a landscape level is lacking. This gap will be filled by our results of the habilitation as indicted in this synopsis.

3.1.1. Human-nature connectedness influenced by landscape change

Addressing the challenge of a comprehensive assessment of human-nature connectedness, **publication I** (Riechers *et al.* 2020a), gives an extensive overview of the five dimensions of human-nature connectedness and how they are impacted by landscape change. The findings are based on qualitative empirical research at four study sites (Bispingen and Dötlingen, Lower Saxony, Germany and Aranyosszék and Erdővidék, Transylvania, Romania), which represent gradients from minor and gradual to relatively major and rapid landscape changes (see Figure 4 on the study sites). Landscape change was shown to have a negative influence on multiple dimensions of human-nature connectedness (see Table 2).

Table 2: Examples of the effects of landscape change and related drivers on human-nature connectedness in Bispingen and Dötlingen, Lower Saxony, Germany adapted from (adapted from Riechers *et al.* 2021f, publication V).

HNC	Main stated drivers of HNC loss	Exemplary quotes
Material	Agricultural intensification; Global production of food; Subsidies for renewable energies	Because they don't know anymore what meat actually means and what it is. And everyone is turned off when you see a slaughterhouse on TV. But the [agricultural] structure and how it reached the slaughterhouse [is not shown…]. That there has been a development [of disconnection; …] and this is not discussed (Bispingen, farmer about the disconnect from material HNC through spatial distance and lack of visibility)
Experiential	Agricultural intensification; Parents disconnected from nature; Multiple competing activities;	This [nature experiences] also vanished through the parents. We don't have farms anymore; one doesn't really take the kids and go places to see what's creeping and crawling there (Bispingen, teacher on the disconnect from experiential HNC through lack of planned experiences)
Cognitive	Landscape simplification	In the last 10 years, I would say, it [the blame towards farmers] increased. Farmers are polluters, farmers torment animals, farmers contaminate the groundwater, farmers are generally responsible for all bad things found in nature (Dötlingen, farmer about the biased knowledge on landscape simplifications)
Emotional	Agricultural intensification; Landscape simplification	There are developments here in the landscape [landscape simplification], which I just don't consider aesthetic. Where I simply say that those disturbances bother me, and they hurt me (Bispingen, forester about the emotional impact of the amount of maize, and impacts of nutrients in the forests)
Philosophical	Agricultural intensification	They really employ an [external] agricultural service to work the fields. Then there are young people sitting on the tractor, with no connection to the specific soil and they smash up everything that is not nailed down (Dötlingen, Environmentalist about the industrialisation of agriculture for economic gain)

Our results showed that all five dimensions of human-nature connectedness are strongly interlinked, especially via emotional and experiential connectedness (Figure 5). This highlights the importance of experiential and emotional connectedness to be addressed when aiming to strengthen human-nature

connectedness, as it can be expected that this will have positive feedback loops to the other dimensions, thereby strengthening human-nature connectedness as a whole.

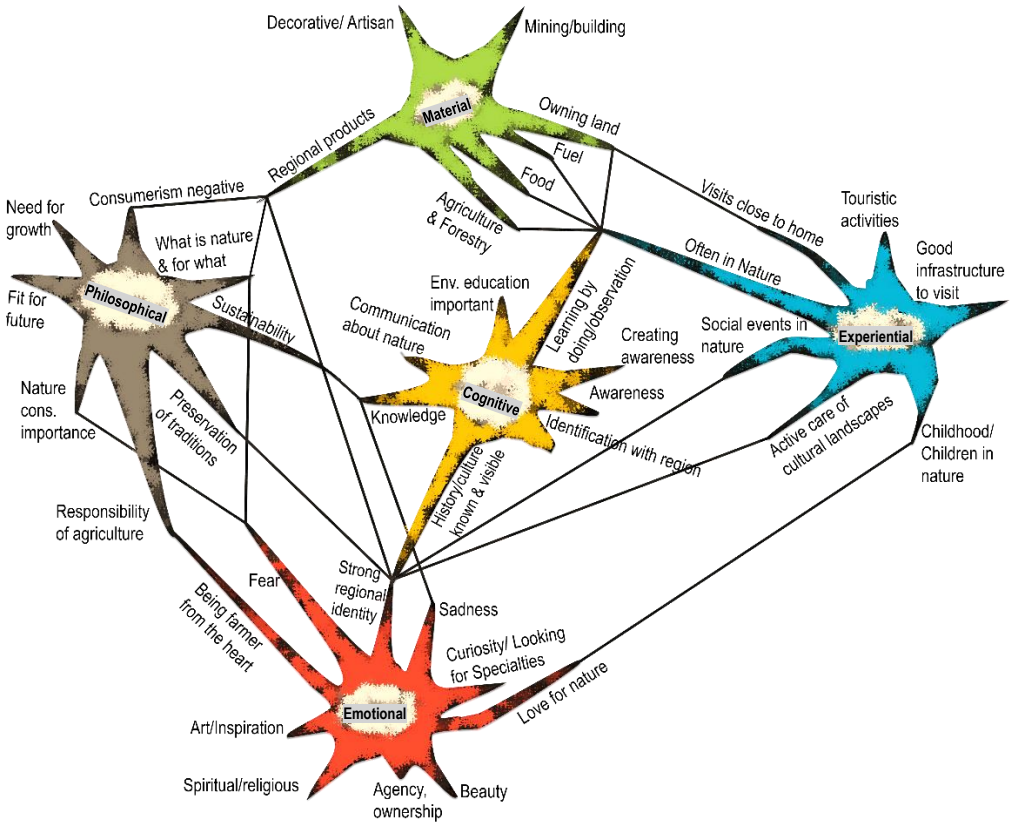

Figure 5: Graphical representation (based on astrocytes of a neural network) of the five dimensions of human-nature connectedness, their manifestations and connections between the manifestations based on qualitative empirical work done in the four study sites of Bispingen and Dötlingen, Lower Saxony, Germany and Aranyosszék and Erdővidék, Transylvania, Romania. Source: own depiction, unpublished, based on publication I (Riechers *et al.* 2020a).

Publication I addressed the influence of landscape change on human-nature connectedness across two countries (Romania and Germany). To go more in-depth regarding place-based specificity, publications II and III focus on only the study sites in Romania and Germany, respectively. **Publication II** (Balázsi *et al.* 2019) addresses the challenges Romanians faced due to several major social and institutional paradigm shifts[2], such as the shifts from:

(1) formal and informal institutional governance after the World Wars and before socialism (before 1947); to
(2) top-down governance during socialism (1947–1989); to
(3) sovereign state governance and transition to European Union (1990–2006); and, finally, to
(4) multilevel governance since European Union accession (after 2007).

[2] This example is also an indication of how paradigm shifts lead to restructuring institutions, in turn, shifting paradigms in the realm of human-nature relations.

Our two study areas in Romania, on which we focused in this publication, showed how human-nature connectedness was influenced by such paradigm shifts. For instance, material connections have weakened over the decades as a result of changes in food production and the new rising consumerism in modern Romania. Changing socio-economic and landscape management was impacting and altering property rights, which in turn negatively impacted experiential and emotional connections. While cognitive connections reflected changes in the knowledge system on the environment, especially in recent years with more awareness of sustainability, and lastly, philosophical connection on what sustainability means for the people was influenced by changes in ideologies and globalisation.

Publication III (Riechers *et al.* 2019) draws on the findings that emotional connections are important and highly interlinked with the other dimensions of connectedness and used an innovative approach that combined transdisciplinary and art-based research in an intensively farmed landscape in Germany. Specifically, this means a qualitative empirical social science approach drawing on workshops and interviews, intending to identify themes of influencing factors on emotional connections to participants' public, natural, favourite places. The study site lies in a landscape that was rapidly changing over the last decade, due to land conversion for intensive agriculture. This conversion changed, or destroyed, participants public spaces or the surroundings of them, and we found two types of responses: "resilient" emotional responses towards landscape change showed a will to integrate these changes, while "non-resilient" responses were characterised by a sense of powerlessness for the participants, which negatively influenced their emotional connections to the landscape they are living in.

3.1.2. Human-nature connectedness and telecoupling

Non-resilient responses to landscape change often included references to a lack of agency to alter unsustainable system/landscape trajectories due to the impact of distal drivers of change. These included increased global trade, changing global diets, and a capitalistic paradigm of economic growth (e.g., Foley *et al.* 2011). Hence, to contribute to sustainability, we see a critical need for understanding the social-ecological interrelationships that determine human-nature connectedness. New research suggests that human-nature connectedness, and human-nature relations in general, require input from humans (Díaz *et al.* 2015; Bruley *et al.* 2021). This co-production process includes management of nature and natural resources that influence human-nature connectedness to support people's quality of life (Palomo *et al.* 2016).

Further, research has shown the importance of analysing telecoupled flows of human-nature connectedness between sending and receiving systems (Schröter *et al.* 2018). For instance, material connections are provided in one system but demanded in another, distant one (Dorninger *et al.* 2017; Schröter *et al.* 2018). Recent literature considers telecoupling essential to assess the sustainability of landscapes management (Koellner *et al.* 2019; Kleemann *et al.* 2020). Whether landscape management promotes human-nature connectedness based on local or telecoupled co-production will have consequences for the sustainability of the social-ecological systems. For example, extensively used landscapes are generally associated with local commercialization channels and circular economies, i.e., low levels of telecoupling; while more intensively farmed ones can be linked to higher levels of

telecoupling. These telecoupled flows often interact with other dimensions relevant to understanding the sustainability of the system, such as people's value systems (Brück *et al.* 2022).

To touch upon how telecoupling – and the underlying economic paradigms that exacerbate how distal drivers influence local landscapes and how human-nature connectedness is co-produced – **publication IV** (Lübker *et al.* 2021) analysed the data collected through the previous publications concerning perceptions of economic growth and possible influences on human-nature connectedness. The data consist of the two study sites in Lower Saxony, Germany, and our results highlight four archetypical perceptions of economic growth:

(1) growth as inherently positive;
(2) growth as being self-evident and without alternatives;
(3) growth as a systemic constraint; and
(4) growth seen as critical and with negative consequences.

Interestingly, all four archetypes are characterized by a common perception of systemic constraints. The interviewees felt constrained by a lack of concrete alternatives to the current economic system, and a lack of individual and societal agency, showing that a system is locked into its current trajectory. These sceptical and sometimes outright critical archetypes of economic growth may highlight landscapes under stress, in which landscape change negatively impacts people, but also the potential to try out or suggest new alternative economic models. Strengthening tangible alternatives to the dominant economic growth paradigm within and with the local communities could be a way to reconnect people to their environments, landscapes and, in the case of farmers, livelihoods (e.g., Table 2).

3.2. Relational values

Increasing attention is being paid in recent academic debates to the role that nature's values can play in enabling social-ecological transformation toward a more sustainable future (Pascual *et al.* 2017). Values have had a massive impact on the transformation of the world, for example, through the primacy of increasing economic productivity rather than the equitable and sustainable use of resources (Foley et al., 2005, 2011). Moreover, such values influence (perceived) options for action and objectives of the local population (as hinted at in Publications III and IV) and can promote conflicts between different populations and marginalised groups (Chan et al., 2016; Díaz et al., 2015). When exploring the values that people hold towards nature and their motivation to care for nature, often three broad distinctions are made between (1) instrumental, (2) intrinsic and (3) relational values (Muraca 2011; Chan *et al.* 2016). (1) Instrumental values represent the value attributed by people to something to achieve a particular end and (2) intrinsic value is the inherent value of nature and its components regardless of people (e.g., Arias-Arévalo *et al.* 2017; Pascual *et al.* 2017). (3) Relational values describe the value that people hold towards nature because of a relation to nature or specific entities of it. Relational values can be defined as having components of 1) preferences, and/or 2) principles and virtues associated with a good, meaningful and satisfying life arising from relationships with nature (individually, shared interpersonally or articulated by policies and institutions) (Chan *et al.* 2016; IPBES 2022). Relational values include some aspects of other types of values (including assigned values and moral values) and

fully encompass eudaimonic values (i.e., the non-substitutable moral considerations regarding what is considered a good life, Chan *et al.* 2018). Finally, the framework focuses on the relational content of the valuation process, in contrast to the valuation process itself, which is always relational (ibid.).

This thesis advances this novel approach of relational values (publication IX, Riechers *et al.* 2022a) and highlights its links to human-nature connectedness and how both are affected by landscape change (publications V, VII and VIII, Riechers *et al.* 2020b, 2021f, a).

3.2.1. Human-nature connectedness and relational values

There remains a lack of clarity regarding how the concepts of human-nature connectedness and relational values are intertwined. Based on the lessons learned in this habilitation, I see human-nature connectedness as a foundation that enables the creation of relational values. To define what relational values are, I will first go through several misconceptions about relational values and explain what they are not.

Activities in nature, that are expressed in experiential connections such as tourism, leisure or recreational activities have often been framed as relational values (Arias-Arévalo *et al.* 2017, 2018), yet I argue that these actions and activities might contribute to create and nourish particular relational values, but they are not a relational value per se. Similarly, aspects of environmental awareness (an expression of a cognitive connection to nature) is not as a value of this relationship. Instead, I define environmental awareness as an outcome of relational values such as, for example, Indigenous and local knowledge. In contrast, learning and ecological/environmental knowledge can be relational values when the dynamic relationship between humans and nature is defined through learning and knowledge (co-)created together with nature. Additionally, emotional connections to nature are also distinctive from relational values. For example, an emotional attachment such as love for nature could indicate strong relational values for nature, while unpleasant emotions (such as hurt, anger, or pain regarding biodiversity or landscapes) might indicate a recent degradation of a natural entity (publications III and V, Riechers *et al.* 2019, 2021f). Finally, some researchers identify ethical values and respect for nature as relational values, but I classify them as philosophical connections to nature. In my understanding, they are not relational values but value orientations or worldviews. Value orientations (also known as held values, underlying values or transcendental values) encompass the values that are important characteristics that guide people to make decisions and judgements about the world around them (Ives and Kendal 2014; Raymond and Kenter 2016). In contrast, contextual values are assigned to specific contexts such as people, places, natural entities or in the case of relational values, relationships.

Instead of seeing human-nature connectedness and relational values as similar, I argue that the distinction is necessary to understand the social-ecological dynamics of landscapes. **Publication V** (Riechers *et al.* 2021f) highlights the interlinkages between human-nature connectedness and relational values (yet still with a lack of conceptual clarity). We found that the relational values of social relationships and social cohesion along with cultural identity foster experiential human-nature connectedness in the form of social events in nature, and that the relational values of cultural identity

and sense of place led to emotional connectedness to nature. To make this distinction even clearer, the next section goes in-depth into the novel approach of relational values and explaining what they actually are.

3.2.2. Understanding relational values

The framing of relational value has the challenge "that an ambiguous term [such as relational values] is popular because everyone sees what they want in it, but there is no common ground for collective action or insight" (Chan *et al.* 2018). To create a common ground for collective action, **publication VI** (Riechers *et al.* 2022a) systematically reviewed literature from the past 20 years that used conceptualisations of relational values (in coastal and marine ecosystems of the Global South) without naming them as such (as the term was only popularised in 2016). Through this work, we were able to present groups of relational values, such as identity, heritage and tradition, social relationships, attachment to places and natural entities, stewardship and responsibility, cognition, spiritual and religious, aesthetic and inspiration, psychological and therapeutic values. Furthermore, to help conceptualise and operationalise relational values, we recommend specificity regarding which relational value group is targeted and their object of value.

The object of value is specifically important, as relational values are not present in natural entities but arise from relationships and responsibilities to them (Chan *et al.* 2016). Thus, empirical research on relational values needs to consider the context-specificity of the case. In general, entities of nature to which people assign relational values may be specific (i) organisms or species (Skubel *et al.* 2019; Marquina *et al.* 2022); (ii) geographic features, locations, and places (publication III, Riechers *et al.* 2019); (iii) an ecosystem (Su *et al.* 2022; Topp *et al.* 2022; Schmitt *et al.* 2022); (iv) a landscape or social-ecological system (often culturally constructed) (Uehara *et al.* 2018; publication VII, Riechers *et al.* 2021a); (v) processes and conditions (such as seasonal influences, ecological degradation, landscape change or restoration, e.g., Sheremata 2018; Fischer *et al.* 2021); and (vi) concepts and generalisations (such as biodiversity or nature in general) (Klain *et al.* 2017), which can include understandings of nature to as having personhood and agency (Bignall *et al.* 2016).

In addition, relational values span gradients in the degrees to which they reflect individually or shared values or to what extent they focus on human-nature interactions or human-human interactions mediated by nature. Relational values can arise both from human-nature relations (such as spiritual or cultural heritage), as well as human-human interactions (such as social relations or social memory) that stem from interactions with and in the natural environment (Muraca 2011) (Figure 6).

Relational values can be developed and articulated on a gradient between individual value creation/articulation to being developed and articulated collectively in a way that creates shared values (Axis X in Figure 6). Axis X represents the idea that relational values can develop, evolve and be expressed and held by individuals as well as by collectives, communities and societies (Chan *et al.* 2018). Shared values represent what are considered "shared principles and virtues" as well as a shared sense of what is worthwhile and meaningful (Kenter *et al.* 2015). In the context of relational values, shared values can be those derived from moral principles towards nature, such as the ideas that "taking

care of nature is the right thing to do" (i.e., stewardship or that we have the social responsibility to mitigate our impacts on nature). In addition, shared values are also represented by those values that are grounded in the traditions and heritage of society and perpetuated through the institutions (Frey 1994). In this context, shared relational values can be the heritage and traditions that emerge from a relationship with nature and through human-human interactions mediated by nature, which can also include those interactions that are articulated by formal and informal institutions (Mattijssen *et al.* 2020; Topp *et al.* 2022).

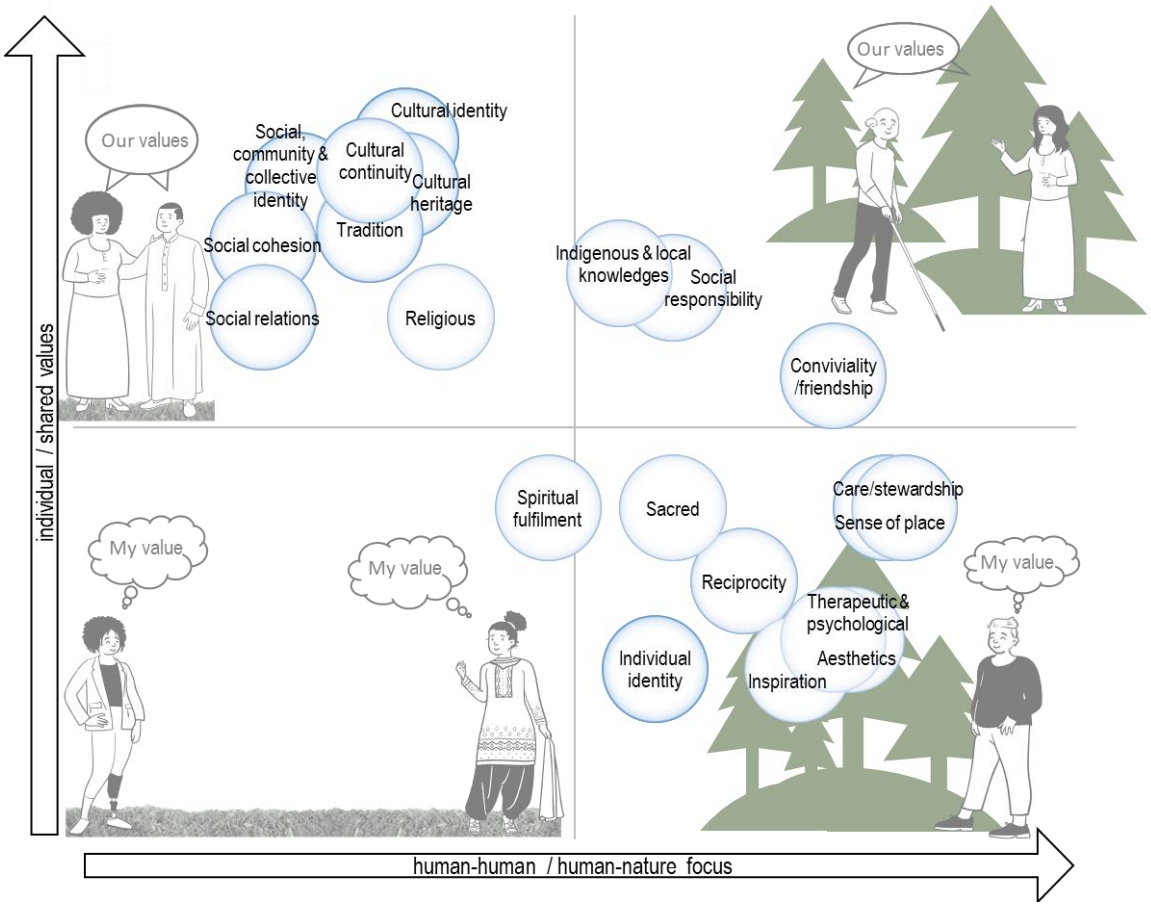

Figure 6: Graphical representation of the relational value categories according to the gradients of being understood more as an individual or shared value (X-axis) and arising more from human-human interactions mediated by nature or more human-nature interactions (Y-axis). The basis of this graphic is a subjective ranking of each value category from 1-10 (ranking done by: Berta Martín-López, Jasmine Pearson, Jacqueline Loos and myself). Both of these gradients are inherently artificial and should not be read as dichotomous. Such a conceptual thought experiment can, however, simplify the complexity of relational values.

3.2.3. Relational values and pro-environmental or sustainable behaviour

Depending on the perception of nature, relational values can differ between social groups and communities of cultures. The expression and formation of relational values can be limited through unequal access, land ownership, or economic practices (Jax *et al.* 2018; publication II, Balázsi *et al.*

2019). Based on this, statements and claims of strong relational values could be used to justify and solidify access or property rights claims. On the one hand, an inclusion of relational values in political and management processes could strengthen marginalised communities if their values are highlighted and integrated into management decisions. On the other hand, it could also increase unequal power relations between communities if the values of the dominant social group, society or culture are used to justify the existing marginalisation of others (Gordon *et al.* 2003). For instance, strong relational values are not always linked to a specific location, place, or region, and do not necessarily depend on the length of residency/occupancy – as it may be the case with the semi-nomadic Roma in Romania. Assuming that relational values are only existent and strong in permanently settled social groups, societies or cultures can reinforce 'an image of the bounded subject' and traditional hierarchies (Gordon *et al.* 2003). These hierarchies often refer to institutionalised values that may equate to unequally distributed access or user rights. Only focussing on place-based valuations can reinforce the exclusion of vulnerable groups that may also assign strong and complex relational values to natural entities even when they are displaced (Gupta and Ferguson 1992).

Moreover, relational values are not necessarily linked with sustainable or pro-environmental behaviour (Norton and Sanbeg 2020; Hoelle *et al.* 2022). Strong relational values may be used to argue for the maintenance of unsustainable practices due to claims of values for tradition, heritage or continuity (Chapman *et al.* 2019; Hoelle *et al.* 2022), such as intensive and unsustainable sheep grazing (Kizos *et al.* 2013; Tóth *et al.* 2018) or the rejection of alpha predators that may compete with human resources (Dickman and Hazzah 2016; Guerra 2018). Furthermore, strong relational values of stewardship or social responsibility can be used to support conservation actions and policies (Mattijssen *et al.* 2020) that could disenfranchise others who use and value nature differently (Sowman and Sunde 2018; Klain *et al.* 2018; Bennett *et al.* 2020). Therefore, much caution and context are needed to understand the complexity of 'undesirable' values of people's relationships with their environment (Hoelle *et al.* 2022).

3.2.4. The fluidity of relational values

Though the literature on relational values is increasing rapidly (see special issue: Chan *et al.* 2018; and e.g. Chapman *et al.* 2019; Mattijssen *et al.* 2020; Schröter *et al.* 2020), much knowledge is still to be gained through extensive empirical research to allow comparable statements across the globe. One of the areas where more explanation is needed is on the linkages between instrumental and relational values. Relational values are described as anthropocentric non-instrumental (i.e., referring to direct benefits to people in the sense of constituents of a good life) (Himes and Muraca 2018), because, in contrast to instrumental and, specifically economic values, the relationship that is of value with a natural object or process is non-substitutable (Chan *et al.* 2018).

However, relational values can be transformed by economic practices, political paradigms, and landscape changes. Depending on inhabitants' perception of nature, relational values can differ between social groups and can often be limited by unequal access, land ownership or economic practices. Worldviews are not static and in extension neither are relational values. Economic needs (income generation and market opportunities), political struggles (e.g., socialist to capitalist paradigm shifts) and

religious transformations (rise and decrease of religious expressions) can influence the preference or creation of relational values. Such changes may bring conflicts over the interpretation of worldviews, linked to changing agricultural practices. This may lead to conflicts and contrasts involving relational and instrumental values, especially when traditional economically practices are given up or changed into environmentally detrimental ones.

3.2.5. Instrumental values connected to landscape change that erode relational values

As mentioned above, relational values are categorised as separate from instrumental values, following the examples of Chan et al. (2016, 2018), where relational values are presented as a third category of value (intrinsic, instrumental and relational values). However, these values can be linked with instrumental values, given that they can both refer to instrumental relationships (Muraca and Bulgarian Academy of Sciences 2016) where humans derive some kind of benefit from nature, although the benefits in relational values are generally non-material. Regarding instrumental values, research shows that they can erode relational values, (e.g. publication VIII, Riechers *et al.* 2020b) as well as strengthen them (Topp *et al.* 2022).

Publication VII (Riechers *et al.* 2021a) draws on results from a large-scale quantitative study on relational, intrinsic, and instrumental values in all six study sites in Romania and Germany to support the hypothesis that instrumental values tended to be inversely related to relational and intrinsic values of nature. Specifically, instrumental values appeared to increase with the intensity of land use while relational and intrinsic values decreased – a pattern that was most strongly apparent when comparing landscapes between Romania and Germany. Our statistical analysis also showed that these values were related to respondents' attitudes towards environmental conservation. Our results of this quantitative empirical social science research, suggest a bundling of relational values into four groups, focussing on:

(1) individual cognition (including intrinsic values);
(2) nature as a place for social interaction and relaxation;
(3) cultural identity and spiritual values; and
(4) instrumental values.

In fact, in publication V (Riechers *et al.* 2021f) showed that in areas in which land use intensity was high and landscape change in the last decades was rapid and widespread, conflicts between economic practices and the relational value people generate from their landscape (or its features) emerged. Interviewees argued that the current capitalistic structure that fosters large, intensive agriculture companies instead of smaller farms forces farmers into unsustainable agricultural practices to be able to keep their farms economically viable. Many farmers had to give up their long-term family farms due to this constant need for investments and growth. If this growth proceeded, contrasts could emerge with smaller farmers whose farmland is often integrated into the larger growing farms but also with conservation NGOs or residents who dislike the growing monoculture landscape. However, the interviewees widely understood that the economic and political systems force farmers to grow and did not always blame the farmers themselves.

The dynamic links between instrumental and relational values might be explained through the strong connection we found between relational values and economic practices (e.g., linked to publication IV, Lübker *et al.* 2021). Economic practices are commonly understood in predominant western perspectives as human activities through which rational, utility-maximising individuals use and transform nature as a selection of resources to satisfy their needs (Gibson-Graham and Miller 2015). While economic practices fundamentally involve instrumental relationships, and our research showed that instrumental and relational values are inversely linked, **publication VIII** (Riechers *et al.* 2020b) hypothesises that relational values are eroding with increasing landscape change. Based on publication V and VII and their place-based empirical data, publication VIII draws on four study areas (in Romania and Germany, as included in this habilitation, as well as in Ethiopia and India). We argue that landscape change, especially landscape simplification, has negatively affected relational values. Specifically, we proposed the hypothesis that increasingly rapid and extreme landscape change erodes human-nature connectedness, relational values and ecosystem services. Trying to understand ways to strengthen human-nature connectedness and relational values, we discern that, fostering local agency may be key – and highlighting the potential for human-nature relations as realm of leverage for sustainability transformation.

By having provided a very comprehensive empirical understanding of human-nature relations in our study sites in Romania and Germany, this habilitation continues with the novel concept of leverage points and the newly developed leverage points perspective to identify places to intervene to foster human-nature relations for sustainability transformation.

4. Leverage points for human-nature relations

4.1. Advancing the concept of leverage points

To reiterate, "leverage points" are places in a complex system in which small interventions can have wide-ranging influences to bring about system change and may hold great potential for system transformation (Meadows 1999). Donella Meadows highlighted 12 places to intervene in a system, which Abson *et al.* (2017) summarized into four system characteristics (Figure 1 and 7):

(1) parameters (e.g., constants, buffer stocks);
(2) changes in feedbacks (e.g., length of delay, strength of feedback);
(3) changes in system design (e.g., information flow, rules); and
(4) changes in the intent (e.g., goals, paradigms) of the system.

These have an increasing order of effectiveness, as they range from shallow, superficial to deep and substantive potential for a system transformation. Both Meadows (1999) and Abson *et al.* (2017) voiced the hypothesis that deep leverage points have greater strength to influence the system than shallow leverage points. Yet, these deep leverage points are underused and under-researched, due to a focus on

"quick-fixes" and short-term solutions (as also voiced in Fischer *et al.* 2007, 2012) rather than transformative shifts (Sala and Torchio 2019).

Publication IX (Riechers *et al.* 2021c) tests this hypothesis, as well as aims to refine the usage of the leverage points concept as a hitherto under-recognised heuristic and practical tool (first used in Dorninger *et al.* 2020). In a systematic review of scientific literature on interventions for cleaner marine and coastal ecosystems, we analysed, among others, interventions for their systemic depths, linkages between these depths and actors named to implement the intervention. We found that indeed a solution-orientation was limited throughout the years, and more articles focus on reactive interventions than on proactive, pre-emptive interventions. Deep leverage points related to changing the system's intent and paradigms are rarely addressed and linkages, especially those spanning multiple system characteristics are missing. This shows the importance of the leverage points perspective to understand the social-ecological systems and classify interventions according to their transformative potential.

4.1.1. How to identify leverage points?

Much research still is needed to create a more coherent, comprehensive, and tested leverage points concept. A question that has often been asked, yet not addressed is how leverage points can be identified in the first place. The leverage points and their transformative potential in this habilitation has been assessed through qualitative expert rankings (publications IX and XII, Riechers *et al.* 2021g, c). To create a more transparent assessment, in this habilitation I propose an index of transformative potential to evaluate proposed interventions. This index is not covered in the publications of this habilitation. Instead this section is based on the conceptual and empirical knowledge created by it and attempts a new approach of answering the question on how to identify leverage points.

Hence, the following is a step by step guide that uses the "number" of leverage points based on the 12 leverage points by Meadows (1999) or the four characteristics of the system by Abson *et al.* (2017) and matrix of the "range" of intervention across the system to create an index of the transformative potential to evaluate proposed interventions. In this section, I will sketch a first possible approach to standardising the identification of leverage points and the transformative potential of interventions. This approach consist of five steps and yields a quantification of the transformative potential of intervention.

Step 1: assessing the systemic depth of change

First, could be an assessment of the systemic depth of change, meaning how impactful (that is, the consequences of the intervention will significantly transform the defined social-ecological system towards the achievement of one or more sustainability goals) the system-wide impacts of the assessed interventions are based on the 12 leverage points by Meadows (1999) or the four characteristics of the system by Abson *et al.* (2017). In this step, the "leverage point number" is chosen. The more concrete the intervention is defined, the better the assessment, as very abstract interventions might address multiple leverage points or system characteristics (Figure 7a). The lower the leverage point/system characteristic, the higher the impact. Interventions that only tackle parameter level changes, may be insignificant for system change (that is, the consequences if this intervention has an insignificant impact

to transform the defined social-ecological system towards the achievement of one or more sustainability goals). It is important to highlight that the evaluation of impact is, again, a subjective judgement potentially by an expert or discussed in a participatory setting. Further, the sustainability goals may depend on the social-ecological system but may relate to the sustainable development goals (SDGs) as identified by the UN (UN 2015).

Step 2: Creating a matrix for system-wide impact

Second, we create a matrix of identifying the system-wide impact of the intervention (in contrast of the system depth in the first step).

Step 2.1. Assessment across the realms of leverage

For this, we assess the impact of the analysed intervention *across realms of leverage* – Re-structure (institutional reform, and collapse); Re-think (knowledge co-production); and Re-Connect (material and non-material interlinkages between humans and nature) (section 1.2.1.) by asking "How wide are the impacts across realms of leverage of this intervention?". On a 4-point scale ranging from "very wide" – signifying a very wide impact across all three realms of leverage of this intervention will occur in the defined social-ecological system in the near future – to "very narrow", that is, a very narrow impact across only one of the realms of leverage of this intervention will occur in the defined social-ecological system in the near future.

Step 2.2. Assessment across system characteristics or leverage points

Then, we assess the impact of the analysed intervention across system characteristics or leverage points, meaning asking: How wide are the impacts *across the leverage points or system characteristics* (system parameters, feedback, design and intent) of these interventions? Again using the same 4-point scale ranging from "very wide" (i.e., a very wide impact across all four system characteristics of this intervention will occur in the defined social-ecological system in the near future) to "very narrow" (i.e., a very narrow impact on only one system characteristic of this intervention will occur in the defined social-ecological system in the in the near future), we can identify the system-wide impact of interventions. With this assessment, the importance of interlinkages between the realms of leverage and the characteristics of the system is acknowledged.

Step 2.3. Creating a matrix

Finally, we calculate the a matrix of intervention impact. This matrix plots the range of realms of leverage against the range of leverage points as seen in figure 7d. A very high impact of the intervention can be identified when the intervention is scoring as 'very impactful' at least once. Figure 7d gives a colour-coded numbering scheme to quantify this intervention impact (i.e., from very high=1 to low=4).

Step three: calculating the transformative potential

Third, to calculate the transformative potential of the interventions, we can add the aggregated leverage points ('number' of leverage points either 1-12, based on the 12 leverage points of Meadows (1999), or 1 to 4 based on the four system characteristics by Abson *et al.* (2017) divided by the amount of leverage

points/system characteristics) to the system-wide impact (1 to 4) and divide it by two (to create a transformative potential index of 1 to 8). The equation for this would be the following:

$$((LP_a + LP_2 + LP_n/LP_n) + X)/2 = TPI$$

In which LP is the characteristic of the leverage point / system, X is the impact of the intervention, and TPI is the transformative potential index. Figure 7d shows a colour-coded ranking of the transformative potential from 1 and 2 = very high, to 7 and 8 = very low (Figure 7e gives calculated examples of the highest and lowest transformative potential index).

Step 1. Assessing the systemic depth of change

Depth of change To which system characteristic(s)/leverage point(s) is the intervention linked?	
System characteristic	**Leverage point**
1. System intent	1. Power to transcend paradigms 2. Mind-set or paradigm that the system — its goals, structure, rules, delays, parameters — arises from 3. Goal of the system
2. System design	4. Power to add, change, evolve or self-organise system structure 5. Rules of the system 6. Structure of information flow
3. System feedbacks	7. Gain around driving positive feedback loops 8. Strength of negative feedback loops, relative to the effect they are trying to correct against 9. Length of delays, relative to the rate of system changes
4. System parameters	10. Structure of material stocks and flows 11. The size of buffers and other stabilising stocks, relative to their flows 12. Constants, parameters, numbers

Step 2.1. Assessment across the realms of leverage

Impacts across realms of leverage How wide are the impacts across realms of leverage of this intervention?	
Rating	**Description**
Very wide	A very wide impact across all three Re's of this intervention will occur in the defined social-ecological system in the near future.
Wide	A wide impact across all three Re's of this intervention will occur in the defined social-ecological system in the in the near future. These wide impacts are expected to occur in most circumstances.
Narrow	A narrow impact across two Re's of this intervention will occur in the defined social-ecological system in the in the near future.
Very narrow	A very narrow impact on only one Re of this intervention will occur in the defined social-ecological system in the in the near future.

Step 2.2. Assessment across system characteristics or leverage points

Impacts across system characteristics How wide are the impacts across system characteristics of this intervention?	
Rating	**Description**
Very wide	A very wide impact across all four system characteristics of this intervention will occur in the defined social-ecological system in the near future.
Wide	A wide impact across all four system characteristics of this intervention will occur in the defined social-ecological system in the in the near future. These wide impacts are expected to occur in most circumstances.
Narrow	A narrow impact across two system characteristics of this intervention will occur in the defined social-ecological system in the in the near future.
Very narrow	A very narrow impact on only one system characteristic of this intervention will occur in the defined social-ecological system in the in the near future.

Step 2.3. Creating a matrix

Matrix of system-wide impact					
	Strength of change				
		Very wide	Wide	Narrow	Very narrow
Across the system	Very wide	Very high	Very high	High	Moderate
	Wide	Very high	High	Moderate	Low
	Narrow	High	Moderate	Moderate	Low
	Very narrow	Moderate	Low	Low	Low

Step 3. Calculating the transformative potential

System-Impact	
1	Very high
2	High
3	Moderate
4	Low

+

Leverage point	
1	or 1, 2, 3
2	or 4, 5, 6
3	or 7, 8, 9
4	or 10, 11, 12

=

Transformative potential	
1-2	Very high
3-4	High
5-6	Low
7-8	Very low

	Impact	Aggregated leverage points	Transformative potential index (1-8 with 1 being highest and 8 being lowest)
Equation	$(X +$	$(LP_1 + LP_2 + LP_n/LP_n))$	$/2 = TPI$
Ex. highest	(1+ (1+	(1 /1)) (1+2+3/3))	/2 = 1 /2 = 1.5
Ex. lowest	(4+ (4+	(12/1)) (10+11+12/3))	/2 = 8 /2 = 7.4

Figure 7: Potential standardisation to identify the transformative potential of interventions based on the strength of change, system-wide impact, linkages across realms of leverage and system characteristics and leverage point 'number' as given by Meadows (1999) or Abson *et al.* (2017).

4.2. A new approach: the leverage points perspective

Based on the scientific advancement made by the Project "Leverage points for sustainability transformation" at the Leuphana University on the concept of leverage points (Abson *et al.* 2017; Leventon *et al.* 2019, 2021), **publication X** (Fischer and Riechers 2019) presents the leverage points perspective. The leverage points perspective is gaining momentum in sustainability science (e.g., Folke 2020), and due to its inter- and transdisciplinary nature. Terminology is still being developed for this new perspective. To clarify some aspects for the readers of this habilitation, table 3 highlights some key aspects of the leverage points perspective.

Table 3: Description of terms used regarding leverage points (publication XIII, Riechers *et al.* 2021g)

Terminology	Descriptions
System transformation	Radical change of systemic interlinkages and systems behaviour with fundamentally different sustainability outcomes
Leverage points perspective	A leverage points perspective recognizes increasingly influential leverage points from shallow to deep, encapsulated by a given system with the advantages to act as analytical tool, metaphor and methodological boundary object
Realms of leverage	Overarching 'thematic areas' that have the influence to transform the system across the four system characteristics
System characteristics	The four system characteristics parameters, feedback, design, and intent are a nested hierarchy and tightly interlinked. Parameters and feedbacks are seen as shallow for system transformation, design, and intent allow for a deeper system change
Leverage Points	Places in a complex system where small interventions can have wide ranging influences to bring about system change and where the right kinds of intervention hold great potential for system transformation
Levers	Interventions that can foster change. Levers are often intuitive, but the direction in which such levers should be 'pulled' may not be
Interventions	Concrete action taken to improve situation and promote sustainability. Levers and interventions are sometimes used interchangeably in the literature

Based on social-ecological systems thinking (Berkes *et al.* 2000), the leverage points perspective emerged as an epistemological view of how systems can be operationalised in the research process. We identified four key advantages of a leverage points perspective:

1. To focus on the influential and transformative places to intervene in a system;
2. To emphasise and address interlinkages between shallow and deep leverage points;
3. To bridge between causal and teleological explanations for system change, how change arises from variables interacting with each other, but also how human intent shapes the trajectory of the system; and
4. To use the concept as a methodological boundary object for different disciplines and transdisciplinary methods.

Publication XI (Riechers *et al.* 2022b) adds to this, specifying ways to operationalise the leverage points perspective for empirical research. In this publication, we highlight the possibility of the leverage points perspective as a boundary object to combine empirical and theoretical frameworks to understand the dynamics of complex social–ecological systems. Specifically, the leverage points perspective fosters a (1) stronger engagement with diverse epistemologies and paradigms, which may potentially be divergent. Based on this combination, research projects that are applying a leverage points perspective as a boundary object can encompass a (2) combination of methods – from natural to social science, from a causal to a teleological focus or from a normal to post-normal science approach. In this publication, we also highlight (3) the newly developed idea of 'chains of leverage' that provides special focus on the interactions between leverage points within a given system. By enabling the inclusions of divergent paradigms, methods and synthesising tool of analysis in the interdisciplinary research process, the leverage points perspective offers a (4) recognition of power imbalances and differing values when implementing possible interventions.

The most ground-breaking aspect of the construction of the leverage points perspective is the idea of "chains of leverage" (based first on ideas by J. Hanspach and J. Fischer). "Chains of leverage" are sequences of how systemic changes flow on from one another and can highlight possible mismatches or inadequacies of interventions at different levels. These sequences and inadequacies of interventions at different levels can be seen in Jiren *et al.* (2021a) regarding formal and informal agricultural institutions in Ethiopia. Their research highlights mismatches between the objectives of the system and intent at the national level versus the objectives and intent in rural landscapes in Ethiopia. Formal and informal institutions pursue the same overarching goal of increasing food security, yet, the intent encapsulated in formal institutions prioritises economic growth, while the system intent encapsulated in informal institutions prioritises local livelihoods. Because the Ethiopian government is more influential than local actors, informal institutions are eroding and substituted with formal ones. This example highlights possibility of the leverage points perspective to identify mismatches or inadequacies of interventions at different levels of systemic depth which may render some interventions without impact.

4.3. Leverage points to foster human-nature relations

Based on the created and advanced novel understandings and approaches to the leverage points concept, I will now highlight the advancements of this thesis on leverage points to strengthen human-nature relations for sustainability transformation. The overall results of this thesis, strongly suggest that strengthening human-nature relations can foster sustainability transformation. Reconnecting humans to nature is, hence, correctly termed as a realm of leverage with great potential.

First, synthesising our empirical knowledge from Romania and Germany based on the qualitative and quantitative studies conducted in all six study sites, **publication XII** (Riechers *et al.* 2021g) showed leverage points in which interventions may foster stronger human-nature connectedness. In this concluding paper, we concretize the call for a reconnection to nature using the leverage points

perspective and propose four leverage points addressing each system characteristic to foster sustainability transformation:

(1) On a parameter level, we suggest to maintain and enhance the structural diversity of landscapes;
(2) On a feedback level, we suggest to maintain and enhance economically and ecologically sustainable small-scale agriculture;
(3) On a system design level, we suggest to strengthen the sense of place; and
(4) On a system intent level, we suggest to strengthen the sense of agency in actors.

These leverage points are naturally nested within each other and hence are interconnected – suggesting that strengthening one of these leverage points might enhance another. These findings highlight the importance of understanding not only the depth of the system of a leverage point, but also how leverage points are interlinked with each other (as also seen in Manlosa *et al.* 2018; Jiren *et al.* 2021a). Intervening in these leverage points, we hypothesised, could effectively foster human-nature connectedness and, in turn, contribute towards a sustainable trajectory of cultural landscapes within Romania, Germany and Europe as a whole.

Testing this hypothesis and scaling-up/distributing the knowledge on human-nature relations, we organised a special issue on "Human-nature connectedness as leverage points for sustainability transformation" in the journal Ecosystem and People. The editorial (Riechers *et al.* 2021b) highlights the contribution of all authors and **publication XIII** (Riechers *et al.* 2021e) synthesises the general findings of the special issue to highlight the key advantages of the leverage points perspective, as presented in publication IX (Fischer and Riechers 2019), to shape human-nature relations.

Our synthesis specified how each key advantage can shape and strengthen human-nature relations. The explicit recognition of deep leverage points helped revealing the importance of addressing paradigm shifts in research and beyond: (1) relational thinking and relational values, (2) a stewardship philosophy, and (3) shifting the economic growth paradigm to focus on human well-being. Regarding the ability to examine the interactions between shallow and deep system changes, the publication highlights specific interlinkages between leverage points to further strengthen the transformative potential of interventions that aim at triggering shifts in our understanding about human-nature relations. The combination of causal and teleological modes of research was used by authors for an approach of envisioning desirable futures in which stronger human-nature connections were key. And lastly, the ability to function as a methodological boundary object was emphasised through the use of projects using arts-based methodologies in participatory, transdisciplinary research.

5. Conclusions

5.1. On human-nature relations

The empirical studies and conceptual advancements of this thesis have revealed the importance of human-nature relations for sustainability transformation, as well as a great potential of a leverage points perspective to shift academic discussions in the long term.

Regarding the connection between human and nature particularly, the experiential and emotional dimensions shape the connections people have with cultural landscapes. These dimensions are often connected with specific relational values, and the differentiation of these two new approaches has been made clear in this synopsis.

Table 4: General links between five dimensions of human-nature connectedness (HNC) and relational values based on a qualitatively collected data from two German study sites (publication V, Riechers *et al.* 2021f)

HNC	Definition of HNC	Linked relational values
Material	Local products with symbolic values	Cultural identity
	Knowing where food comes from	Stewardship eudaimonic; Social responsibility
Experiential	Passive and active recreation	Stewardship eudaimonic
	Social events in nature	Social cohesion; Social relations; Cultural identity
	Childhood spent in nature	Individual identity; Social memory
Cognitive	Knowledge on local culture and landscape	Cultural identity; Ecological literacy
	Knowledge on sustainability topics	Stewardship principle; Ecological literacy
Emotional	Negative and positive emotions to nature	Individual identity; Social responsibility
	Emotions regarding the trajectory of land-use changes	Stewardship principle; Sense of place; spiritual values; sense of agency; Social cohesion
	Sense of place/regional identity	Cultural identity; Sense of place
Philosophical	Treating nature appropriately	Stewardship principle; Stewardship eudaimonic; Social responsibility; Sense of agency; Social cohesion

The articles in my habilitation showed that cultural landscapes are changing in Europe and all over the world, with astonishingly comparable trajectories toward unsustainable futures. Our earth's current environmental and climate crisis will continue to erode the fundaments of sustainability, if we do not break the downward spiral of increasing disconnections from nature. Identifying leverage points and implementing an intervention to strengthen human–nature relations will be a great challenge in the coming years.

This thesis highlighted the importance of the interlinkages between shallow and deep leverage points – emphasised through the novel approach of "chains of leverage" (Publication XI, Riechers *et al.* 2022b). For human-nature relations, this means that structurally complex landscapes and structurally rich social relations mediated by nature are linked (Publication XII (Riechers *et al.* 2021g). Further, redesigning the function and structure of formal and informal institutions (a deep leverage point) directly affect the feedback mechanism and parameters of the system (a shallow leverage point) (as also seen in Manlosa *et al.* 2018; Jiren *et al.* 2021a). In the context of European cultural landscapes, this indicates that strengthen sense of place and a sense agency may enable self- and re-organization of cultural landscapes by opening the possibility to renegotiate people's values for values and the goals of the social-ecological system – which may ultimately enhance structural diversity of landscapes and small-scale agriculture.

This thesis also lays the ground for the hypothesis that degrading landscapes might also degrade social relations, which, in turn, leads to contrasts and conflicts between actors and social groups. These insights are supported by the newly published Intergovernmental Panel of Biodiversity and Ecosystem Services (IPBES) value assessment report (IPBES 2022). Published only in summer 2022, the IPBES report highlights the understanding of the relations between different worldviews and values of nature, as well as a values typology in which relational values play a crucial role. This clearly shows the

importance of human-nature relations and emphasises the need to embed diverse values of nature (relational, instrumental, intrinsic) into decision-making and policy-making.

The outstanding role of human-nature relations as a realm of leverage for sustainability transformation has been made clear in recent scientific discussion. It has been adapted and scaled-up for different rural landscapes (Fischer *et al.* 2022), environmental policy management on societal and European level (Mattijssen *et al.* 2020; Richardson *et al.* 2020), for Indigenous and local knowledge (Burgos-Ayala *et al.* 2020; Loch and Riechers 2021), gender transformative changes (Manlosa *et al.* 2018), as well as regarding climate change adaptation (Rosengren *et al.* 2020; Egerer *et al.* 2021). Yet, much debate on relational thinking and relational values as leverage point for sustainability transformation is still to be had (West *et al.* 2020, 2021; Raymond *et al.* 2021).

5.2. On leverage points

Overall, the novel findings and innovative approaches this habilitation entails have contributed to an ever increasing interest and use of the leverage points concept and perspectie in the realm of reconnecting humans to nature. For instance, the IPBES is actively engaging with the leverage points concept (Chan *et al.* 2020), albeit in a more vague, abstract manner. In addition, the IPBES value assessment highlights the capacity for human-nature relations to leverage transformative change (IPBES 2022) and uses the concept of leverage points (based on the four system characteristic popularised by Abson *et al.* 2017) in the newly started report on transformative change.

Further, two working groups of the Program for Ecosystem Change and Society (PECS) incorporate leverage points as key factors. One group focuses on “Ocean equity to foster sustainable futures” (led by M.R. and S. Villasante) and one on “Collective and care-full transformations for sustainability science” (M.R. part of the team). Further, a LEVERAGE project led by the Finish Environmental Institute (SYKE) uses a leverage points perspective to foster a circular economy (M.R. invited as expert); an application for a DFG network on leverage points for climate change adaptation (potential lead by J. Petzold and M.R.) has been written, as well as many more papers and research ideas (a literature review on papers using leverage points is underway).

Further research should focus on the scale dependency and agency to intervene in social–ecological systems to foster transformative change. The findings in this thesis suggest that deeper leverage points are linked to interventions on a national policy level, which is difficult to be influenced by individual actors. For example, individual agency might be limited regarding refocussing a growth-centric economic paradigm which influenced land use and consumer behaviour in both countries. In addition, more research is needed to concretises the identification of leverage points and that goes beyond experts subjective assessments (but see a first attempt in this thesis), as well as the operationalisation and testing of “chains of leverage” through empirical case studies.

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Research

The influence of landscape change on multiple dimensions of human–nature connectedness

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ABSTRACT. Human–nature connectedness is hailed as a potential remedy for the current sustainability crisis, yet it is also deeply affected by it. Here, we perform a comprehensive assessment of human–nature connectedness that includes material, experiential, cognitive, emotional, and philosophical dimensions. We show that these dimensions of human–nature connectedness are strongly interlinked, especially via emotional and experiential connectedness. Our findings showcase a cross-country comparison of four focal landscapes in Transylvania, Romania and Lower Saxony, Germany, which represent gradients from minor and gradual to relatively major and rapid landscape change. Based on content analysis of 73 in-depth interviews, we show that landscape change was seen by the interviewees to have a strong, and often negative, influence on multiple dimensions of human–nature connectedness. Focusing only on isolated dimensions of human–nature connectedness could inadvertently exacerbate the sustainability crisis because unawareness about relationships between dimensions of connectedness may lead to false predictions regarding policy implications.

Key Words: *agricultural intensification; landscape sustainability science; smallholder farming; social-ecological systems*

INTRODUCTION

Humanity has already passed planetary boundaries (Rockström et al. 2009), and status quo trajectories of human behavior continue to exacerbate the threats to our planet (Steffen et al. 2015, IPCC 2018). For terrestrial systems, unsustainable trajectories can be readily observed by studying landscape change expressed through the sociocultural consequences of land-use and land-cover changes (Bürgi et al. 2004). The structural simplification of landscapes through abandonment or intensification has long been recognized as a key threat to terrestrial ecosystems, negatively influencing wild and farmland biodiversity (Green et al. 2005, Tscharntke et al. 2005), the stability of farm incomes (Di Falco and Perrings 2003, Abson et al. 2013), and the diversity of crop varieties (FAO 2011). Moreover, recent studies highlight negative effects of landscape simplification on rural communities (Riechers et al. 2020). Landscape change, in turn, is closely interlinked with other unsustainable social-ecological trends such as anthropogenic climate change (IPCC 2014) and rising demand for energy-rich foods (Khoury et al. 2014).

Although the ecological consequences caused by landscape change are well documented (e.g., Foley et al. 2011), landscape change can also have detrimental effects on human–nature connectedness (Chan et al. 2016). These effects could lead to a downward spiral of ever increasing disconnection of people and societies from nature, which may further exacerbate the global environmental crisis by enhancing unsustainable behavior patterns (Pyle 2003, Nisbet et al. 2009, Kahn et al. 2010). In contrast, the beneficial effects of connections between humans and nature include positive outcomes for health (Maller et al. 2006, Shanahan et al. 2016), the cognitive development of children (Taniguchi et al. 2005), and overall happiness and well-being (Capaldi et al. 2014). Based on these outcomes, scholars state a need for strengthening human connections with nature (Folke et al. 2011, Zylstra et al. 2014). However, many calls for such "reconnection" lack concrete insights about what human–nature connection means and how it might be fostered.

Literature on this topic is fragmented among disciplines and encompasses a wide range of concepts and means to operationalize notions of human–nature interactions (Ives et al. 2017). Within this field, prominent literature includes notions of a "connectedness to nature scale" (Mayer and Frantz 2004), "nature relatedness" (Nisbet et al. 2009), and "connectivity with nature" (Dutcher et al. 2007, Restall and Conrad 2015; for a more comprehensive overview, see Ives et al. 2017). What is missing to date is work that recognizes multiple dimensions of human–nature connectedness and systematically links these dimensions to important features of social-ecological change such as landscape change.

To address this gap, we use a multidimensional conceptualization of human–nature connectedness and apply it to four contrasting landscapes undergoing change. Drawing on Ives et al. (2017, 2018), we recognize five dimensions. (1) The material dimension includes food, fuel, or other goods; research on this dimension has focused largely on biophysical flows (Wackernagel et al. 1999, Haberl et al. 2004, Dorninger et al. 2017), including teleconnections (Yu et al. 2013). (2) The experiential dimension relates to activities in nature and is based on decades of work, e.g., works by Miller (2005), Soga and Gaston (2016), and Keniger et al. (2013). (3) The emotional dimension spans aspects such as spirituality, aesthetics, and place attachment (Kals et al. 1999, Stedman 2003, Brown and Raymond 2007). (4) The cognitive dimension captures awareness and knowledge about natural systems (e.g., Bradley et al. 1999, Schultz 2001, 2002). (5) The philosophical dimension relates to conceptions of humanity's place in nature (e.g., van den Born 2008, Raymond et al. 2013). These five dimensions cover a multitude of disciplines and conceptual framings that together span decades of research in their respective fields. Here, we do not aim to provide a literature review or an in-depth analysis of these categories (for

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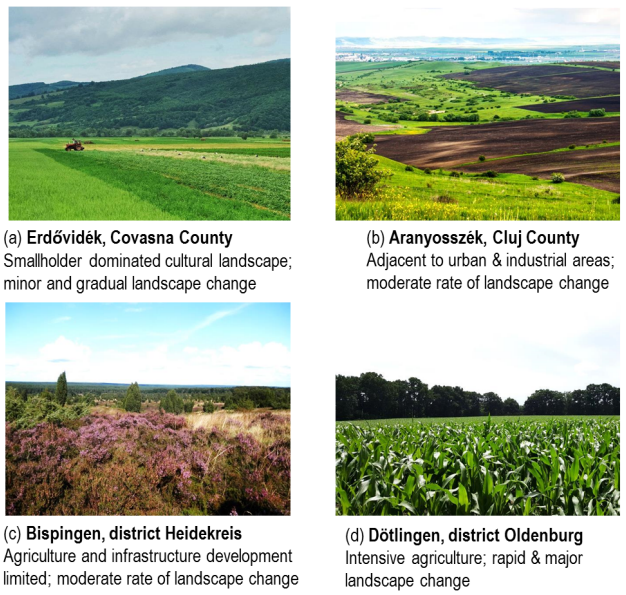
that, refer to Ives et al. 2017, 2018); rather, we aim to give a balanced and, therefore, simplified overarching empirical assessment of these dimensions. To reach this aim, we studied each of these five dimensions in four contrasting cultural landscapes in two countries (Romania and Germany), which represent a gradient from minor and gradual to relatively major and rapid landscape change. Drawing on data from all four landscapes, we sought to identify local perceptions of human–nature connectedness, to characterize relationships among different dimensions of human–nature connectedness, and to elicit the interplay between landscape change and human–nature connectedness.

METHODS

Focal landscapes

We focused on four landscapes: two in Transylvania, Romania, namely Erdővidék (Covasna county) and Aranyosszék (Cluj and Alba counties; Fig. 1); and two in Lower Saxony, Germany, namely Bispingen (district Heidekreis) and Dötlingen (district Oldenburg). The focal areas capture a gradient of minor and gradual (Erdővidék, Romania and Bispingen, Germany) and more rapid and major (Aranyosszék, Romania and Dötlingen, Germany) landscape change in their respective countries. Further, in all four focal areas, prior research was undertaken that facilitated the contextualization of our empirical study and the data collection process. Although both countries, and all four focal landscapes, have differing political, economic, and social place-specific differences, we compiled results from the four focal areas to show overall trends and differences in human–nature connectedness between the countries (for details, see Balázsi et al. 2019, Riechers et al. 2019). Our qualitative empirical work with large sample sizes allowed us to combine detailed place-based knowledge with a cross-country comparison.

Fig. 1. Example landscape photographs and descriptions of the four focal landscapes.



(a) **Erdővidék, Covasna County**
Smallholder dominated cultural landscape; minor and gradual landscape change

(b) **Aranyosszék, Cluj County**
Adjacent to urban & industrial areas; moderate rate of landscape change

(c) **Bispingen, district Heidekreis**
Agriculture and infrastructure development limited; moderate rate of landscape change

(d) **Dötlingen, district Oldenburg**
Intensive agriculture; rapid & major landscape change

Erdővidék is a smallholder-dominated cultural landscape, with large patches of forest and grassland and abundant wildlife. The landscape has changed only very slowly over the centuries, including during Romania's transition periods from a presocialist to socialist and now democratic society. Driven by socioeconomic and institutional change, increases in both land abandonment and intensification are considered possible in the foreseeable future (Hartel et al. 2016). Although changes have been slow in Erdővidék to date, ongoing governance challenges and socioeconomic changes could pose a risk to the landscape and its social structures in the long run (e.g., Horcea-Milcu et al. 2018). Local industry declined in the period of socialism, and Erdővidék struggles with poor socioeconomic viability and emigration of its youth. However, infrastructure development has increased in the last decade because of access to European Union (EU) funds.

The landscape in Aranyosszék is flat, crop-dominated, and subject to strong urban influences because of its proximity to the cities of Cluj-Napoca and Turda. Following Romania's accession to the EU in 2007, land-use intensity has increased, and smallholder vegetable cultivation has been increasingly replaced by industrial croplands. Family farming is declining because of an ageing population and strong competition with supermarkets. However, industrial development and small businesses have increased due to improvements in infrastructure.

The landscape in Bispingen (district Heidekreis) lies in eastern Lower Saxony and partly inside the Lueneburger heath nature park (protected under Germany's federal nature conservation act), which was established in 1907. Environmental protection laws have slowed landscape change because of restrictions to agricultural intensification and large-scale infrastructure projects. Especially for the agricultural sector, these limitations have posed economic challenges, making small-scale farming increasingly unviable and causing conflicts between farmers and nature park authorities. Tourism is an important income source for people within the landscape.

The landscape in Dötlingen (district Oldenburg), located in mid-west Lower Saxony, has changed substantially over the last 20 years because of agricultural intensification, including the expansion of maize cultivation, mass animal husbandry, and biogas production. Associated drivers have included EU agricultural subsidies, as well as national subsidies for renewable energy production. In the district of Oldenburg, the proportion of agricultural land under maize production increased from 18% in 1995 to 33% in 2016 (Landesamt für Statistik Niedersachsen 2018*a,b*) while decreases have been observed in water and air quality (Velthof et al. 2014).

Data collection

To understand different dimensions of human–nature connectedness, the relation between these dimensions, and how they are influenced by landscape change, we used problem-centred interviews (Flick 2006). Interviews were held in Romanian, Hungarian, and German using a semistructured interview guideline, which was partly adjusted to the interviewees' profession (Atteslander 2006; see Appendix 1 for full interview guidelines). The guideline included sections on interviewees' material, experiential, cognitive, emotional, and philosophical connectedness, which were assessed through questions on the use of local natural products, habits and frequency of nature visits,

knowledge of nature and the landscape, perception of beauty, favorite places, and the feeling of and attachment to their homes. Regarding landscape change, we asked specifically for perceived changes in the recent decades, how these changes influenced interviewees' lives, and how interviewees perceived the trajectory of changes for the decades to come. The interview guidelines were adjusted to fit the local context in the respective countries (Appendix 1). Because of different historical events in Romania and Germany, the discussion around landscape change and its drivers led to the capture of different time spans. Whereas most interviewees in Romania felt a need to explain the drastic political, social, and economic changes in the country starting in the socialist area from 1947 onward, German interviewees typically focused on changes in the last 20 to 40 years.

For the interviews, we addressed informed laypersons and experts who we expected to be connected to a given landscape based on prior information about actors and actor groups or organizations in the focal areas. Those areas were mainly related to agriculture, forestry, policy-making regarding environmental issues, priests, and long-term inhabitants, usually with a high level of civil engagement. Based on these initial interviews, we used snowball sampling to reach other potential interviewees (Flick 2006). The interviewee age ranged from participants in their 30s to 90s. Although we aimed for gender balance, more men than women were interviewed because of the social structure in agriculture and politics. This sampling approach resulted in a total of 73 interviews with an average length of 71 min (Erdővidék: $N = 20$, Aranyosszék: $N = 19$, Bispingen: $N = 17$, Dötlingen: $N = 17$).

Data analysis

Interviews were transcribed verbatim and analyzed using MaxQDR Plus 12 (VERBI Software, Berlin, Germany) and NVivo 10 (QSR International, Doncaster, Australia). Data were analyzed using summarizing qualitative content analysis (Mayring 2008). Based on the five dimensions of human–nature connectedness as described by Ives et al. (2017, 2018), we created a deductive coding tree that was iteratively adjusted inductively, driven by the narratives and topics raised by the interviewees. The deductive approach helped to focus existing theories and allowed comparability between the focal areas; it focused primarily on the five predefined categories of human–nature connectedness and known aspects of landscape change. The inductive approach ensured that all relevant specificities and topics not covered in the coding tree were able to be captured and unexpected statements made by interviewees were sufficiently incorporated. Codes were successively grouped together to form categories of an increasing level of abstraction (Mayring 2008). Table 1 shows the resulting final categories and their subdivision (subcategories) within the five dimensions of human–nature connectedness. For example, one type of emotional connection is captured by the category "spiritual and religious feelings". This category, in turn, is divided into two subcategories: "Christian-based" and "mystical" connections.

To assess relationships between different dimensions of human–nature connectedness, we extracted stated relationships. For example, we may have coded an interviewee's statement into the category of emotional connectedness such as sense of place, which was related by the interviewee to experiential connectedness such as social activities in nature (e.g., "I feel like home here so I spend a lot of time outside"). Another interviewee might have spoken of material connections such as provision of food, and linked this connection to experiential activities such as a high frequency of nature visits (e.g., "I collect mushrooms in the forest every week"). Such relations were captured and used to illustrate relations between the different dimensions of human–nature connectedness. The direction of the relationships and their strength were not coded because they typically could not be identified clearly from the qualitative statements made by the interviewees. The same procedure was used to combine information on landscape change and categories of human–nature connectedness. To guarantee anonymity, we do not give the age, gender, or profession of the interviewees here.

RESULTS

We first identify perceptions of human–nature connectedness (Table 1) and highlight their interrelations (Fig. 2). We then illustrate the interplay between landscape change and human–nature connections.

Dimensions of human–nature connectedness and their relationships

Interviewees stated that their material connections to nature stemmed from the use of fuel (biogas, wood), food (collected, self-grown), building material, collection of artisan goods, owning land, agriculture and forestry, and the use of regional products. In Transylvania, strong material connections stemmed from traditional smallholder farms because using materials from nature for subsistence (firewood, food, etc.) was very common. Interviewees related material connectedness to experiential and emotional connectedness (Fig. 2): experiential connectedness through extraction of goods and time spent on working the land; emotional connectedness through a sense of responsibility and sense of belonging to particular places (e.g., where inhabitants produced food, hay, or collected water).

Experiential connections were identified as frequent nature visits, especially close to home. They included recreation and social activities in nature. The stimulation of the senses and motoric development, and especially interviewees' own childhood experiences, were seen as constituents of experiential nature connectedness. Experiential connectedness, in addition to its aforementioned relation to material connectedness, was linked by the interviewees to emotional connectedness (Fig. 2). In particular, social activities in natural settings (experiential) were related to inhabitants perceiving a sense of place (emotional). When discussing their love for nature (emotional), interviewees often referred back to childhood experiences in nature (experiential).

Cognitive connections were defined as learning by doing and observing in nature, especially through an active awareness of daily encounters with nature. Self-identification with the landscape, knowledge about the environment and farming practices, and especially the knowledge and visibility of specific historical events and cultural sites were perceived as key components of cognitive connectedness to nature. In addition, raising awareness for nature through education (formal and informal), active communication about environmental topics in peer-groups, and general environmental education were deemed as another pillar for cognitive connectedness. Cognitive

Table 1. Results of the cross-country, summarizing content analysis, grouped into five dimensions of human–nature connectedness. Categories and subcategories are themes that emerged from the interview data.

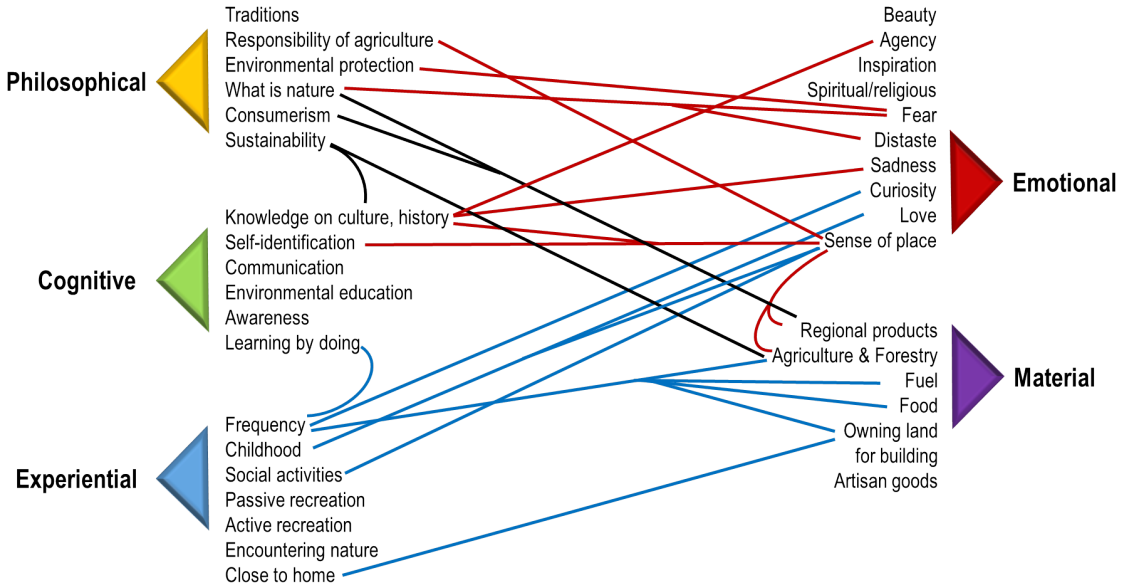
Dimension	Category	Subcategory
Material	Fuel (biogas, gas, wood)	Subsistence, industrial
	Food (collected, self-grown)	
	Agriculture and forestry	Subsistence, small scale, large scale, collective
	Decorative or artisan goods	
	Owning land	Private, community, state, collective or cooperative
	Mining or building materials	
	Regional products	Symbolic, not appreciated enough, too expensive, trust
Experiential	Frequency of visiting nature	Work, leisure
	Passive recreation	Solitude, silence, contemplation
	Active recreation	Sports, hiking
	Social activities in nature	Family and friends, festivals, traditions
	Encountering nature	Using senses, motoric development
	Visits close to home or on own land	
	Own childhood	
Cognitive	Learning by doing or observing	
	Identification with region or landscape	
	Active communication on nature topics	
	Environmental education	
	Knowledge of local history, culture, and nature	Informal, formal
	Awareness	Increased awareness in daily encounters with nature
Emotional	Sense of beauty	Natural nature, wide view, landscape diversity
	Strong regional identity or sense of place	Social structure, attachment to cultural landscape and home land
	Agency, responsibility, ownership	
	Spiritual and religious feelings	Christian-based, mystical
	Love of nature	Especially trees, animals, being a farmer from the heart
	Arts or inspiration	
	Curiosity or looking for special features	Discovering something new, extraordinary, special experiences
	Sadness	Loss of biodiversity, knowledge, awareness, traditional farming
	Fear	Of unstoppable intensification, loss of regional identity, brown bear (*Ursus arctos*)
	Distaste of industrialized livestock production	
Philosophical	Sustainability, fit for the future	Economic stability, all is connected, more important than aesthetics
	Consumerism negative	Constant need to grow
	Preservation of traditions	
	Importance for environmental protection	Exchanged for economic gain, has to be done right
	Agriculture comes with high responsibility	For own family, heritage, consumers
	What is nature and what is it for	Ideological fronts hardened, role of humans in nature

connectedness was related to philosophical, experiential, and emotional connectedness (Fig. 2). For example, through the discussion of sustainability (philosophical), interviewees linked their knowledge (cognitive) with a normative perspective of human–nature relationships, and in that context, they often expressed sadness regarding the current landscape change (emotional). Cognitive connectedness was further related to emotional connectedness because the knowledge and awareness of a given landscape's specific history and culture fed into a strong sense of place.

Emotional connections were partly positive, stemming from love for nature, spiritual and religious connections to it, aesthetics, and, moreover, feeling inspired and creative by being in nature. Feelings that fostered emotional connectedness were further related to agency, responsibility and ownership, a strong sense of place, and curiosity to look for new and special encounters or experiences in nature. Emotional connections also came from negative emotions such as fear and sadness regarding the state of the landscape and a dislike of industrialized livestock production. Emotional connectedness, in addition to the aforementioned relations, was linked by the interviewees with philosophical connectedness (Fig. 2). As an example, the normative notion of the need to preserve the landscape (philosophical) and the discussion of what nature is and who owns it (philosophical) was related to a fear regarding current landscape changes (emotional).

Philosophical connections were identified from discussions around differing notions of sustainability or the need to be fit for the future (from the German: *zukunftsfähig*). A critical view of consumerism and the constant need for growth (e.g., more products or more farmland) increased philosophical nature connectedness. Moreover, the perceived importance of environmental protection, preservation of traditions, the highlighted responsibilities of agriculture and forestry, and the discussion of the definition of nature (and for whom it exists) were pillars for philosophical connections. For philosophical connectedness, in addition to its aforementioned relations, interviewees also saw a link with material connectedness (Fig. 2). The discussion of the use of regionally produced goods (material) was linked to negative opinions of consumerism in general (philosophical). For example, some interviewees stated a lack of trust in commercialized production and critically questioned

Fig. 2. Graphical representation of relationships among the five dimension of human–nature connectedness (material, experiential, cognitive, emotional, and philosophical; from Ives et al. 2018) based on the content analysis of four focal areas (see details in Table 1). Lines indicate relationships between the categories of human–nature connectedness as highlighted by the interviewees. For ease of interpretation, lines from experiential and emotional connections are shown in blue and red, respectively.



modern consumption patterns such as high rates of processed meat consumption.

Interplay between landscape change and human–nature connectedness

In all four landscapes, material connectedness was perceived to be declining due to the decoupling of consumers from local production processes and the increased consumption of nonlocal goods. In both landscapes in Transylvania, landscape change was related to changes in state governance, which resulted in shifts in land ownership. Nationalization and collectivization of private property by the state during communism led to a loss of material connectedness because the goods produced were often allocated to other localities. However, when connections to inhabitants' own land were reestablished following the collapse of communism, socioeconomic conditions changed as well, preventing a durable reconnection of material connectedness:

> *[…] the land was given back after the 90s. Everyone turned back to the practices used before the collectives [were established]. Everyone did their share, as they could, with horses, oxen, and cows. They were struggling with it for about 10 years. […] now they want to get rid of it. Now we don't know how to convince farmers to rent our land.* (Aranyosszék, teacher).

In Lower Saxony, smaller agricultural farms and local products declined because of global and national political and economic drivers. Many goods that still provide a material connection to nature have changed from being livelihood necessities to becoming symbols of regional identity (e.g., specific regional varieties of potatoes or honey). Because of the increase in biogas plants and wind parks, some villages, especially in Dötlingen, have become energy self-sufficient. Although this self-sufficiency provides a new type of material connection to nature, it has come at the cost of a large proportion of land being used for maize production, which is viable largely in combination with mass animal husbandry.

Whereas experiential connectedness in Lower Saxony was perceived as stable, in Transylvania, it transformed with a change in rural lifestyles. Recreation and leisure increased while farming experiences decreased. Moreover, high rates of emigration weakened the experiential connections with "home":

> *In Erdővidék, more than 60% of young people leave their home landscape because of a lack of jobs. Some turn back after making some money, some commute between home and abroad, [some] never look back. The last two are the worst because the majority remains [abroad]. Those who come back build their homeland at the beginning, but then are trapped again when their finances run out.* (Erdővidék, teacher).

Further, in Transylvania, cognitive connectedness to nature was shaped by shifts in knowledge systems and political ideologies (presocialist, socialist, democratic). The shifts affected individuals and the community's collective cognition regarding the management of the landscape and its resources. Most notably, inherited and experience-based knowledge became increasingly supplanted by formal and disciplinary knowledge. Shifts in political ideologies (e.g., socialism, communism, capitalism, environmentalism) appear to influence cognitive connectedness. Interviewees stated that the traditional knowledge of the

community might get lost because of a lack of interest in it by the younger generation.

> *The knowledge about nature, of what nature is, I think, they don't get that now, [...] the relation [to nature] which is inherited. Obviously, inherited knowledge includes the names of trees and things. [...] In other words, there is an emotional bond, whereas in learned knowledge, we just know a lot of things.* (Aranyosszék, priest).

Cognitive connections in the two Lower Saxony focal areas were often generated through stimulating and exciting experiences such as visiting new places, rare sightings of particular plants or animals, or special atmospheres (Table 1):

> *[The view] has something mystical. The wide plains and the juniper [*Juniperus communis*], and, when the fog lies upon it and the sun comes through. That... that is wonderful.* (Bispingen, Tourism).

Such cognitive stimulating experiences were often connected to a structurally diverse landscape, which, in turn, was connected to emotional connectedness.

In fact, in all four landscapes, emotional connectedness was linked by the interviewees to a structurally diverse landscape. The most highlighted themes related to emotional connectedness were special landscape features, seasons, animals, and a wide view of the landscape (Table 1). In Transylvania, emotional connections came from stories about social relationships that existed in the past, for example, working the land gathered the community in nature. Interviewees talked nostalgically about lost traditions (e.g., cleaning pastures in spring, community work for hay making) and social relationships that had become weakened because of changing lifestyles. In Lower Saxony, and Dötlingen specifically, interviewees expressed sadness, especially with regard to the topic of environmental protection and the current landscape trajectory. This sadness was linked to a feeling of loss of agency and ownership of nature, while still feeling a sense of responsibility for it, as exemplified by a story in which a tree was cut illegally due to agricultural expansion:

> *My favourite tree has been cut down. I thought: This cannot be true. [...and even though I tried to find the responsible persons] the big beautiful tree, which I loved, was of course gone.* (Dötlingen, employee in an environmental protection authority).

Most interviewees showed negative feelings regarding landscape changes. In Dötlingen, where landscape change had been most rapid, anger and sadness for the perceived destruction of the landscape, as well as for the resulting conflicts affecting the communities' social relationships, were particularly pronounced. However, in all focal areas, sense of place, love for nature, and spiritual expressions remain important.

Themes related to philosophical connectedness in Transylvania included meanings of nature, heritage values, and the role and place of human beings in the natural world, revealing sustainability issues (although this term was rarely used). The most common associations with sustainability were respect for nature and family heritage. The family's land and traditions regarding its management occupied a central role, especially in Erdővidék. Philosophical connectedness in the Lower Saxony focal areas was defined by the influence of landscape change. Differing understandings of who owns land and the landscape, as well as contrasting definitions of what constitutes nature, showed differing paradigms among the local people. The current trajectory of agriculture, perceived to be driven by a paradigm of growth, was often seen to be contradictory to environmental protection:

> *They always say - you have to do more, you have to get bigger [agriculture but also in general...] or is this just a dream of some (economic) growth? I don't know. Is there an end somewhere?* (Dötlingen, young farmer).

DISCUSSION

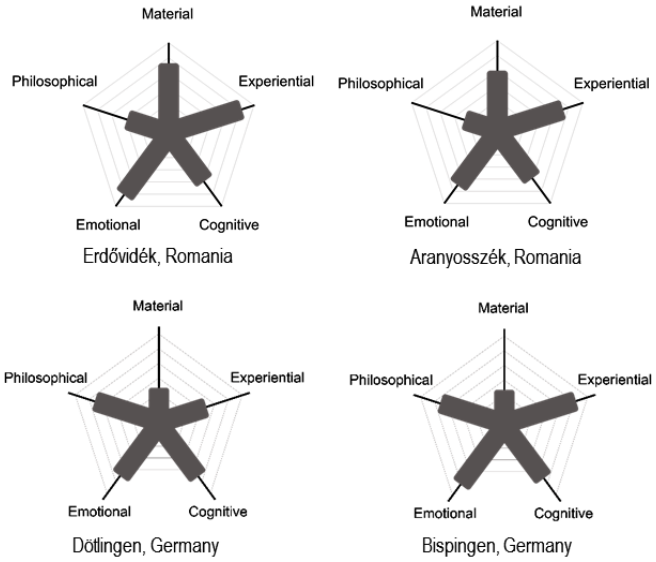
Drawing on four different landscapes in two countries, we elicited the following four ideas. First, the experiential and emotional dimensions of human–nature connectedness seemed to play a key role for our interviewees and had links to many other dimensions. This interpretation might show that those two dimensions could foster, through ripple effects, a multitude of connections when strengthened. Second, in general, many human–nature connections were linked to each other, and reinforcing and balancing relationships seem likely to influence ambitions to strengthen overall human–nature connectedness. Third, landscape change was stated to be eroding and changing human–nature connectedness in the focal areas. Lastly, there are a multitude of human–nature connections, and hence, research should not be solely compartmentalized into disciplines. Although in-depth specific studies are of utmost importance, overarching synthesizing studies should not be left aside. Knowledge about the heterogeneous and context-specific character of human–nature connectedness is therefore crucial.

Emotional and experiential connectedness had the most connections to the other dimensions and seem to act as key connectors (Fig. 2). In particular, emotional connections such as love (Wilson 1984, Schultz 2001) and place attachment (Stedman et al. 2004) had multiple connections to other dimensions. Likewise, the experiential connection of frequent visits to nature (Soga and Gaston 2016) was linked to other dimensions of connectedness (Fig. 2). Because disconnection from nature is likely to exacerbate the global sustainability crisis, it is important to find concrete ways to foster and strengthen human–nature connectedness. However, most calls for reconnection have remained vague and abstract and lack concrete insights about a comprehensive notion of what this connection means and how to foster it. Our findings point to a multidimensional notion of human–nature connectedness with many interlinkages among those dimensions. Our results showed that the experiential and emotional dimensions of human–nature connectedness could be particularly important entry points when trying to enhance and strengthen human–nature connectedness because these two dimensions were linked to many other connections. A possible focus on emotional connections could be done via art (Riechers et al. 2019) or through a focus on personal sustainability (Ives et al. 2020).

Apart from the key role of experiential and emotional connectedness (Fig. 3), we found a high degree of interconnectedness among these dimensions. As an example, in our results, a strong sense of place (an emotional connection) was related to philosophical (e.g., preservation of traditions), material

(e.g., regional products), cognitive (e.g., knowledge of regional history and culture), and experiential (e.g., social activities) dimensions of connectedness to nature. Although we do not know the causal relationships among these links, these findings suggest that there will likely be ripple effects when there is a change in any dimension of human–nature connectedness, positive or otherwise. Our findings thus emphasize the heterogeneous character of human–nature connectedness and the attention to dynamic interlinkages needed to study this phenomenon comprehensively. Reinforcing the relationships between different types of connections, for example, could foster useful ripple effects (or even reinforcing feedbacks) across multiple dimensions of connectedness.

Fig. 3. Schematic depiction of the current strength of material, experiential, cognitive, emotional, and philosophical connectedness in the four focal areas of Erdővidék, Aranyosszék, Dötlingen, and Bispingen. Bars are a subjective interpretation based on the collective interview statements from each focal area and depicted here schematically to allow comparison among the focal areas.



Across the four focal areas, we found the trend that rapid landscape change appeared to decrease the overall levels of connectedness. This trend could continue due to continued simplification of landscapes, and also as values might change slower than the landscapes, creating a situation in which values are linked more to memories of landscapes than to the currently existing ones (Horcea-Milcu et al. 2018). Even though we found vastly differing political contexts in which the landscapes changed over the last 20 years (Balázsi et al. 2019, Riechers et al. 2019), the trajectory of changing human–nature connectedness was similar. The five dimensions of human–nature connectedness appeared to be relevant for all four focal areas, and discussions around landscape change touched upon comparable issues in both Romania and Germany. We thus consider it plausible that similarities can also be observed in other rural landscapes elsewhere in the world. Indeed, a recent comparison considering additional study systems suggests there were generalizable links between landscape change and the erosion of cultural and individual identity, human–nature connectedness, and sense of agency (Riechers et al. 2020). However, despite the potential value for human–nature connectedness, structural landscape diversity is deteriorating in many parts of the world (Foley et al. 2005), as is small scale agriculture (e.g., Mikulcak et al. 2013). In areas of rapid landscape change, sense of place and biocultural values are at risk (Hartel et al. 2018). Finally, trajectories favoring economic growth over social equity not only lead to landscape simplification but can also lead to an increase in conflicts (Scoones et al. 2019). Quantitative analyses of such interlinkages could show insights into complex patterns between landscape change and human–nature connections in their various forms (Jansson and Polasky 2010, Dobbs et al. 2014) and could potentially help to inform decision makers about large-scale management processes.

Our empirical study is the first to apply the interdisciplinary framework proposing five dimensions of human–nature connectedness by Ives et al. (2017, 2018). The conceptual framework was broad enough to cover all important aspects of human–nature connectedness that we identified through the deductive and inductive coding process. It allowed us to capture a wide variety of relationships between different types of connections and to include a focus on how these relationships were perceived to alter through landscape change. Assessing material, experiential, cognitive, emotional, and philosophical perceptions of connectedness seemed to capture heterogeneity successfully, both in concepts and people's experienced realities, and opens the possibility for integrating different disciplinary perspectives on human–nature connectedness, including biophysical flows between societies and nature (Wackernagel et al. 1999, Haberl et al. 2007, Dorninger et al. 2017), behavioural approaches (Capaldi et al. 2014, Soga and Gaston 2016), and approaches that focus more strongly on philosophical aspects (Dutcher et al. 2007, Nisbet et al. 2009).

CONCLUSION

The empirical work from four different landscapes in Romania and Germany highlight four major results. We found multiple links among material, experiential, cognitive, emotional, and philosophical dimensions of human–nature connectedness in the lived experiences of our interviewees. Landscape change, in all four landscapes, showed a change and a decrease in human–nature connectedness, and hence, we hypothesize that a similar trend might be observable in other landscapes. Improved human–nature connectedness has been hailed as a possible remedy to the global sustainability crisis. However, the relationship between human–nature connectedness appears to be mutually reinforcing such that there is a two-way link; that is, human–nature connectedness can also be eroded quickly through unsustainable landscape trajectories. To combat a spiral of disconnectedness and landscape change, we suggest focusing on the importance of strong emotional and experiential connectedness as pivotal points in overarching human–nature connectedness and reinforcing and balancing relationships among the dimensions. We acknowledge that societal changes (economic, cultural, etc.) are likely to influence human–nature connectedness. However, such societal changes drive landscape change; therefore, we believe that landscape change acts as a useful phenomenon though which such complex societal changes are played out and can be explored.

Whether landscape change is a proximate or ultimate driver of changing human–nature connectedness is a question deserving further research.

We also suggest that more firmly establishing the causal links between human–nature connectedness and sustainability could be an important research focus. Human–nature connectedness is not something that can be readily manipulated across entire social-ecological systems or landscapes, and sustainability is also a highly complex and multidimensional concept. These factors pose challenges for disentangling the relationship between changes in human–nature connectedness and sustainability outcomes. Finally, applying the conceptual framework used here to other contrasting landscapes would be useful to assess whether there are indeed broadly applicable interventions that could foster human–nature connectedness and thereby benefit sustainability.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/11651

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Data Availability Statement:

The data are not publicly available due to restrictions; they contain information that could compromise the privacy of our interviewees. For questions please contact M. R.

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The impacts of social-ecological system change on human-nature connectedness: A case study from Transylvania, Romania

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ABSTRACT

Contemporary Romania has been subject to several major social and institutional shifts that have had implications for the connectedness of humans with their environment. Four major governance eras have influenced human-nature connections: (1) formal and informal institutional governance after the World Wars and before socialism (before 1947), (2) top-down governance during socialism (1947–1989) and (3) during sovereign state governance and transition to European Union (1990–2006), and (4) multilevel governance since European Union accession (after 2007). We analyzed two cultural landscapes in Transylvania with respect to changes in human-nature connectedness. The two systems were similar at the beginning of the 20th century, but developed differently in their intensity of landscape management in the 21st century. Drawing on 41 semi-structured interviews, we examined changes that influenced landscape management and human-nature connectedness, considering five dimensions of connectedness: material, experiential, emotional, cognitive and philosophical. Material connections have weakened as a result of changes in food production and rising consumerism. Experiential and emotional connections were influenced by socio-economic and landscape management changes. Cognitive connections reflected changes in the knowledge system on the environment. Philosophical connection was influenced by changes in ideologies and globalization. Our findings highlight the central influence of social and institutional change on perceived human-nature connectedness. Understanding this influence provides important pointers for how to reconnect humanity to nature in the coming decades.

1. Introduction

The global ecological crisis has sparked critical reflection of humanity's roles and responsibilities for the natural environment. There is increasing recognition of human dependence on natural systems, although uncertainty exists about how to achieve a balance between human well-being and ecosystem integrity (Fischer et al., 2015). Both research and policy communities have addressed problems such as habitat loss (Millennium Ecosystem Assessment, 2005), the transgression of biophysical limits of the globe (Rockström, 2009; Steffen et al., 2015) and anthropocentric climate change (IPCC, 2014). While scientists and policy-makers are aware of environmental problems and their complexity, there is a knowledge-action gap between science, policy and practice (O'Brien, 2013), which hampers transformational change (Fischer et al., 2007).

Human-nature connectedness (HNC) has recently been re-emphasized as a key concept for leveraging sustainability changes in social-ecological systems (SES) (Abson et al., 2017; Kopnina, 2017; Ives et al., 2018). In particular, it is recognized that there are multiple dimensions of HNC: material, experiential, emotional, cognitive and philosophical (Ives et al., 2017, 2018). While several studies have addressed the multi-dimensional complexity of HNC (Mayer and Frantz, 2004; Hofstra and Huisingh, 2014; Ives et al., 2018), fewer have emphasized its implications for sustainable landscape management (Bauer et al., 2009; Gonzalez et al., 2009). Cultural landscapes, are interesting and relevant from SES perspective (sensu Ostrom, 2009; McGinnis and Ostrom, 2014) because they are rich in culture as well as biodiversity; with connections between humans and nature playing critical roles (Hartel et al., 2014; Elands et al., 2019). Scholars argue, for example, that an emotional and experiential connection with nature has many positive outcomes for human well-being (Capaldi et al., 2014) and pro-environmental behavior (Hedlund-de Witt et al., 2014; Klaniecki et al.,

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2018), and may promote conservation initiatives of natural and cultural heritage within landscapes (Miller, 2005).

In this paper, we examine how perceived changes in the social-ecological system have influenced perceived HNC in two cultural landscapes in Transylvania (Romania). Both study areas have been subject to multiple complex and rapid changes triggered by shifts in governance and political paradigms over the past century (Câmpeanu and Fazey, 2014; Hanspach et al., 2014; Hartel et al., 2016). Notably, there were four distinct periods of socio-political and institutional changes in Romania which influenced the rural communities and land use: (1) pre-socialism (before 1947), (2) socialism (1947–1989), (3) sovereign state government and transition to EU (1990–2006), and (4) EU membership (2007-present). To the best of our knowledge, there is no available information about how the above changes have influenced HNC in the rural landscapes of Romania.

Understanding the richness of HNC and how they are influenced by institutional and social changes in the Romanian rural landscapes is important because these landscapes have exceptional socio-cultural and natural values (Horcea-Milcu et al., 2018; Molnör and Berkes, 2018). Further the farming practices still sustain species rich ecosystems, including landscape elements and species which have severely declined or are protected in Western Europe (Dahlström et al., 2013; Biró et al., 2014; Loos and Wehrden, 2018). However, changing socio-economic aspirations (Hartel et al., 2018), often linked with weak social capital (Hartel et al., 2014) and poor institutional performance (Mikulcak et al., 2015), pose several challenges in adopting and implementing sustainable landscape stewardship. Exploring the richness of HNC and how they change under various socio-political contexts can guide researchers and decision makers in governing these rural landscapes.

Our paper therefore has two objectives: 1) to identify perceptions of changes in the social-ecological system over time, including in governance, land use, and socioeconomic conditions; and 2) to highlight the effects of these changes on material, experiential, cognitive, emotional and philosophical dimensions of HNC. In order to meet these objectives in the studied landscapes we used an interdisciplinary heuristic interpretation that recognizes material, experiential, emotional, cognitive and philosophical dimensions of connectedness to nature (Ives et al., 2017, 2018). Our methodology, including background information on the case study landscapes, our interview data collection method, and our coding analysis, is presented in the following section. We follow with results, structured according to the two objectives. We continue with a discussion that emphasizes that the landscapes we analyzed were subject to dynamic social, political and economic transitions in recent decades. We highlight that the SES changes had several similar effects on the two landscapes, but we also identified context specific effects. We conclude by stressing the importance of understanding various dimensions of HNC, both for understanding past changes and for the future management of cultural landscapes.

2. Methods

2.1. Selection of sample areas

We focused on two rural landscapes in the southeast and northwest of Transylvania, Romania. These landscapes belong to distinct regions with similar historical and cultural backgrounds, namely Erdővidék (in Covasna County) and Aranyosszék (in Cluj and Alba Counties). The two areas had similar development trajectories at the beginning of the 20th century, but developed differently in their intensity of landscape management in the 21st century. Now, the two areas (Fig. 1) represent the two extremes in the development of Romanian rural landscapes: Erdővidék is a smallholder-dominated cultural landscape, dominated by forests and grasslands, and geographically isolated, while Aranyosszék currently consists mostly of intensive arable land with smallholdings in remote areas, and overall stronger urban influences (for more information see Appendix A in Supplementary material).

2.2. Data collection

In order to collect data on HNC over time in a changing social-ecological system, we conducted in depth interviews with a range of stakeholders in each landscape (Erdővidék, n = 20, Aranyosszék, n = 21). We wanted to achieve rich data, where we collected a broad range of opinions and themes. We therefore aimed for diversity in the types of stakeholders that we interviewed. To achieve a broad coverage of perceptions and opinions on SES changes and HNC dimensions, we aimed to identify the most relevant stakeholders and interest groups from both study areas, including foresters, farmers, wildlife rangers, long-term residents, local leaders, teachers, nature lovers, priests, artists and students. Interviewees were approached using snowball sampling (Bryman, 2012), where we started with a small group of easily accessible participants, and asked them to recommend knowledgeable people to talk to on our subject (landscape changes and HNC). We conducted n = 41 interviews in Romanian and Hungarian languages with an average length of 66 min. The average age of interviewees varied from 47 years in Erdővidék (26–79 years old) to 60 years in Aranyosszék (43–90 years old). The gender ratio was 33 men and 8 women, which is explained by the snowball sampling approach; the social patterns in Transylvania mean men's occupations are more connected to landscape management than women's, leading participants to be more likely to recommend male interviewees. The education level of the interviewees varied from elementary classes (4 years) up to university. We covered ethnic variety (Romanians, Hungarians, Roma) respecting the recommendations of locals for the selection of interviewee.

In order to generate deep reflection during our interviews, we generated a semi-structured interview guideline for problem-centered interviews, which was refined during a round of pilot interviews (see full guideline in Appendix B in Supplementary material). The questions referred to perceptions on SES changes and HNC dimensions, and were grouped on general topics such as: habits of visiting nature, perception of beauty, connection to the landscape or homeland, changes in the landscape, perceptions on nature conservation and renewable energies. We included elements of participatory mapping (on a printed map of the study areas) and photo elicitation (preselected pictures). We often asked participants to show on a map where they were talking about, or to explain what something looked like referring to pictures. These techniques were not intended to produce spatial or visual data, but were used as tools to facilitate discussion and to keep the interviews grounded within the study landscape. Interviews were transcribed verbatim, in the original language.

2.3. Data analysis

We analysed the transcripts using NVivo 11 Pro (QSR international) software. Coding was done in the original language. Translation was done only at the point of write-up when selecting original, illustrative quotes. We used qualitative content analysis (Mayring, 2008) with inductive and deductive coding. The deductive coding derived from recent literature on SES changes (Hanspach et al., 2014; Hartel et al., 2016) and on HNC (Ives et al., 2017, 2018). The inductive coding derived from adjusting the coding tree iteratively and consistently as new (relevant) topics emerged. We increased the level of abstraction of the content by merging similar codes successively into subcategories, then similar subcategories into categories, and finally organizing the categories on topics, then themes.

Discussions on SES changes resulted in categories of codes including agriculture, society, forest management, environmental protection and nature conservation, wildlife management and hunting, local to national economy, formal and informal institutions, urbanization and infrastructural development. Between them, our respondents provided

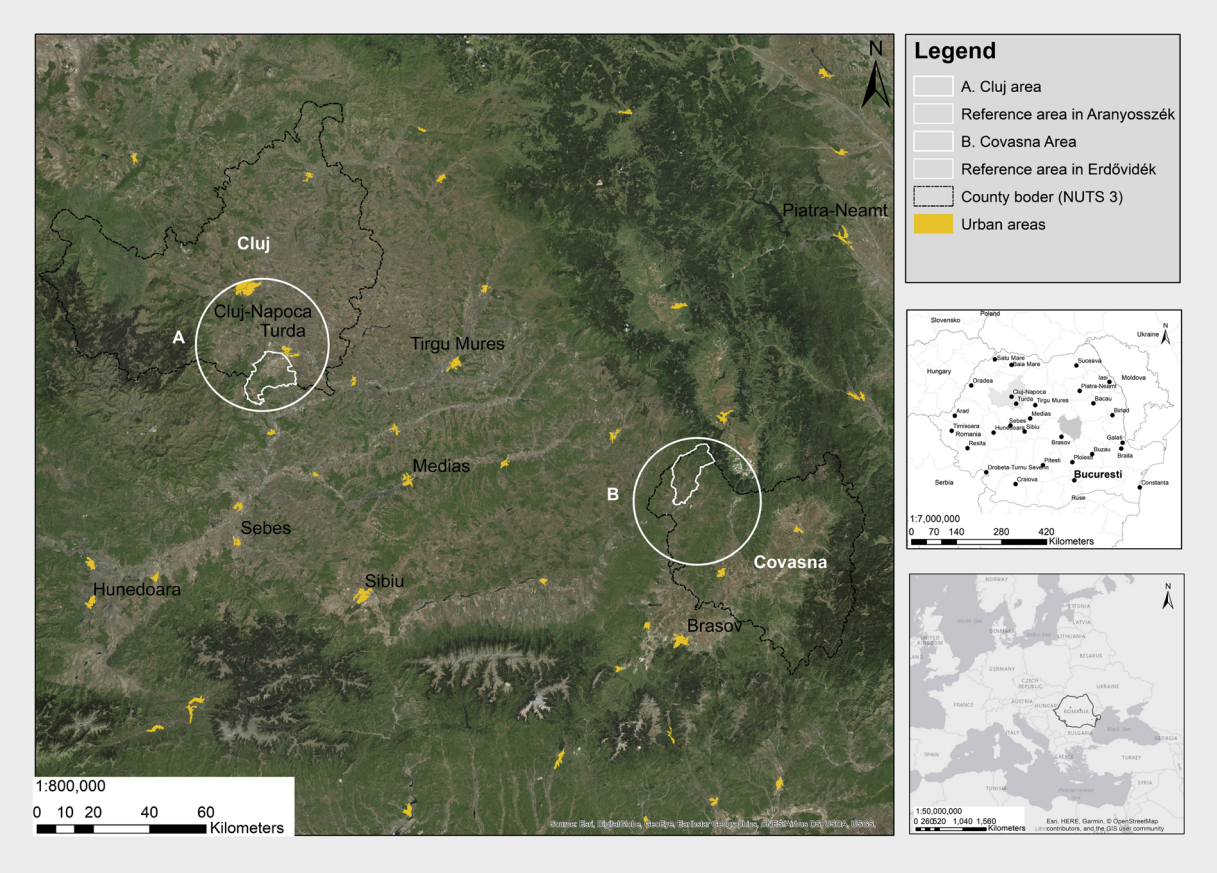

Fig. 1. Study area indicating the locations of the reference areas. The inset shows the location of the study areas within Romania and Europe. (Map author: Balázsi Á., Source: Esri, HERE, Garmin, OpenStreetMap.

narratives that covered approximately the past century (since World War II) and followed almost the same division as described by some scholars (Câmpeanu and Fazey, 2014; Hartel et al., 2016): the pre-socialist (before 1947), the socialist (1948–1989), the sovereign state & EU transition (1990–2006), the after EU accession to present (after 2007). We recognize that not all participants were adults during the era about which they reflected, and that memory is often fallible. However, we use these narratives as representations of the way in which our respondents perceive that 1) landscape has changed; and 2) how that change affects their relationship with nature. We do not therefore seek to challenge or fact-check these narratives, but rather explore within them how people frame and represent these changes.

The HNC theme was split into the five dimensions of HNC: material (e.g. provision from nature for livelihood & land management), experiential (e.g. social relationships linked to land use & culture; activities in nature/landscape), emotional (e.g. bond with landscape & nature; sense of home), cognitive (e.g. knowledge in resource management; nature awareness) and philosophical (e.g. meanings of nature for human life). Each dimension covered subcategories of codes about personal or collective, internal or external connectedness. Where evidence existed we coded paragraphs on HNC to eras.

To find out whether and how SES changes influenced HNC dimensions, we performed the following analysis. First, we linked the SES changes to HNC dimensions running a matrix query using NVivo software. For this we used as common variables the eras, or the pieces of paragraphs that were coded for both themes to find out causal links between SES changes and HNC dimensions. Thus, we obtained three matrixes: (i) combining SES changes with eras; (ii) combining HNC dimension with eras and (iii) combining SES changes with HNC dimensions. Then we analyzed the texts (i.e. the matrix enabled access to original text that was coded in both variables) to see if any causality existed between coding categories (e.g. material connection & 1990–2006, cognitive dimension & institutional changes). The causalities between SES changes and eras and HNC dimensions and eras, are described in Table 1 and Appendix C. The major, and the most evident influences of SES changes on HNC dimensions that emerged from the interviews were described in the Section 3.2 Changes in human-nature connectedness.

3. Results

3.1. Objective 1: perceived social-ecological changes

3.1.1. Governance changes

Interviewees described changes in Romania's governance system as a transition of mainly informal institutional governance (before socialism) toward a formal, top-down government during socialism, and after its fall, aspirations toward multilevel governance (Fig. 2, Appendix C - Major system changes in Romania over time and influences of those on the local landscapes). Before socialism, widespread respect of locally agreed rules (e.g. use of natural resources) was highlighted. Later, socialist propaganda suppressed local rules of resource management and those who refused to obey (e.g. collectivization of land, losing ownership of forests) were punished or intimidated. Despite this, several interviewees noted that many had preferred the period of socialism, because it created a sense of socio-economic stability. The post-socialist period was associated with "*revolution*", "*freedom*" and "*high hopes*". Yet, interviewees were disappointed about this period, because real democracy remained elusive. In the 1990s "*everything remained a bit without law*" (Erdővidék, wildlife manager) and corruption increased. Today, interviewees felt that the top-down system strongly limits local leaders to proactively govern local resources.

Table 1
General changes in human-nature connectedness in relation to higher-level social-ecological change. This table combines information about changes in historical periods of Romania that influenced the five dimension of HNC we addressed. The table reflects the perception of the interviewees from both study areas.

HNC	Before 1947	Socialism 1947–1989	Sovereign state & EU transition 1990–2006	EU membership 2007-present
Material				
Provisions for livelihoods & land management	Peasant farming & provisions for subsistence	Abolition of traditional land use & provisions from gardens (allowed 0.3 ha/family)	Restitution of land and property rights & extensive management for livelihoods	Technologisation, market economy, agribusinesses & partial livelihood
Experiential				
Social relationships linked to land use & culture	Shared community work	Compulsory work in collectives	Less community work & technology weakened social relationships	Interest for events environment & culture
Activities in nature	Focus on work	Technologisation of agriculture, leisure & recreation encouraged	Decreasing work, increasing leisure & recreation	Decrease in activities & children spend less time in nature
Emotional				
Bond with landscape & nature	Farming connected people & nature	Disturbance by expropriation & devaluation of heritage	Elders attached to land & heritage, decreased bond for youth	Connection weakened & youth increasingly disconnected
Sense of home	Preservation of natural & cultural heritage of homeland/landscape	Emigration for better life & strong emotional connection	Environmental quality of homeland appreciated	Community belonging weakened & preservation of local values
Cognitive				
Knowledge in resource management	Traditional knowledge and informal rules	Professional knowledge and formal rules & traditions less practiced	Land management for economic reasons	Aspirations for western styles of management
Nature awareness	Life close to nature & awareness of ecological processes & collective care	Disconnection due to industrialization & no environmental education	Low environmental awareness & limited access to information	Environmental education & community engagement & access to information
Philosophical				
Framing of the value/ role of nature	Urge to maintain the heritage for coming generations & subsistence	Nature as principal provider of goods & services in the visions of socialism	Capitalistic ideologies, limited access to resources & unsustainable management	Rising environmentalism, tendency to protect traditions and heritage

3.1.2. Changes in landscape management

According to interviewees, landscape changes manifested as shifts in land use, land management and ownership (Fig. 2, Appendix C in Supplementary material). Before socialism, the landscapes were managed for the subsistence of family farms in private and common ownership forms. Interviewees often described this period as a reference for proper landscape management, when production, needs of community and ecological processes were much more in balance than today. During socialism, the farming was taken over by the government (i.e. 'state') and the land was managed for industrial production, often unsustainably. Private ownership was suppressed either by expropriation (in the case of forests), or collectivization (in the case of arable land). Collective farms served state interests, while local people were executors of the national production plans on their former land. With the end of socialism, state production ceased in both landscapes and locals turned back to former ownership forms and managed the land traditionally, mainly for subsistence or family profit (Erdővidék from animal husbandry, Aranyosszék from vegetable production). Forest management suffered from unsustainable management and sometimes illegal activities (e.g. logging, property shifts) as interviewees described.

Major differences in landscape trajectories between the two study areas were described after 2000. In Erdővidék farm sizes increased (from less than 5 ha to avg. 50 ha) since 2007, when EU subsidies became accessible. The Common Agricultural Policy of the EU, while being economically important for farmers, created a phenomenon of cultivating crops and keeping animals primarily for subsidies instead of to meet local needs. Forest management became more professional because of EU environmental regulations, and access to certification schemes (e.g. quality certification - FSC). In Aranyosszék traditional vegetable production fell when supermarkets opened international competition in the early 2000s. Stringent conditions and national bureaucracy made it almost impossible for farmers to sell local products in the supermarkets. Most recently, the landscape has become dominated by industrial crop production, whereas small-scale farming has survived only in remote areas. Since 2007, EU subsidies have improved conditions for agribusiness (avg. size of a farm 200–600 ha), following western production standards. The quality of forest management has not improved much and was strongly criticized by interviewees.

3.1.3. Socio-economic changes

Before socialism, people were less dependent on the monetary economy than on benefits and goods offered by nature locally for livelihood (Fig. 2, Appendix C in Supplementary material). Strong social cohesion existed due to social networks and shared activities related to landscape management, such as haymaking, pasture cleaning or wood extraction. During socialism, people felt that the land served the interests of the state instead of locals. While rural emigration was common in both areas, Aranyosszék also experienced some influx from other regions. Erdővidék was more economically affected than Aranyosszék after the collapse of industry and state companies in the 1990s. EU accession (2007) and globalization further amplified socio-economic instability (e.g. intra-EU migration, lack of labor force locally, weak economic competitiveness). However, EU membership facilitated access to new funds (e.g. agricultural subsidies), and living standards generally increased.

3.2. Objective 2: changes in human nature connectedness

Changes in the SES affected HNC in both landscapes. Changes in both study sites were broadly similar, as summarized in Table 1 (see also Fig. 2, Appendix C - Major system changes in Romania over time and influences of those on the local landscapes). However, differences existed in the degree of change in HNC, as described in more detail in this section.

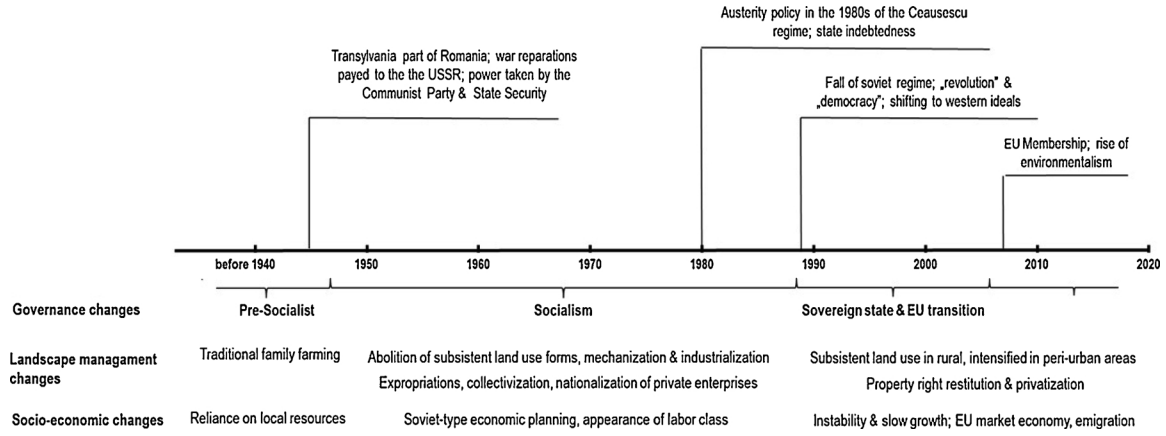

Fig. 2. Timeline of social-ecological system changes as described by local interviewees. The figure shows big events in Romanian history above the timeline. Below, we outline the four eras that our respondents talk about, and summarise the perceived broad changes in social-ecological systems.

3.2.1. Material connections to nature

Material HNC was perceived as declining in both landscapes in comparison with the past, but was still present in the sense that some local materials continued to be important. All types of SES changes described in the previous section were perceived to have influenced material connections. "*There is no one left who will work the land with two horses, two cows and three pigs. This will be disappearing (…). At one or two houses, you still can buy milk, but in former times, every household had milk. (…) Many of them grow crops for their own use…eggs, ducks, geese are not a problem. But there are many that buy pork from others* [i.e. locally]*, or go to the supermarket to buy the meat they need"* (Aranyosszék, hunter). Socio-economic changes pushed the material needs of society from a landscape-dependent context toward a global one.

3.2.2. Experiential connections to nature

Major changes that influenced experiential connection were: (1) giving up farming and transformation of rural lifestyle, (2) less time spent in nature, especially for young people, (3) interest of the urban population in the natural values of rural areas. Interviewees spent time in nature because they had a traditional household or worked in professions related to nature (e.g. farmers, foresters, wildlife managers) and/or liked to spend time in nature for a wide range of reasons (e.g. hobbies, artistic activities, participation in public events). Experiences from being outside, collection of goods from nature (e.g. mushrooms, wild fruits, and medicinal plants), leisure and recreation were the most prevalent. Childhood experiences in particular emerged in almost all of the discussions related to nature. "*I always wondered, I was curious, and hoped to discover something new tomorrow*" (Aranyosszék, farmer). Interviewees mentioned that childhood experiences had changed. Due to technology and other distractions, children spent considerably less time in nature: "*In former times, it was natural that you spent time outside* [at the summer settlement near the mountain meadows]*, sitting in the evenings beside the fire, while the parents went home to bring food, or wood from the forest. Today we are afraid, children are afraid* [of nature]" (Erdővidék, forest and wildlife manager).

Changes that occurred within the landscape, in combination with socio-economic changes, determined the way interviewees related experientially with nature. Erdővidék kept its rural appearance, as small farms remained a functional part of the landscape. Due to a lack of urban influences, the area remained rural. "*People from here are in contact with nature almost every day*" (Erdővidék, carpenter). Aranyosszék has changed more substantially, with some villages primarily inhabited by weekend residents, and others becoming attractive for urban migrants, offering "*better living conditions than in the city"* (Aranyosszék, teacher) and access to new leisure experiences in nature (e.g. running, cycling, hiking).

3.2.3. Emotional connections to nature

Interviewees associated nature with positive emotions describing relaxation (e.g. sense of calm, stress release), attachment (e.g. love for nature), happiness (e.g. joy, pleasure), and freedom. Negative emotions were associated with situations were humans impacted nature (e.g. anger, frustration, hurt, rejection). Childhood experiences with nature showed positive effects on emotional connectedness. "*My father took me in the forest for the first time, which deeply touched me and it still does*" (Aranyosszék, decision maker). Interviewees discussed emotions linked to values of nature or landscape features that conserved memories and feelings and included experiential connections as well. The most highlighted were seasonal and other changes in nature, wild and domestic animals, forests, gorges, agricultural land, streams, sounds, flowers, mountains and views. „*Once I saw a scene, I rarely cry, but then my eyes became wet. (…) It was summer with red sky. The grandfather was spreading manure from the cart while his little grandchild was dancing on the horizon with her blond, floating hair. It was such a nice view"* (Erdővidék, forest and wildlife manager). Interviewees linked the landscape to their personal roots and sense of responsibility, and expressed a deep emotional bond and a sense of home, composed of landscape, nature and community belonging.

3.2.4. Cognitive connections to nature

Cognitive connections changed with system ideologies (e.g. socialism, communism, capitalism, environmentalism) and their associated knowledge systems – that is, differential relative importance of formal (e.g. professional, disciplinary based) and informal (e.g. traditional, inherited, observation based) knowledge about nature and the surrounding landscape . Interviewees were concerned about the loss of informal knowledge that had implications for emotional connections and attitudes toward nature. "*With inherited knowledge, the relationship is inherited. Implicitly, it includes the names of trees, things (…) but there is an emotional bond that is missing in the acquired knowledge*" (Aranyosszék, priest). Even if informal, traditional knowledge survived in the memory of the community, young people were less interested to apply it. Socio-economic changes during and after socialism amplified governmental changes, and created conditions for many to lose their sense of responsibility for the landscape. Young people were increasingly less interested to work the land and expectations about life changed. Environmental awareness has generally increased since 2000, but remains poor for some issues (e.g. littering, human-wildlife conflicts).

3.2.5. Philosophical connections to nature

Philosophical connections covered physical, moral and spiritual values for humanity, which ought to be conserved to assure a future for humanity. This dimension included people's value systems, and was influenced by experiences, emotional and cognitive connectedness to

nature. It was revealed in stories about: (1) nature and its role in human life; (2) human attitudes and the need to conserve nature beyond cognitive statements; and (3) cultural heritage preservation and sustainability. Nature was considered many times as a living being and part of life, and represented a deep meaning, associated with God, totality, absolute freedom or psychological well-being. "*I see nature as yet undestroyed reality of God in our lives, even though we tried it hard* [to destroy it]" (Aranyosszék, priest). "*We live close to nature and closeness determines that our inner and upper world, our spirit and soul is connected to nature.*" (Erdővidék, teacher). "*Today, society and globalization suggest that every person is valuable but in fact, we are just dust.* (…) *Nature tolerates us for a while. After a time,* [nature] *will get bored of* [us]*, switch something and humanity will come to its end*" (Erdővidék, student). More discussions addressed the human self and nature from philosophical perspectives in Erdővidék than in Aranyosszék. Interviewees often revealed the responsibility of humans for protecting nature: "*Nature can exist without me, but I cannot exist without nature*" (Erdővidék, forester and wildlife manager), "*it is a functional part of our society"* (Erdővidék, decision maker). Sustainability (the idea, not the term) emerged in stories about the care for family heritage (the farmland), which played a central role for landscape connections. *'Society has changed. Less and less people do farming and those who have kept farming mainly do it on large areas and rather for more and more profit* [monetary]*, than doing it from heart.* [Investigator: What does farming from the heart mean to you?]. *It used to be a general way of life for livelihood. My grandfather got the land from his father and nourished it* [managed] *as if it would be a piece of his soul. He tried to maintain the meadows and the arable to be able to leave it to his child. He knew, that his child would live from the land, and the child's descendants too. Today, many* [farmers] *work on rented land and it matters less how the condition* [of land] *it will last, because next year maybe someone else will rent it'* (Erdővidék, student).

Interviewees talked about changes in general over the last 100 years, and explained that the value system shifted, which made them to think pessimistically about the future of their landscapes: "*We became very selfish*" (Aranyosszék, teacher).

4. Discussion

4.1. Social-ecological change and its implications for human-nature connectedness

After World War II both landscapes were intensified in response to changing political and economic paradigms (e.g. socialism, capitalism). Against the context of these changes, there was also a pattern of generally weakened connections between communities and their landscapes, which also had various social consequences (e.g. individualism, emigration). A major difference between the study areas was that Erdővidék, because of its relatively higher level of isolation, kept its rural character and extensive management. Aranyosszék, in contrast, changed towards a more urbanized, intensively cropped landscape that followed western aspirations. In Romania extensively managed landscapes (e.g. in Transylvania, Moldova, Maramureș, Bucovina) generally experienced a revival coinciding with the time after the fall of communism, and are widely seen as important hotspots of biocultural diversity (Babai and Molnör, 2013; Barthel et al., 2013; Dorresteijn et al., 2013). Thus, Romania is privileged compared to other post-communist countries of Central and Eastern Europe such as the Czech Republic (Bičík et al., 2001), Hungary (Mihók et al., 2017) or Slovakia (Lieskovský et al., 2015), where the loss of extensive landscapes was more prevalent. However, the survival of extensive landscapes in Romania happened primarily due to economic constraints rather than being a conscious governance choice (Öllerer, 2013; Mikulcak et al., 2015).

Several dimensions of HNC in our study were reported by our participants as being affected by social-ecological changes. Two types of material connectedness existed, namely of (i) those who still *directly use* nature (using products for their own consumption or selling them in local markets), versus (ii) those who *indirectly use* nature (acquiring local products for consumption, e.g. from local markets). Emotional and experiential connections were highly prevalent in both landscapes, and many emotional and experiential connections were linked to cognitive and philosophical dimensions of human-nature connectedness (e.g. childhood experiences, connection to homeland), as also shown by other studies (Salmon, 2000; Bourdeau, 2004; Frantz et al., 2005). Our results underline the strong emotional bond to local landscapes as "home", suggesting that landscape and nature were overlapping concepts to many interviewees. Many scholars have highlighted that rural areas typically experience stronger levels of nature connectedness than urban ones (Hinds and Sparks, 2008; Martin and Czellar, 2017), because both culture and traditional knowledge about nature play a more important role in rural areas (Bennett et al., 2016; van Zanten et al., 2016; Díaz et al., 2018).

Changes in paradigms and ideologies strongly influenced HNC. While changes were not always immediately apparent after a given social-ecological change (Fig. 1), following time lags, shifting values and practices can have major long-term consequences for HNC (Dallimer et al., 2014; Horcea-Milcu et al., 2018). As our results show, material and experiential connections were perceived as generally weakened with the onset of industrialization (in the 1950s) and modernization of rural lifestyles. Whereas extensive farming still connected many people to nature, especially in Erdővidék, the presence and function of people changed in both landscapes since the 2000s. Young people especially have become increasingly disconnected experientially and emotionally. Consequently, the loss of material connection appears to be a precursor for declines in experiential, emotional and cognitive connections, which may be an important consideration for the sustainable management of social-ecological systems (Auer et al., 2017; Ives et al., 2018; Muhar et al., 2018). Moreover, in our case studies, the ideological shifts also weakened cognitive and philosophical connectedness. Perhaps most importantly, informal knowledge systems and the attitude of the community towards nature changed. Recent work has emphasized the importance of HNC for environmental behaviors and landscape conservation (Brown et al., 2018; Klaniecki et al., 2018). Scholars highlighted that cognitive and philosophical dimensions are vulnerable when trade-offs between commodity production and value conservation are established (Mikulcak et al., 2013; Rode et al., 2015; Baccar et al., 2017). Finally, the loss of traditional knowledge may have irremediable implications for SES and HNC in Romania and all over Europe (Reif et al., 2008; Fischer et al., 2012; Bezák and Mitchley, 2014; Molnár and Berkes, 2018). We acknowledge that changes and value shifts are part of the cultural landscapes, yet the question is how conscious and sustainable the decisions are that drive the transition.

4.2. Intervening within a social-ecological systems to foster human-nature connectedness

As the results showed, HNC is an important element of Transylvanian SES and were deeply affected by its changes. Yet, transitions toward sustainability have to be consciously established by different actors to achieve measurable impacts. We see the strongest traps that slow sustainable development in the: (i) instability of SES, because of the transition of governance system from the top-down governance model of soviet socialism towards the EU multilevel governance model; (ii) exclusion of formal and informal social networks from consultation, decision making, and active management of resources; (iii) paradigm traps of disciplinary oriented resource management (e.g. forestry, agronomy, hunting, public administration) that deepen conflicts between institutions and create the avoidance of responsibility and solutions; (iv) weakening sense of responsibility of younger generations for cultural and natural heritage; (v) weakening community cohesion and connection with the landscape, due to urbanization and industrialization of rural areas and migration; (vi) poor

availability of financial resources and weak capacity to access that which does exist.

Our results suggest an accelerated erosion of natural and cultural capital over the last 5–10 years. We therefore believe that intervention to foster sustainability is highly necessary. Furthermore, our results revealed a favorable momentum for intervention in SES that could foster HNC in the future. Overall, Transylvania's SES are trapped in conflicting aspirations between development and conservation (Horcea-Milcu et al., 2018). Nieto-Romero et al. (2016) showed that information sharing and visioning in Transylvania are not enough to break through the barriers that stand against desired changes in a community, but many local leaders would actually prefer landscapes that imply rich HNC in the future. More than this, SES are sensitive to changes, because of the unsteady governance of Romania (i.e. predominantly top-down), that on one hand should be undergoing a process of decentralization in alignment with the EU, and on the other hand remains characterized by the central power of the prevailing political parties (Dragoman, 2011; Matei, 2013). This situation incentivizes rural flight and a disconnection of locals from landscapes (Favell, 2018; Sandu et al., 2018). Similar to our results, Mikulcak et al. (2015) and Hartel et al. (2016) emphasized that decision-making power is limited locally and the institutional context is the most influential barrier of development.

Current and future generations are confronted with the challenge of finding sustainable solutions for environmental problems of the coming decade in Europe and the world (Folke et al., 2011; Bodin, 2017; Grier et al., 2017). Understanding how social and institutional change has influenced human-nature connectedness, in turn, provides important pointers for how to re-connect humanity to nature in the coming decades. Drawing on our results, we argue that it is important to find ways to foster and strengthen HNC in local communities, even as broader social, political and economic changes shift opportunities for interacting with the landscape. Intervening in the governance system (e.g. making governance participative, changing policies that govern natural resources) would thus appear to be the most influential way to create shifts in HNC, towards sustaining the diversity of values (ecological, social, cultural) within the cultural landscapes and reconnect people to nature (Ives et al., 2018; Fischer and Riechers, 2019). However, governance of SES is a priori difficult given the complexity and unpredictable dynamics of both natural environment and human societies (McGinnis and Ostrom, 2014). Setting up priorities and ideologies that foster an environmentally sustainable society has to be balanced with what communities consider valuable and what is valuable from sustainability perspectives (Kaltenborn and Bjerke, 2002; Hermes et al., 2018). Reconnection of people to nature is possible by meaningful interaction with nature in close proximity where people live and work (Miller, 2005).

Hence, we argue that a future dialogue and consensus for a sustainable government will be vital for the SES of Romania. Novel institutional arrangements such as the communities of practice (Wenger and Snyder, 2000) and collaborative governance (Ansell and Gash, 2007) can emerge in order to facilitate cross sectoral collaborations for landscape stewardship. Institutional collaborations can be facilitated by academia through transdisciplinary projects (Lang et al., 2012), where various institutions work together to identify key sustainability issues, understand them and co-create the solutions for addressing and solving them (Emerson et al., 2012; Hartel et al., 2019). Ansell and Gash (2007) set up variables for collaborative governance systems to foresee whether a governance system will produce successful collaboration or not. When connecting the findings of Ansell and Gash (2007) to ours to achieve collaborative governance in Romania, the following intervention points emerge: (i) offering positive examples of cooperation a conflict solving models that overwrite the present and past experiences; (ii) creation of platforms that facilitate communication and cooperation between governmental and non-governmental actors; (iii) incentives for social networks to participate in decision making and management; (iv) decreasing power and resource imbalances; (v) facilitation of leadership models and effective institutional designs.

We recognize the complexity of interactions between SES and HNC dimensions, and the many factors that can influence their relationship. Furthermore, we acknowledge that many of the changes that occurred in SES and HNC dimensions in the last century in Transylvania, or widely in Romania, cannot be seen separately from the processes of Europeanisation, and indeed globalization that were influential across the world. However, have shown that for our two study landscapes, perceived changes in the SES over time are related to perceived changes in HNC over time, and we have been able to identify a number of conditions related to the governance system, land management and social-ecological context that have shaped HNC. In response, we believe that the most valuable cultural landscapes of Romania need a strong participative governance that would allow local values and HNC to be celebrated, preserved, and even restored. Such processes should stand to protect the natural and cultural heritage of the communities and develop economically viable, but sustainable rural policies, even in the face of broader processes of global change. This is especially important when global ecological crises require decision makers and stakeholders at every level to turn toward a sustainable future.

5. Conclusions

We found that changes of social-ecological systems weakened human-nature connectedness in two cultural landscapes in Transylvania, Romania that were similar at the beginning of the 20th century, but developed differently in their intensity of landscape management in the 21st century. In particular, the shifting political and economic paradigms (e.g. socialism, capitalism) of the last decades are perceived as being the most influential drivers of change in landscape management and human connection to nature (HNC). While multiple dimensions of HNC (material, experiential, emotional, cognitive and philosophical) remained meaningful in both landscapes, the accelerated erosion of the natural and cultural capital due to less sustainable development makes us concerned about HNC in the long run. Therefore, we argue for collaboration between multiple actors in order to strengthen the HNC and navigate the SES toward sustainability.

Building on the theoretical foundation of multidimensional HNC (Ives et al., 2018) this paper belongs to those empirical studies that firstly address all five dimensions of the HNC in SES framework at a landscape level. We find this particularly important because the theoretical literature offers quite a vague and abstract meaning of "*re-connection*" of humans with nature as a solution for sustainability transformation and response to global ecological crisis, without a guideline on how to achieve it. The sense/meanings of HNC dimensions in cultural landscapes can be complex and diverse, and require different solutions on horizontal (from one landscape to the other) and vertical (local to national or global level) approaches. Therefore, our first recommendation is for synergic interventions in the governance system (i.e. top down and bottom up) that could generate tangible outcomes (e.g. decisions, regulations, funding system) for sustainable management of cultural landscapes of Transylvania. Second, we also suggest mainstreaming natural resource management and the intangible landscape values into every relevant institution responsible for the management of the cultural landscapes. This could result in sustainable landscape stewardship models. Third, we recommend planning the development of SES toward sustainability and making decisions based on the scenario of a desired sustainable future. We argue that such interventions should be made through alterations to the governance system that influences decision-making within the SES.

Notwithstanding, the focus of our study in an international context is narrow, but offers a good perspective on regional/local peculiarities of HNC on a gradient of changes of cultural landscapes of Transylvania (Romania). The similar historical periods of the governmental systems of Romania and of other post-communist countries, makes the study relevant for Central and Eastern Europe. Further, our results might be

comparable with other studies elsewhere in the world, where shifting governmental paradigms, or/and landscape intensification changed HNC. Therefore, we support further empirical research on the multi-dimensional HNC concept to promote solution for reconnecting of humans with nature.

Declaration of Competing Interest

None.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.landusepol.2019.104232.

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Article

Stories of Favourite Places in Public Spaces: Emotional Responses to Landscape Change

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Abstract: Understanding emotions is necessary to analyse underlying motivations, values and drivers for behaviours. In landscapes that are rapidly changing, for example, due to land conversion for intensive agriculture, a sense of powerlessness of the inhabitants can be common, which may negatively influence their emotional bond to the landscape they are living in. To uncover varied emotional responses towards landscape change we used an innovative approach that combined transdisciplinary and artistic research in an intensively farmed landscape in Germany. In this project, we focused on the topic of favourite places in public spaces, and how change in such places was experienced. Drawing on workshops and interviews, we identified themes of externally driven societal and internal personal influences on the public favourite places. "Resilient" emotional responses towards landscape change showed a will to integrate the modifications, while "non-resilient" responses were characterised by frustration and despair. We argue that identifying emotions towards change can be valuable to strengthen adaptive capacity and to foster sustainability.

Keywords: land art; landscape change; leverage points; nature connectedness; sustainability transitions; thematic analysis; transdisciplinary research

1. Introduction

Scholars and laypersons alike increasingly express discomfort with an ever accelerating growth-based economy and the resulting global environmental changes [1–3]. The current economic system with its premise of unlimited growth can cause conflicts with values held by individuals [4,5]. For example, food production is increasingly fragmented, with consumers geographically removed from the products and sites of production [6], leading to a sense of "food from nowhere" [7]. The social and ecological impacts of food production and exchange are rendered invisible to consumers, and can also be alienating for those experiencing industrialized food productions in their home landscapes [6]. This sense of alienation can stem from different normative standpoints on how the land should be used (instead) [8].

Landscape change can be vast and rapid, such as in the Chaco region in South America which is subject to the highest rate of land clearing in the world [9]. Elsewhere landscape change has been more gradual. For example, the use of agricultural land in Lower Saxony, Germany, where our study area is situated, is increasingly intensified. Here, maize cultivation increased from ~11% of the total agriculturally used land in Lower Saxony to ~21% in 2016 [10,11]. Other widespread contemporary changes in landscapes include changes in social composition (e.g., in traditional cultural landscapes where smallholder farming is being lost) [12], changes in the landscape horizon (e.g., through wind parks, deforestation or re-forestation [13]), and widespread losses in biodiversity [14].

Generating a better understanding of how landscape change influences the emotional worlds of inhabitants can be important as a first step to highlight possible intervention points to strengthen

adaptive capacity and foster sustainability by helping inhabitants to navigate change. Emotional responses to change have been surveyed regarding education (see overview in Reference [15]), yet mostly lacking in landscape studies. Hence, in our study, we aimed to (i) uncover emotional responses of inhabitants to landscape change; and (ii) elicit areas of intervention to empower local communities. We show that while not always conscious, reactions towards landscape change are often intense and vary from resilient responses that aim to incorporate the new reality, to non-resilient reactions of retreat and despair. Resilience, in this context, refers to the ability of a social-ecological system with its inhabitants to maintain its essential functions, including the capacity to adapt to future changes [16].

While most efforts to combat detrimental environmental changes have focused on changing specific parameters (e.g., the rate of land clearing) or relationships between parameters (e.g., increasing fines to prevent illegal land clearing), this often has not fundamentally changed the trajectories of the systems [17]. Addressing more deeply rooted causes of unsustainability, in contrast, is more difficult to do but may hold greater potential for system transformation [18]. This broad perspective, in turn, dictates that a diversity of approaches to knowledge production is embraced. Suitable approaches need to be able to take into account normative aspects, inequalities, politics and power asymmetries and work more directly across the interface of science and practice [19].

Against this background, in this paper, we explore issues of landscape change and people's emotional responses towards it through engaging with art-based research called social land art within a transdisciplinary case study [20] in the district of Oldenburg, Germany. Social land art links art, society and science and builds on a strong notion of participation [21,22] that in this study was fostered through intensive workshop settings that included discussion and the creation of art itself.

Following an explanation of the study site, we outline the transdisciplinary research approach including the involvement of a network of artists, and we describe our methods of data collection and analysis. We then present the results, showing how emotions towards landscape change were expressed. The paper concludes with a discussion that highlights the importance of understanding emotional responses as potential intervention points for sustainability transformation.

2. Methodological Approach

2.1. Study Site

The district of Oldenburg (Landkreis Oldenburg) is located to the South-East of the city of Oldenburg (approximately 175,000 inhabitants [10]) in the mid-western part of Lower Saxony, Germany. The district covers approximately 100,000 ha, of which two-thirds are used agriculturally, predominantly as cropland. The percentage of maize (silage and grain maize) grew from 18% in 1996 to 32% in 2015 [11].

Our study was part of a transdisciplinary collaboration [21] with the artecology_network, a German-wide collective of artists. In the district of Oldenburg, the involved artists seek to create awareness and possible solutions for land-use and nature conservation through close interaction with local actors.

2.2. Material and Methods

Our study was based on a close collaboration between an artist and an academic researcher on the topic of favourite places in public spaces. The art form used by the artist was social land art which sees itself as a link between art, society and science and entails a strong notion of participation [21]. The process of data collection was based on previous art workshops conducted by the artist. Problem framing and research questions were developed in close collaboration between the researcher and the artist. To address the overarching goal of uncovering emotional responses towards landscape change, the collection of empirical data followed a participatory qualitative research approach (Figure 1). Data was collected by the academic researcher in a setting organized by the artist. The project was structured as follows: Workshops were the core of the interactions starting with two-days in August 2017, one-day

in September 2017, and a one-day closing workshop in February 2018. Between September 2017 and February 2018 all participants (excluding the artist) worked with and created art in their favourite public places (Figure 1, Figure A1 in Appendix A), which were visited and discussed on site at the closing workshop afterwards.

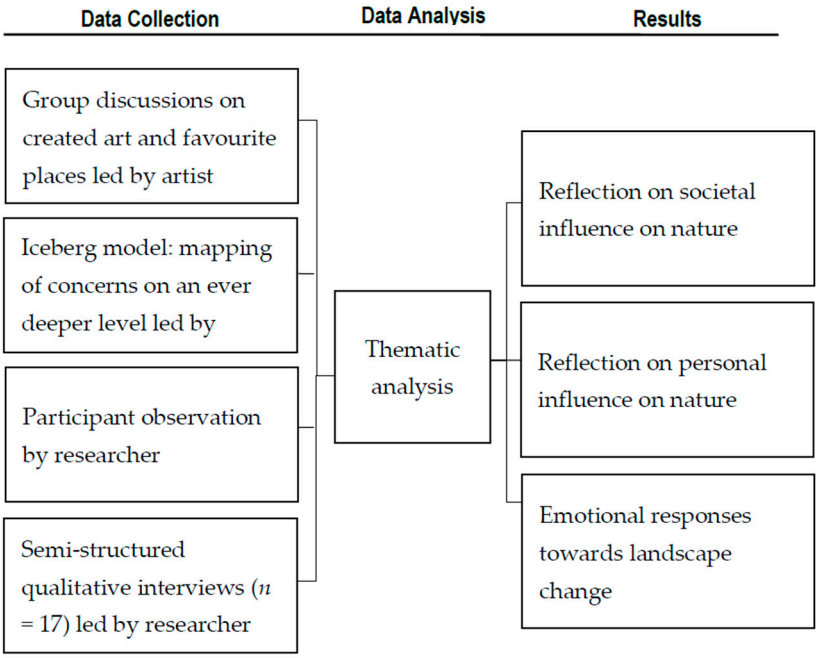

Figure 1. Overview of the data collected in 2017/2018, data analysis and structure of results.

The workshops included crafting and design sessions led and supported by the artist on topics such as the influence of their own artwork on places through various artistic expressions ([23], Figure 1, Figure A1). Action focused sessions, evolving around practical art installations done by the participants, alternated with reflective sessions. Haptic and sensual experiences with natural objects and processes of art creation in trial and error fashion (colour, pattern, structure, strong and light restructuring of the place) were the focus of the artist-led active session parts. Reflections focused on participants' meanings of nature, descriptions of their favourite places and their relations to and influences on them, which was led either by the artist or the academic researcher.

Participants were able to register without charge for the project, which was advertised through local news media, resulting in eight participants (three male, five female) including the artist and the researcher. Participants shared an affinity towards art and stated a high importance of nature in their lives, which was reflected in their professions or hobbies. Further participants were residents of the area and some were acquainted with each other.

Drawing on these workshops, the following data was collected by the researcher: (i) audio recordings (8.4 h of group discussions), (ii) participant observations, and (iii) qualitative workshop data such as mapping of concerns and an iceberg model [24,25]. Another 17 additional interviews on nature connectedness in one commune in the district of Oldenburg with local experts and informed laypersons knowledgeable of the landscape were conducted to complement the data. Those interviews were conducted simultaneously for a separate international study by the first author. Those interviews were collected using problem-centred interviews with a semi-structured interview guideline [26]. The guideline included sections on interviewees' human-nature connectedness and their experience of landscape change that happened in the last decades and, how these influenced interviewees' lives. We interviewed a diversity of informed laypersons and experts who we expected to be connected to a given landscape (e.g., farmers, foresters, policymakers, long-term inhabitants, priests) and

used snowball sampling to reach possible interview partners and cover contrasting opinions [26]. The interviews had an average length of 75 min and were held in German by the first author. In this paper the results from parts of the interviews were included in the data analysis of this study, to have a more informed overview of occurring landscape changes and to contextualize statements of the participants.

Data used in the paper were analysed based on a modified thematic analysis [27]. The modified thematic analysis aimed at identifying patterns of meaning across the whole dataset, combining multiple forms of data (recordings, observations, qualitative workshop data, and interviews). We identified patterns (societal influences on favourite places; personal influences; spectrum of "resilient" responses to those) through a process of inductive data coding and structuring (comparable to Reference [28]) and pattern development and revision. This approach entailed a close discussion with the artist about observations and preliminary results after the workshops and in the data analysing process. This implicated iterations between an inductive development of patterns and data generation in workshops to allow for the identification of underlying meanings and continuous refinement of themes. Furthermore, preliminary results were used in the preparation of the next meeting to highlight questions or fill in existing gaps in the data. For example, after the first workshop, the researcher noted a gap between the emotional depth which was achieved by the art and the explanation of what triggered those emotions. Hence, the iceberg model was used to express underlying drivers of emotions in words and speech. The iceberg model exercise created a strong impact on the participants and hence was referred to by them in later workshops.

3. Results

Results of the workshops ranged from art installations that were created by the participants at their favourite places and discussions around art and favourite places during the workshops. The art was defined by the artist as social land art, as a dialogue between art, society and science. Social land art is strongly process-based, thus neither the art installations nor photographs thereof constitute the final outcome (Figure 1, Figure A1). We like to stress that the following results are mainly based on an analysis of qualitative data that has been generated in a transdisciplinary process in close collaboration between artists and an academic researcher. However, it is not an evaluation of the process and results of the artistic-research process of social land art. Yet, with its data analysis, it aims to bridge the gap between the haptic, emotional and creative experiences created by the artist in the workshops with the cognitive exercises and statements usually used in academic research. Other visible results of the art project can be found elsewhere (www.naturarte-wernerhenkel.de, Lieblingsplätze poetische Orte in der Natur, [23]).

In the first section of the results, we will present societal influences, such as changes by the landowners and changes in the surrounding landscape which changed the atmosphere of the favourite places of the participants and their responses towards it. In the second section, we will elaborate on the influence the participants felt they had on their favourite places and nature in general, and how they responded to their felt influence.

3.1. Societal Influences

Unlike favourite places on private property, favourite places in public spaces can be highly influenced by structural, societal landscape changes, as well as other individuals. Such influences can often neither be stopped nor reversed. In extreme cases, landowners or visitors can alter a public favourite place detrimentally, and such changes by individuals can be an indicator of broader systemic influences: "*My favourite tree has been cut down. I thought: This cannot be true. They cannot cut this one here!*" In this case, even though the participant tried to get hold of the responsible person because the tree had been cut illegally to expand agricultural land *"[. . .] the big beautiful tree, which I loved, was of course gone."*

Even when a public favourite place itself is not changing directly, the surrounding landscape can be subject to intense changes, negatively affecting the participant's attachment to and atmosphere of the favourite place. General landscape changes such as intensification of agricultural land, manifested, for example in an expansion of maize fields, newly built biogas plants, animal stalls, or wind turbines that are visible in the distance. Increased infrastructure, such as more and better roads and more traffic also changed the atmosphere of favourite places. The atmosphere might also be changed more subliminally by the smell of industrial animal husbandry, by changing plant species composition, or by slow environmental changes such as climate change: *"[. . .] the biggest problem I see today is the nitrate problem. Ammonia. In the last around 20 or 25 years, the increase of nitrate-loving plants took on a dramatic scale. That did not exist before*."

Response from Participants

In response to such collective influences, participants expressed concerns for themselves and their favourite places. One concern was expressed as the fear that in an intensively used landscape space for solitude vanishes. A safe haven for retreat, reconciliation and recreation was deemed as very important for interviewees' health. Further, participants stated that nature, in general, loses its magic and wonder. The time it can take to be able to fully relax at a place can be long, and frequent disturbances might prevent a feeling of rest. Another concern was: *"What is left of nature?"* This was posed especially in the summer months in which maize stands high across the fields. This concern was blended with a perceived threat to the survival of humans and other species, because "*we cannot live without nature*".

In the discussions, participants expressed a range of responses to external influences on their public favourite places. At one end of the spectrum was a "resilient" response: becoming aware of the impacts of externally driven change on natural health, and of the landscape changes, within the microcosm of a given small favourite place. This type of response encouraged working with the changes, incorporating them and evolving resiliently with an equal amount of nature connectedness and attachment in the new conditions. Participants with this response felt a sense of responsibility to enter into a public dialogue to change their own and others' perspectives. At the other end of the spectrum was a "non-resilient" response: a sense of frustration and emotional and experiential detachment from the place. Feelings such as sadness, despair and apathy were expressed due to a sense of responsibility for a place but a lack of agency. "*The facts are just created, and then it is destroyed. And you are standing there and you are thinking: yeah. And now it is broken, what should I do now?"*

3.2. Personal Influences

Apart from externally driven, societal influences, participants expressed concerns regarding their own influences on their public favourite places and nature in general. Those reflections covered day-to-day interactions with nature as well as the effects of their own artwork. Reflections on personal influences included an outright fear to disturb the atmosphere of the favourite place even through small scale artistic impacts. "*My greatest threshold now is the concern, an inner resistance, to intervene in this place. To change something. To have a presence there.*" Participants were concerned they were a disturbing factor in an otherwise peaceful and stable place. Simultaneously, they were painfully aware that every action in one's life has an unavoidable influence on nature locally and globally. *"This awareness, I called it realist-schizophrenia of my modern life. Because I know, even though as a gardener I work the whole time in and with nature, and teach permaculture etc. [. . . and my] intention [is] there. Yet, [I] still drive the car every day, shop in the supermarkets and I know all those chains and connections. [. . .] but [we] are entangled in this system."*

Responses from Participants

A non-resilient response to such concerns was discussed as descending into a downward spiral of blame, anger or despair regarding one's own negative influence and incapacity to counteract detrimental influences on nature. *"[. . .] a great, deep, fundamental pain, grief. Despair. Helplessness.*

Or often again a bewilderment about this state of semi-sleep—to just continue in this form of existence." A more resilient response was a discourse on transcending this dichotomy between the inconsequential and hypocritical unsustainable every-day behaviour and the ideal state of a sustainable and careful treatment of nature.

In a different theme, participants argued that a favourite place in a public space was artificially created and had to be maintained, for example through eliminating weeds, unorderly branches or unsightly shrubs. If the place was left unmanaged, the place could no longer convey a sense of belonging and connection. According to this discourse, managed land was beautiful, because this reflects effort and work put into it. Yet, within the same discourse participants also expressed concern regarding the intensification of use as well as overuse, especially with regard to agricultural practices. A suggested possible response was to acknowledge the plurality and diversities held and established by multiple persons, land use practices and demands on land. It was proposed to create a holistic self-awareness that is cognizant that the intensification of nature is driven by external land use intensification as well as by one's own (increasing) utilitarian values.

By the end of the workshop's most intensive session, there was a proposition for a general solution. Participants agreed to not look for the maximum efficiency of a piece of land through a focus on agricultural yields or revenues. Instead, participants argued for an "overall optimal" and holistic use that acknowledges diversity. This entailed making room for non-use while acknowledging the need to use land without guilt or blame. This required "*harmonies next to each other*", that is, ways to navigate and compromise between nature conservation, recreation, food and energy production.

4. Discussion

Due to the haptic, creative and conceptual approaches combined in the long-term artistic expression through-out and between the workshops this art project was able to uncover honest and often underlying emotions of the participants. As the focus of this project was not on the cognitive expression of problems or based on formal or scientific knowledge surrounding those, participants were free to use their senses and creativity to express themselves through physical manifestations of their feelings, before translating it together with the group into words. Both *social land art* and transdisciplinary research emphasise that research takes place not just *for*, but *with* people [22] hence both approaches helped to enable closer collaboration between art and science. The project idea and process was based on previous work done by the artist, the research problem and question were developed in close cooperation between the researcher and artist. This close cooperation led to questions such as: What is scientific data? or How can art and science be combined? What are the genuine qualities of the approaches? These questions were addressed by the artist and researcher in their transdisciplinary process. This approach shows novel ways to generate knowledge and suggests ways to combine artistic and academic approaches to uncover emotional responses to landscape change.

Our findings suggest that bringing in artistic research practices into transdisciplinary research can be helpful to uncover a deep emotional connection to landscapes, benefitting from the fact that art can be a catalyst for human emotions ("elicitation of aesthetical emotional meanings" [29]). We are convinced that the depth and honesty of complex (and contradictory) emotions and their connections to nature could not have been elicited with conventional research methods. Working artistically proved to be a way of helping participants understand and address their own problems through democratized research that incorporates a diversity of knowledge forms [30,31]. Additionally, the artistic process required active involvement by participants to go out into nature and observe, create and change natural places. By appreciating different forms of knowing and acting, and using dialogical ways to explore these, complexity, uncertainties and disputed values of various different actors involved can be made explicit [16,19].

Our study showed deep-rooted attachment to and care for nature in general, as well as for specific public places. Externally driven, rapid landscape changes influenced participants' own involvement and responsibility towards 'their' landscapes. Moreover, participants also scrutinized their own

influence on nature and their favourite places. The results showed a spectrum of concerns and responses that highlight the complexity of emotions that are rarely uncovered by conventional research methods. In general, emotions can fulfil a central functional role in the cognitive processes and can have a strong effect on peoples' behaviour [29,30]. Emotions can be understood as a filter through which factual knowledge is understood. They are influenced by needs and goals and linked to behaviour and decision making [29,30]. We postulate the importance to recognize emotions regarding sustainability and tap into them, for the full potential for transformational change. Assessing emotions or emotional affinity to nature, however, is difficult, shown through a debate about cognitive concepts that focus on individual beliefs and measure connectedness to nature as a cognitive concept instead of an emotional one [29,31]. However, emotions are seen as an approach to avoid a division between cognitive and affective processes [32]. Both can be drivers for change, yet deep emotional motivations and reasoning are complex and often not shown in public. Moreover, culture, individual maturity and education are closely intertwined with emotional reactions [33].

The district of Oldenburg provided many examples of a cultural landscape under change. Reactions towards change can be immediate, such as a burst of anger and frustration. In contrast, they can also be more implicit, such as an undirected feeling of helplessness or fear of one's own ignorance and apathy, which are only uncovered through contemplation. The precise nature of reaction to changes in the "natural world" is strongly influenced by personal understandings of what nature is or ought to be. For example, responses towards landscape changes may vary if nature is understood as a cultural landscape that includes the human component. In contrast to an understanding of a pristine, untouched wilderness [34], our results suggested that our participants in the district of Oldenburg understood nature as being dominated by humans. While we observed a spectrum ranging from the need of strong human management to a non-intrusive, cautious, empathy-driven approach to nature, both extremes are symptomatic of a perceived human-nature divide. Such a divide is seen probably particularly in heavily managed landscapes [35], which call for active management approaches to produce high revenue or alternatively, require active efforts to remediate environmental damages. Our approach clearly uncovered discomfort and underlying disagreement with the current landscape trajectory. Participants acknowledged that various parameters characterizing the landscape indicate increasing unsustainability, and recognized reinforcing feedbacks around profitability and land use intensity. Participants perceived landscape changes as an uncontrollable force driven by uneven power dynamics, especially when they felt emotionally and cognitively attached to the places under change. Thus, perceived landscape changes are related to people's feeling of belonging and attachment to places [32,36]. A perception of powerlessness, in turn, appeared to erode a sense of agency and empowerment, thereby undermining the motivation of local people to try to transform the system they feel uncomfortable with [2,37]. This raises questions about the differentiation between public and private spaces and in how far they allow for active participation and decision-making. Especially, when the emotional qualities for public places are often not considered when it comes to planning decisions. Deprivation of agency and a resulting disconnectedness could lead to apathy, disengagement and reluctance to engage emotionally and politically. In stark contrast, for some individuals, distress could foster active engagement, be it through changes in individuals' personal behaviour or through raising awareness and encouraging political engagement [38,39]. In yet other instances, emotional distress, in combination with feelings of urgency and helplessness can have adverse effects in the form of scapegoating those perceived to drive landscape changes, especially as emotional reactions often remain unconscious.

Based on our analysis, we see the following possible realms of leverage for improving the sustainability of the Oldenburg district: (1) Fostering collective knowledge generation to enable information flow and exchange can create mutual empathy and understanding, and thus prevent slipping into an unconstructive blame game. (2) The motivation and engagement arising from emotional discomfort could be made transparent in order to actively foster local transformational change as seen by the actors involved. (3) Meaningful participatory processes also would be favourable

to stop a spiral of disengagement and apathy by strengthening information flow, creating knowledge and a sense of agency [40]. There is a clear need for transformative change that permeates the whole social system—from the emotions of individuals to attitudes of social groups, and ultimately to societal structures and processes [2].

5. Conclusions

We investigated emotional responses to landscape change, especially by agricultural intensification, through a transdisciplinary collaboration involving artistic research. We unveiled widespread subliminal discomfort with the current economic system. Participants expressed a spectrum of emotional responses, ranging from "resilient" incorporation of changes to "non-resilient" reactions such as frustration and despair. We understand emotions as being a lever for change, and our results highlight the necessity to more deeply engage with emotional responses to landscape change. This is important, we argue, because emotional responses are crucial regarding realms of leverage, such as (1) fostering dialogue and collective knowledge generation, (2) using a sense of discomfort as a motivational source for transformation, and (3) stopping a spiral of disengagement through meaningful participatory processes. This will include confronting issues of agency and participation regarding land-owners, land-users and regulating bodies. Normative attitudes of many actors may wish for a transformational shift, but the feeling of helplessness and inability to change the economic and political systems undermine their ability to actually work towards transformation. In a social and ecological system that feels uncontrollable and that is, for many, heading in a highly problematic direction, a sense of agency among those affected is crucial. We encourage applying innovative and unconventional research approaches that allow for exploring different ways of knowing and acting, such as transdisciplinary or artistic research, to identify and enable interventions towards a sustainability transformation.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Figure A1. Explanation of some of the art (exemplified but not captured by the pictures below). The art is not captured in the pictures and confusion with art in a conventional sense should be avoided (neither the picture itself is art, nor the art on the picture is a good representation of what the "art" was). Description of some of the installations seen below can be found at https://leveragepoints.org/2018/05/21/lieblingsplatze-poetische-orte-in-der-natur/.

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ORIGINAL ARTICLE

Discourses for deep transformation: perceptions of economic growth in two rural communities in Lower Saxony, Germany

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Abstract

Ecological degradation stemming from the paradigmatic pursuit of economic growth is well known. Transforming the current dominant economic discourse will be a great challenge of our time and one that can foster a transformation to a more sustainable state. Little research exists concerning perceptions of growth by individuals in rural areas. In this empirical study, we analysed 33 interviews from two rural communities in Northwest Germany through qualitative content analysis. Our results highlight four archetypical perceptions of economic growth: (1) growth as inherently positive, (2) growth as being self-evident and without alternatives, (3) growth as a systemic constraint, and (4) growth as critical and with negative consequences. Differing perceptions about five key themes within broader societal discourses shape the four archetypical perceptions. All four archetypes are characterized by a common perception of systemic constraints, a lack of concrete alternatives to the current economic system and a lack of individual and societal agency, showing a system that is locked into its current trajectory. The understanding of the consequences of growth, stemming from the knowledge of rural inhabitants, can lay the groundwork for future research on discourses of growth. We envision a strengthening of tangible alternatives to the dominant economic growth paradigm within and with the local communities as necessary for a sustainability transformation.

Keywords Agricultural intensification · Degrowth · Landscape · Sustainability science · Leverage points · Social-ecological systems · Social imaginaries

Introduction

At present, humanity is facing severe ecological problems (IPCC 2018; Millenium Ecosystem Assessment 2005), which are the consequences of human activities, especially the global paradigmatic pursue of economic growth (IPBES 2019; Foley et al. 2011; Kallis et al. 2018). This growth in production and consumption drives growth in resource use, leading to resource depletion (Steer 2013; Brown et al. 2014; Kallis et al. 2018), and increasing emissions and waste (Stern 2004; Sebri 2015). Therefore, steering away from the current dominant paradigm of economic growth is urgently needed in order to transition to a sustainable economy (Jackson 2011; IPBES 2019).

Yet, steering away from economic growth is complicated because the current dominant paradigm is deeply integrated into the social, institutional, political and economic fabric of global societies (Fournier 2008; Raworth 2017). For example, agricultural production continues to be intensified worldwide and the global food supply doubled over the last four decades (Godfray et al. 2010), yet the number of undernourished people is increasing (FAO 2019). Moreover, agricultural intensification causes land-use change and the expansion of monofunctional croplands (Foley et al. 2005), rising emissions (Ripple et al. 2014) and can lead to alienation of its inhabitants towards their home landscapes (Balázsi et al. 2019; Riechers et al. 2020b). Despite this, increasing food production through agricultural intensification is still seen as the primary means of ensuring food security (Shaw 2007; Jiren et al. 2018).

Instead of only trying to mitigate the negative consequences of unlimited economic growth, society and science should focus on one of the root causes of

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unsustainability: the growth paradigm itself. Drawing on the leverage points perspective (Meadows 1999; Abson et al. 2017; Fischer and Riechers 2019) we emphasize the importance of a paradigm shift—a socially shared profound change in a fundamental model or perception of events—to foster a sustainability transformation and leave the limited paradigm of economic growth behind. To facilitate a transformative paradigm shift to another economic state societal beliefs, values and perceived consequences related to growth have to be analysed (Strand et al. 2016; Pansera and Owen 2018).

One key determinate of the beliefs, values and perceived consequences related to growth are the societal discourses around the subject. Discourses are defined as an ensemble of ideas, concepts, and categories through which meaning is given to phenomena (e.g. Hajer and Versteeg 2005). Discourses are meaningful stories that shape the way in which societies perceive their environment (Keller and Poferl 1998; Litfin 1994) and are assumed to play a central role in how individuals process information, communicate and reason (Jones et al. 2014). Any interpretation of a phenomenon must be embedded in this repertoire of social collective discourses, which limits the ability of actors to make meaning of proposed actions and thus limits the space of what is feasible (Hermwille 2016).

Because the constraints that discourses impose are open to challenge, discourses can be changed (Darier 1999). Therefore, discourses can transform into instruments of coordination in a field of multiple possible futures—creating a development path to be followed (Beckert and Bronk 2019). For example, a shift in the discourse about economic growth could lead to a paradigm shift, as a discourse outside the current mainstream paradigm, if internalised by many, can influence political or market power (Beckert and Bronk 2019). Growth positive discourses considerably limit society's capacity to think of alternative visions of the future outside the system (Pesch 2018: 1141). A strengthening of alternative economic discourses could give room to new imaginative spaces and enable humans to perceive alternative ways to live and work (Strand et al. 2016; Pansera and Owen 2018).

Here it is important to note that discourses do not originate with the individual; rather they circulate in societies to provide a repertoire from which people can produce their own stories (Lawler 2002). Exploring the diversity, similarities and differences in the stories people tell about economic growth is therefore an important first step in thinking about how societal discourses and ultimately the dominant economic paradigm might be transformed. In this paper, we seek to construct a set of archetypes that capture shared facets of individuals' perceptions of economic growth in relation to themes that have been identified in societal discourses around economic growth. In particular, if there are perceptions of economic growth that could challenge the dominant paradigm of economic growth.

We explore these perceptions in rural communities, since little research has been done in this regard and we acknowledge that individual's views regarding economic growth are likely to be shaped by the particular contexts in which they experience economic growth and its consequences. We focused on perceptions that emerge in agricultural landscapes because negative social-ecological consequences of growth are already evident in the agricultural sector (Horrigan et al. 2002; Barker 2007; van der Horst and Vermeylen 2011). Apart from ecological degradation (Young et al. 2005; Bürgi et al. 2017), landscape change can negatively affect the local community structure and traditional cultural heritage of a landscape (Riechers et al. 2020a, b). Competing demands on landscapes become locally tangible, and inhabitants can experience and recognize the resulting landscape changes (Chapman et al. 2019; Riechers et al. 2019). Studying perceptions of economic growth in places dominated by the agricultural sector is, therefore, potentially enlightening because many of the positive and negative consequences of economic growth in the agricultural sector are tangible and directly experienced by rural communities.

To answer the question how inhabitants of rural agricultural communities perceive economic growth, we analysed archetypical perceptions of economic growth across two rural landscapes. It is important to understand the differences and commonalities between perceptions of growth in relation to key themes that have emerged in the broader societal discourses on economic growth, such as technology (Jasanoff 2004) and agency (Sewell 1992). An understanding of these perceptions is necessary to understand which criticisms of growth are already prevalent in society and which themes within societal discourses around sustainable economies might not yet resonate with different communities. Hence, we specifically aim to (i) highlight different, but overlapping perceptions of growth that are prevalent in rural communities, (ii) analyse which themes within broader societal discourses these perceptions relate to. In doing so we seek to contribute to the literature that explores alternatives to the current dominant growth paradigm, and the barriers related to challenging that dominant paradigm.

The paper is structured as follows: after an explanation of the two cultural landscapes under investigation, we describe our methods of data collection and analysis. We then describe the four archetypical perceptions of growth that emerged from data analysis and the five key themes prevalent in societal discourses. The paper concludes with a discussion that emphasizes the importance of understanding various discourses of growth while highlighting the existence of critical growth discourses in society. The analysis presents a reconstruction of the various archetypical ways in which rural communities understand the role of economic

growth. This is an exploratory piece of empirical research. It does not seek to be representative or comprehensive regarding the rural communities studied, but rather to provide tentative insights. Moreover, our primary interest is in the diversity of perceptions of growth and their relation to broader societal discourses found in these communities rather than how these perceptions are shaped by the societal or institutional roles of individuals within these communities.

Material and methods

Study area

To analyse rural agricultural communities, we chose two study areas located in Lower Saxony, Germany. In Lower Saxony, agricultural production has been intensified during the last twenty years, leading to landscapes with increased monocultures (e.g. Linhart and Dhungel 2013) and occurrences of mass livestock farming (Niedersächsisches Ministerium für Ernährung, Landwirtschaft und Verbraucherschutz 2017). We chose two communities with contrasting development trajectories from a gradual and minor landscape change in the last two decades to a major and rapid change through agricultural intensification. The commune of Dötlingen belongs to the district Oldenburg and is located in western Lower Saxony. The landscape around Dötlingen has experienced a rather rapid landscape change due to the expansion of maize cultivation, mass animal husbandry, and biogas production (LK Oldenburg 2018; Niedersächsisches Ministerium für Ernährung, Landwirtschaft und Verbraucherschutz 2017), negatively influencing the water and air quality (Velthof et al. 2014), and how people relate to 'their' landscape (Riechers et al. 2019). The commune of Bispingen belongs to the district Heidekreis and is located in the east of Lower Saxony, partly in the Lueneburg Heath nature park (protected under Germany's federal nature conservation act), which was the first official protected area in Germany in 1909 and hence has a long history and cultural heritage. In and around the Lueneburg Heath nature park, intensification of agriculture has been slowed by environmental regulations posing economic challenges to small-scale farmers (Riechers et al. 2020a).

Data collection

We held semi-structured, problem-centred interviews, which encouraged free storytelling and subjective descriptions. The interview guideline was adapted to fit the personal context of each interviewee and follow-up questions were adjusted to the topics brought up by the interviewees (Atteslander 2006). A copy of the interview guideline can be found in the supplementary material. In the interviews, we asked questions about habits of visiting nature, as well as perceived landscape changes of the last ~ 20 years and desired future developments for the next 20 years. When discussing landscape changes interviewees focussed on the driving forces behind such changes. Without prompting, the interviewees included statements about economic growth and the impact it has had on their livelihoods. The interviews also included more specific questions related to interviewees' human-nature connectedness, as this study was part of a larger international comparison (Riechers et al. 2020a).

We interviewed persons who we expected to be connected to the landscape based on prior information about actors and actor groups/organizations in the communes. This includes interviewees from the areas of agriculture, forestry, tourism, policy-making, nature conservation and the church, as well as long-time inhabitants. After an initial contact to experts, we used snowball-sampling (Flick 2006) to reach persons with possibly contrasting opinions on the landscape change (i.e. growth oriented large-scale farmers vs sustainability oriented small-scale farmers). Interviews were held with individual actors and small groups. The interviewee age ranged from people in their thirties to people in their eighties. For this study, 33 interviews with an average length of 75 min were analysed (Bispingen: $n = 17$; Dötlingen: $n = 16$).

Data analysis

All interviews were undertaken in German, only the quotes used in this paper were translated to English. Interviews were transcribed verbatim and analysed with MaxQDA Plus 12 (VERBI GmbH). Data were analysed using structuring qualitative content analysis by Mayring (2000), which focuses on the elaboration of a category system. Using a qualitative content analysis, text material can be described by assigning aspects of meaning to the categories of a category system and by assigning relevant parts of the material to the categories of this system (Schreier 2014).

Our analysis had two iterative steps: identifying (1) themes within the broader societal discourses on economic growth and (2) the range of archetypical perceptions of economic growth held within the two communities. For our analysis, we combined a deductive and inductive approach. First, we created a deductive coding tree using scientific literature on economic growth discourses to identify key themes around economic growth, which are present across most individuals' perceptions of growth, but with different connotations and meanings attached to them. The archetypical perceptions were differentiated based on the differing perspectives that respondents had towards these five themes. Secondly, we took an inductive approach to search for additional themes that emerged from the qualitative content analysis, with the intention of identifying cross-cutting themes that were found across the archetypes developed

in the proceeding deductive step. This inductive approach ensured that the priorities and values held by the interviewees were captured in great detail. The codes resulting from our content analysis were successively grouped together to form categories of an increasing level of abstraction (Strauss and Corbin 1998; Fleming and Vanclay 2009b). The coding resulted in four archetypes being identified, related to the five themes (Table 2). Two key additional themes emerged from the inductive step of the qualitative content analysis. For consistency in the analysis all the coding was undertaken by the lead author. During the data analysis, we aimed at preserving the qualitative character of interviewee's statements, yet the aggregation of the categories into archetypical perceptions and themes is a simplistic form of presentation and represents only a certain perspective on the content of the interviews. We did not seek to develop separate archetypes for the two communities, but rather capture the diversity of perceptions that span the two different communities.

Results

The review of the scientific literature identified five overarching themes within societal discourses on economic growth: (i) assessment of development and progress, (ii) attitude to consumption, (iii) perception of lack of alternatives, (iv) understanding of the future, (v) perception of systemic constraints (see literature in Table 1). The subsequent qualitative content analysis of the interviews identified four archetypical perceptions of economic growth found in the rural communities studied. In the following, each archetype is described, beginning with a short summary. Table 2 provides an overview of each archetype and their relation to the five themes. These archetypes are, however, not completely distinct and have overlapping aspects showing a fluid gradient from positive towards negative attitudes to economic growth.

Archetypical perception: growth as inherently positive

In this archetype, growth was perceived as inherently good and the prevalence of the growth paradigm was particularly evident. Growth was understood as desirable and beneficial for the interviewees and was not questioned.

One of the reasons given for the positive connotations of economic growth was the idea that growth is beneficial for the whole region because it can create important infrastructure. An economically prosperous region could offset demographic change and job vacancies through rural–urban migration by offering enough schools, jobs and recreational activities: "Agriculture has experience a renaissance in the last 20 years. It is ever bigger, ever better". If growth fails to

Table 1 The five overarching themes within societal discourses oneconomic growth as derived from the literature

Themes	Assessment of development and progress	Attitude to consumption	Perception of lack of alternatives	Understanding of the future	Perception of systemic constraints
Literature sources	Schumpeter (1942), Levins and Cochrane (1996), Alcott (2015), Kerschner and O'Neil (2015), Asafu-Adjaye et al. (2015), Kerschner and Ehlers (2016), Kerschner et al. (2018)	Schor (1995), Rosenberg (2004), Brown and Kasser (2005), Saren (2007), Paulson (2017)	Asara e al. (2015), Swyngedouw (2015), Kallis et al. (2018)	Kallis et al. (2018), Kelz (2019), Coulter et al. (2019)	Levins and Cochrane (1996), Jackson (2009), Schneider et al. (2010), van Griethuysen (2010)

materialise, interviewees feared that their communes might die out. Another reason given for the positive assessment of growth was that growth means more economic success for some interviewee's own companies. Accordingly, growth was associated with a successful career, higher incomes and opportunities. The current structural change in the German agriculture system that led to a few large farms displacing smaller ones was perceived as an opportunity to expand one's business: "And now we're the only ones left here. […] And this change was very radical. […] But above all things, I see, as mean as it sounds, opportunities for growth". Whether a company is positively or negatively affected by the growth imperative therefore has an influence on the perception and assessment of its owner of growth itself.

A strong expression of the positive perception of the current growth paradigm was how it was equated with regional development and progress. Respondents stated that agriculture has been improving in the last decades, with bigger often being used interchangeably with better. The focus of the interviewees regarding progress was on modern technology, especially computer technology and large agricultural machinery. “I am enthusiastic about technology, innovative technology is very important to me […] If I thought that agriculture was a branch of industry that would not develop any further technologically, then I would have kept working in business.” The respondents viewed growth as a condition for technological innovations, which made agriculture a modern profession. The mechanisation and intensification of agriculture were seen as an improvement compared to traditional agriculture. The interviewees distanced themselves from traditional agricultural practices, which were considered inefficient and strenuous. Therefore, modern agriculture was understood as a natural and necessary development, which was also linked to a changed self-image of respondents working in agriculture, who viewed themselves as entrepreneurs rather than as farmers.

In this archetypical perception economic growth was seen as unrestrictedly positive and necessary and growth is, therefore, an important component of the future for the interviewees. Companies were classified as "fit for the future" if they continue to show growth potential. In certain statements, the word "prospering" was used synonymously with "growing”. A characteristic feature of this archetypical assessment of growth as desirable in the long term is the assumption that there are no limits to growth. "No, I don't think there are any limits [to growth]. I mean, there is still enough land in the world to feed the population”. Technological solutions and innovations play an important role for any environmental problems that may arise and such innovations were considered desirable in their own right.

Archetypical perception: growth as self-evident and without alternatives

In this archetype, growth was perceived more neutrally and as a self-evident fact. Some interviewee statements described intensive, growth-oriented agriculture as the only realistic form of agricultural activity and believed that there are no feasible alternatives to this growth.

Negative ecological or social consequences of growth in intensive agriculture were noted but justified by the fact that respondents were not aware of any better options: “Everyone burns infinite amounts of energy, without asking where it comes from. We do not want nuclear power. Nobody wants wind power around his or her yard. So I think biogas is an alternative energy source and if you want it you have to live with maizification". In this context, it is often stated that hopefully other technologies will be invented in the future which will have less negative consequences while still sustaining growth.

The perception of a lack of alternatives to growth was justified by the fact that certain products must be available in large quantities and at a low price. Society's attitude to consumption was often mentioned in connection to criticism of the negative consequences of growth: "[Animal cages] are way too cramped, but it's all about the price. And nobody is willing to eat meat once a week, meat is consumed every day and as cheap as possible.” Consumer behaviour was stated as a reason for detriments of the food production, ethical problems in animal husbandry and the negative consequences of biogas electricity production. While societal consumption patterns were criticised, the possibility of using less of a resource was not mentioned in this context.

The prevalence of the growth paradigm forced farmers to keep pace with this growth and some farmers mentioned that they would like to operate more sustainably than they currently do. In contrast to the previous archetype, the focus was no longer on the success of the farm, but rather on the justification that farmers have to work unsustainably to be economically viable and thus maintain their business and make a living: "I don't think it can work any other way at the moment, you can't produce milk any other way these days if you want to live off it somehow". Development through growth is part of the growth paradigm, and therefore farmers must invest continuously in the development of their farms to remain competitive. For this purpose, loans were often taken out, farmers became indebted and therefore had to continue to grow to pay off their debts. The impossibility of a smaller, sustainable or ecological agriculture was emphasized repeatedly. Many respondents described examples in which economic concerns were prioritised over nature or nature conservation concerns. For example, nature conservation regulations were described as being ignored or circumvented by certain farmers to obtain greater economic

Table 2 Overview of the four archetypical perceptions and their respective codings from the qualitative content analysis

Archetypical Perception	Assessment of development & progress	Attitude to consumption	Perception of lack of alternatives	Understanding of the future	Perception of systemic constraints
Growth is inherently positive	Growth = progress; technological innovation is important; modern; solution for problems	Consumption not questioned; used as reasoning for necessary growth	Alternatives are not needed	Economy will continue to grow = positive & beneficial; businesses need to grow to be prosperous	Economic system is good & fair; no systemic constraints
Growth is self-evident & without alternatives	Growth = progress; less enthusiastic; rather neutral	Consumption accepted; used as excuse for unsustainable behaviour	A lack of alternatives is recognized but not criticized	Economy will continue to grow = self-evident & accepted; businesses need to grow to be prosperous	Systemic constraints are hinted at, but not criticised
Growth is a systemic constraint	Technological progress = driver of systemic constraints; not inherently positive; promotes growth	Consumption criticised as main driver; no wish to radically change behaviour	A lack of alternatives is clearly perceived; growth is only option; needs to be pursued regardless of negative consequences	Economy will continue to grow = forced & negative; businesses need to grow to be prosperous	Growth is imposed; No individual ability to act or to have impact; creates less individual responsibility
Growth has negative consequences	Technological progress = driver of systemic constraints; negative consequences	Consumption promotes growth & is unsustainable; could & should be changed	Lack of alternatives perceived very critically; preference for alternatives to growth	Future of growth unsure; limits to growth exist; negative assessment of future except when alternatives are known	Perception of strong constraints; No individual ability to act or to have impact; creates feelings of helplessness & frustration

The archetypes progress from a perception of growth as inherently positive and exclusively desirable, to a perception of growth as a self-evident and without alternatives, a fact, which the interviewees regard rather neutrally and acceptingly, to a perception of growth as a constraint, which is imposed on the interviewees by society and the surrounding system, to a clearly negative and critical view of growth and its consequences

benefits. Since growth was perceived as self-evident, natural and the only feasible option, a future without growth oriented intensive agriculture was inconceivable. An acceleration of the current development trajectory also seemed probable to the respondents, while possible limits to growth were not mentioned.

Archetypical perception: growth as a systemic constraint

In this archetype, interviewees perceived economic growth as a systemic constraint, as the growth paradigm has become socially and institutionally entrenched and compulsory. This was described and perceived more concretely and considered more problematic than in the previous archetype.

Some interviewees described an abstract systemic constraint, naming the external pressure without its concrete driving forces. Other respondents blamed the negative consequences of growth on politics, without any further context, while some interviewees explained the perceived systemic constraints through specific local, national or international political processes. For example, it was mentioned that political subsidies led to growth in intensive agriculture and deprived farmers of their capacity to act. The distribution of subsidies on a national and international level was strongly criticised and blamed as a source for various ecological problems. The subsidisation of biogas and intensive farming, as well as locally unfitting nature protection requirements were especially criticised: "The trend is clearly in contrast to what the population is always praising and what politicians are saying. We all talk about preserving the natural, the small-structured agriculture and we only create laws in such a way that only the big ones count". A consequence of subsidies provided for biogas related maize production was that "energy farmers", as they were referred to, had a higher income and competed with smallholder famers for scarce arable land, which led to an increase in rental prices of farmland. Small-scale farmers in the region typically rent land (in addition to their own agricultural land holdings) to maintain economically viable agricultural holdings. Some small-scale farmers could no longer afford the rising rental prices of farmland on their leased land, forcing them to abandon agriculture and lease their land to larger-scale, more economically viable, farmers. "It's definitely the case that only the big farms still have a chance. The smallholder farms only go down. The industrial ones then lease the land from the perished farmers and plant them, so that they get proper subsidies, meaning they plant monocultures".

This systemic pressure was partly used to explain individual behaviour, but was also described clearly as a societal problem. This systemic constraint seemed to arise from a higher power and hence the individual was hardly attributed any ability to act, reducing interviewee's sense of responsibility. Therefore, many respondents did not blame farmers for the consequences of their perceived unsustainable agricultural practices but blamed an unsustainable system: "The situation is super hard, because in the end the farmers have to grow to survive. […] You can't blame them either. The German system is designed for growth, and that's what's happening in agriculture." The die-off of smallholder farms was related to the systemic pressures and was perceived as strongly negative.

Respondents believed that the economy will continue to grow in the future, but perceived this future rather critically. This understanding of the future often refered to the naturalness and self-evidence of growth, the necessity of modern agriculture, institutional path dependencies and a lack of alternatives, which do not permit any alternative future trajectories.

Archetypical perception: growth as critical and with negative consequences

In this archetype, the growth-based economic system is criticized because of its inherent systemic constraints and the perceived negative ecological or social consequences of growth-focused intensive agriculture.

The interviewees were aware of systemic constraints and formulated a need for change. The interviewees perceived the growth of intensive agriculture as a fundamental problem from which subsequent negative consequences arose, emphasizing the seriousness of these long-term problems: "They only treat the symptoms, but no one wants to investigate the causes: Dismantle factory farming, release animals, produce less. I am a fan of the post-growth economy". The most frequently mentioned negative consequences of growth were ecological problems. The maizification of agriculture was viewed particularly negatively, many interviewees were critical of the maize monoculture, as it seemed to result in a loss of biodiversity. A further point of criticism relates to the use of insecticides and other artificial pesticides or fertilizers, which were considered responsible for bee mortality. The interviewees were aware of the seriousness of these problems and said that this development will probably have strong negative effects in the long term: "The foundation they're just messing up, nature, they don't pay any attention to it anymore. The soils […] are filled with poisons. That can't go well in the long run and the insects die out here. So, nature is changing. I think you have to notice that".

Other frequently stated ecological consequences included the overexploitation of natural resources, climate change, impoverishment of structural diversity and a high nitrate input through mass animal husbandry in the region. The interviewees often connected concrete ecological

consequences to sources from intensive agriculture and explained the complex relationships between the system components.

Another consequence of agricultural growth, which was criticised by the interviewees, was negative landscape change, such as wind turbines, biofuel plants, land consumption in agriculture and large monoculture maize fields. A structurally diverse landscape or untouched nature was missed, as they were seen as more ecologically valuable and aesthetically appealing: "It is a problem for me, that the emotional bond [with my hometown/ its landscape] is cracked due to the things we've discussed. […] Because from my understanding, I think a lot of things are wrong and short-sighted".

Certain emotional reactions to growth and its negative effects were characteristic in this archetype. Interviewees reported social tensions, which arose from intensive agriculture and reacted with resignation and hopelessness to environmental problems caused by intensive agriculture. In this perception of growth, the societal consumption behaviour was strongly criticised. The societal demand for cheap products, which were said to be consumed carelessly, was described as a reason for the negative environmental consequences of food production. The consumption of meat in particular was perceived as a social problem, with some interviewees being very critical about the ethical, health and environmental consequences of mass animal husbandry. The interview participants often emphasised the desire for more intentional consumption, with a focus on the regionality and seasonality of products.

Many interviewees either doubted the sustainability of growth and its future continuation or already perceived localized limitations. Respondents continued to be influenced by the growth paradigm and had difficulty imagining a future in which the economy is no longer determined by growth. This perception was often complemented by a negative, worrisome attitude towards the future, since no realistic and desirable alternatives were known, which worried the respondents: "And of course you think of yourself and your family and your children. Many generations have worked to give their children a better life, but I think that what we do will not make it better".

Yet, alternatives to an intensive, growth-oriented agriculture were also mentioned by some interviewees: "If I actually turn this farm back a bit to what it was in 1910 […] there were still sheep and there were some cows. If I turn these things back and have my own local marketing, then I could live just as well, or perhaps better, than if I continue in this development-madness in agriculture of today". Respondents mentioned the importance of sustainability and described which practices they use to be more sustainable in their everyday lives. Organic farms were described positively, as they combine parts of modern agriculture with ecologically compatible cultivation of land, thus producing high-quality products and preserving a diverse landscape. Alternatives to the growth-oriented political system were also mentioned. Respondents felt more hopeful about the future if they knew about alternatives. Some farmers stated that their attitudes towards growth-oriented industrial agriculture had changed and that they were willing to consider more sustainable alternatives.

Emergent cross-cutting perspectives on economic growth

The inductive step of the qualitative content analysis identified two key cross-cutting perceptions of economic growth: The co-evolution of growth and technological progress and the lack of agency individuals perceived in relation to economic growth.

The role of technology was typified by perceptions of close links between technological progress and economic growth. The co-evolution of technology and economic growth as well as strong path dependencies related to technological change were common themes expressed across the four archetypical perceptions of growth outlined above. For the most growth positive interviewees, technology was likely to be viewed as a solution to diverse environmental and societal problems: "There is still enough land in the world to feed the population. With our money, we could also irrigate more land, we could desalinate ocean water, it's all a matter of technology". However, the more common perception of the role of technology was as another form of economic development over which individuals lack agency in choosing or rejecting: "A modern agriculture with modern machinery is necessary. You can't do everything like in the old days". For some interviewees, technology formed part of the systematic constraint: "He [the farmer] is stuck in this hamster wheel. Either he goes along with it [growing machines and production], or he becomes an organic farmer, or he goes down. There's not much more choice there".

A lack of agency in relation to economic growth emerged as a second cross-cutting theme across the four archetypes: "My dad always says that they place a carrot on a stick in front of us; ever more, ever more… [Interviewer: They?] Yes, well, all of them. They always say "you have to do more, you have to grow" […]. It's always about the economy". In particular, the dominance of economic thinking and economic rationales for decision making was a key point expressed by many interviewees: A and our overall system is business-friendly, and that takes precedence over everything else. And that's why, so to speak, the business community has a strong backing, and that sometimes leads

to less responsible behaviour. So this idea of sustainability is expressed verbally a lot, but do companies really act like it …".

The lack of individual agency was also linked to the consolidation of corporate power: "And they [the farmers] are hardly independent any more […] Someone comes along and says "this is the return on investment, I'll build it for you". And then they are dependent. They earn good money, certainly. But whether that's smart in the long run, for the individual farmer […] Whether that's a fulfilment? I don't know". There was a sense of helplessness in the face of larger societal changes: "I understand this [shift from small scale to industrial agriculture] as a process that did not just take 10 years, this has been going on for a long time and one can't stop it. I mean, you can't turn back time".

Discussion

We identified four archetypical perceptions on a gradient between positive and negative attitudes towards economic growth. Each perception was embedded in the experiences of the respondents in relation to changes in technology, societies and the landscapes in which they live. Caution is therefore required in attempting to make any generalizations regarding the representativeness of these four archetypical perceptions on economic growth to broader society, or the direct relationships between societal discourses and individuals' perceptions of growth. Similarly, while the co-evolution of technology and growth was highlighted by many interviewees, it is beyond the scope of this paper to try and explain the causal relations between technological change and perceptions of growth. Indeed, we would argue that this explorative approach to identifying archetypical perceptions of growth would benefit from replication in different contexts, to help shed light on what shapes such perceptions.

While this study did not explicitly seek to study differences between the interviewees, we had nevertheless thought that there might be key differences between the two landscapes regarding perceptions of growth (i.e. that perceptions would be more negative in the more rapidly changing and intensively farmed landscape), yet this was not obviously the case. Moreover, while our sample did not allow us to stratify the perceptions across different professions, or demographic factors, we also did not see clear distinctions with the responses based on such factors. One possible explanation of this is that the perceptions we identified were not solely based on the personal circumstances and experiences of individuals, but were shaped by the discourses that those individuals are embedded in at both the community and broader societal scales (Hajer and Versteeg 2005; Jones et al. 2014). Further investigation of the relation between personal experiences and perceptions of growth in rural communities, and how they are mediated by societal discourses would be an interesting avenue of future research.

Three of the four archetypes ranged from neutral to negative with regard to the impact of further economic growth, and only one of the archetypes expressed growth as a positive driver of change. Our interviewees, far from being experts on economics, harboured restrictions or criticism towards economic growth stemming from lived experiences in their rural areas. Resource limitations and an unequal distribution of power and benefits (e.g. Scoones et al. 2019) were not studied but learned from experiential knowledge (see also Riechers et al. 2019). Resource limitation is often a relatively abstract concept and hence for many people difficult to relate to. Within the agricultural sector, however, the competing demands on resources become locally tangible, and local people can experience and recognize the resulting landscape changes.

One important cross-cutting topic in the interviews was technology, possibly because sociotechnical imaginaries are co-produced with social-ecological systems (Jasanoff 2004). These imaginaries, which can be understood as visions and expectations of future possibilities, are embedded in the social organization and influence policy preferences as well as practices of scientific research and technological innovation (MacKenzie 1996; Fujimura 2003; Jasanoff and Kim 2013). They are charged with meaning and implicit understandings of what is good or desirable for society (Wynne 2005; Fortun and Fortun 2005; Jasanoff and Kim 2013). Even though many interviewees perceived path dependencies and negative consequences arising from "forced growth through continuous innovation", they praise "bigger and better" technological innovations, stating they are modern and necessary and traditional agriculture is outdated and unrealistic in this age. Technological innovation is necessary for the economy to grow (Schumpeter 1942) and growth ultimately leads to investments in research, which leads to new innovations which is supposed to lead to more growth, job creation, welfare and prosperity (Kerschner and O'Neil 2015; Kerschner and Ehlers 2016). Some interviewees also hoped that technological innovations, through growth, will fix the problems of intensive agriculture, which were created by this growth (e.g. Pansera and Owen 2018). In political contexts, technological innovations are also supposed to solve environmental and social problems (Chertow 2000; Asafu-Adjaye et al. 2015). In the fourth archetype, interviewees saw technological progress most strongly as a driver of systemic constraints (Table 2). While alternative societal discourses would need to include qualitative progress and modern technology, they would also need to enable a mental decoupling of progress and growth, to avoid path dependencies and allow for a transition to a sustainable economy.

Perhaps the most striking commonality across the four archetypes was that the interviewees saw themselves as

having little or no agency regarding the continuation of economic growth, either as individuals or as a society (Table 2). The lack of perceived agency was matched by a similar lack of perceived alternatives to the current growth paradigm, even amongst those who viewed economic growth as a largely negative development. Economic growth was perceived as a societal structure over which, or often even within which, the interviewees had little agency.

This is an important finding, as agency has been identified as crucial in determining changes to social practices, including those related to building alternatives to the current growth paradigm (Boonstra and Joosse 2013; Brossmann and Islar 2019). Moreover, this suggests that the feedbacks between structure and agency (sensu Giddens 1984) may be locked into and reinforcing the current paradigm. It may be in part that the dominance of the economic growth paradigm is so strong, alternative structures are failing to emerge, which in turn limits the possibility of transformative change (Sewell 1992). The 'intent' of the system, which is the emergent goals to which the system is aligned (Abson et al. 2017), shapes societal structures. The system intent often mirrors a prevalent mental representation of imagined futures (e.g. Beckert 2013), and just as with imagined futures, multiple goals can exist and even clash. In the case in our study, for example, the societal goal is mismatched with individuals' goals. The influenced social macrostructures, in turn, limit the ability of individuals, or societies to imagine alternative system goals and system designs (Beckert 2013). This potentially creates a locked-in trap where current societal structures limit the agency of individuals to create alternative more sustainable economic systems. This can be seen in the political arena, where instead of having economic discussions with distinctly different opinions and alternative visions, the growth paradigm is unanimously agreed upon and alternative concepts are perceived as not legitimate (Asara et al. 2015).

The perceived lack of alternatives to economic growth was a dominant theme across all four archetypical perceptions, which shows that growth discourses of naturalness, self-evidence and no alternatives limit a person's capacity to think outside the box (Pesch 2018). This suggests that in order for alternative social imaginaries "the dimension through which human beings create their ways of living together and their ways of representing their collective life" (Thompson 1984: 6) to emerge there has to be a 'decolonization' of such imaginaries from the current growth paradigm (Latouche 2009; Kallis and March 2014). However, this raises questions regarding who leads such a 'decolonization'. Can it be imposed from powerful actors within the capitalistic, growth-focused system, such as politicians or corporations, which could be perceived as another form of colonization? Or do these new imaginaries have to emerge from within our society, as "bottom-up" initiatives that are anchored in the experiences of local communities? One academic attempt could be within the theoretical framework of post-normal science, which rejects an absolute demarcation between science and society to foster visions and praxis for sustainable futures (Funtowicz and Ravetz 1993; Strand et al. 2016).

The development of alternatives to the current growth paradigm, such as the notion of degrowth (Fournier 2008; Martinez-Alier et al. 2010), may therefore represent an opportunity to challenge the dominant growth paradigm if they provide concrete examples of meaningful, context specific, alternatives to growth (Berg and Hukkinen 2011). Concrete alternatives to growth, which can be experienced by individuals as achievable and desirable, may spark meaningful alternative economic discourses and reduce the perception of a lack of individual agency regarding challenging undesirable economic growth. Concrete alternatives can offer an opportunity to reflect on a new system and open up spaces to communicate possible new political and cultural ideas (Muraca 2015: 184). It is not necessary that people agree on every aspect of the degrowth vision [even the degrowth movement does not define itself as a homogenous group (Demaria et al. 2013)], it is necessary that new ideas are envisioned and shared, that go beyond the limited growth paradigm. Here we suggest that recently emergent transdisciplinary approaches in sustainability science such as living labs (e.g. Bergvall-Kåreborn and Ståhlbröst 2009; Bulkeley et al. 2016), and real world experiments (Caniglia et al. 2017) may provide avenues for the exploration of alternative societal discourses, but more research on this is necessary.

Discourses can actively be changed because the constraints that discourses impose are open to challenge (Darier 1999). The strengthening of alternative discourses is especially important, since discourses shape what can and cannot be communicated and thought, delimit the range of policy options and thereby serve as precursors to policy outcomes (Keller and Poferl 1998; Litfin 1994; Hajer and Versteeg 2005). With an awareness of how a discourse is operating, it becomes possible to conceive how that discourse might be challenged, or to consider the adoption of a different discourse or the creation of a new discourse altogether. Therefore, resistance in discourses is a site for agency and transformation. Further, conflict between growth positive and growth critical discourses can create opportunities to engender new discourses. An analysis of resistance in discourses, hence, can demonstrate the points where new discourses, with new actions and possibilities, might begin (Fleming and Vanclay 2009a, b). Key questions remain regarding the extent to which alternative societal discourses around economic growth have the ability to change and transform structures in society that are deeply embedded in and reinforcing of the dominant growth paradigm. Similarly, the extent to which new societal discourses can emerge from

the current colonized imaginaries (Latouche 2009) and how such discourses emerge (Pansera and Owen 2018) is a question requiring further research.

Finally, we would note that even within the current dominant paradigm, multiple contested and potentially conflicting discourses exist. It is likely that in the development of alternative visions for a sustainable economy a similar plurality of discourses will emerge. This can be embraced and further research could focus on understanding what this multitude of discourses could mean for the individual and also how such pluralism should be addressed in the search for alternatives to growth. This study has shown, that society as well as the individual person may hold multiple perceptions of growth, but in contexts as those studied in this article, these are oftentimes characterized by growth critical aspects. This shows a need for sustainable, post-growth imaginaries, which could open up spaces for people to imagine a just and prosperous society beyond growth.

Conclusions

In this empirical study, we identified four archetypical perceptions on economic growth in two rural communities in Lower Saxony, Germany: (1) Growth as inherently positive, (2) growth as self-evident and without alternatives, (3) growth as a systemic constraint, and (4) growth as critical and with negative consequences. These perceptions were shaped by themes within broader societal discourses including an assessment of progress, attitudes towards consumption, an understanding of the future, perceptions of systemic constraints and lack of concrete alternatives to the current economic system. Interviewees perceived that they have little or no agency regarding the continuation of economic growth—as both individuals and as a society. One possibility to strengthen people's agency is the exploration of alternatives to the current growth paradigm to provide concrete examples of meaningful, context-specific options. These alternative ideas could influence social imaginaries, by opening up spaces to think and dream of possible desirable futures without economic growth. These imaginaries would then find their way into societal discourses, which in turn shape which actions and behaviour changes seem possible and can be done. The possibility to think and talk about this transformation creates a pathway of change. Therefore, an understanding of how and why individual perceptions and societal discourses and imaginaries emerge and how they influence one another is likely to be a crucial area of sustainability research for transformative change.

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SPECIAL FEATURE: ORIGINAL ARTICLE

Valuation of Nature and Nature's Contributions to People

Human–nature connectedness and other relational values are negatively affected by landscape simplification: insights from Lower Saxony, Germany

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Abstract

Landscape simplification is a worldwide phenomenon that impacts biodiversity in agricultural landscapes. Humans benefit greatly from nature's contributions to people in both material and immaterial ways, yet landscape simplification can undermine these contributions. Landscape simplification can have negative consequences, for example, for human–nature connectedness and other relational values. Major and rapid land-use change, together with a declining appreciation of nature by individuals and societies, in turn, could cause a downward spiral of disconnections. Our empirical research combined a comprehensive assessment of five dimensions of human–nature connectedness with the lens of relational values to assess how these are influenced by landscape simplification. Focusing on two rural landscapes with differing agricultural development in Lower Saxony (Germany), we conducted 34 problem-centred interviews. We found that landscape simplification, especially if rapid, negatively influenced human–nature connectedness and particular relational values such as social relations, social cohesion or cultural identity. We postulate that human–nature connectedness might have a balancing influence on preserving relational values, buffering negative impacts of landscape simplification. Losing connections to nature could potentially foster conflicts among actors with different values. We conclude that combining the notions of human–nature connectedness and relational values can generate valuable insights and may help to uncover new ways to foster sustainability.

Keywords Agricultural systems · Cultural landscapes · Leverage points · Social-ecological systems · Sustainability

Introduction

Landscape simplification is the most important driver of change negatively impacting biodiversity and nature's contributions to people (IPBES 2019; Díaz et al. 2019). Landscape simplification often involves a loss of multifunctional, cultural agroecosystems and the expansion of monofunctional, intensive croplands (Foley et al. 2005). This trend poses a major threat to terrestrial ecosystems because it causes declines in wild and farmland biodiversity (Green et al. 2005; Tscharntke et al. 2005), the diversity of crop varieties (FAO 2011) and threatens the stability of farmer incomes (Di Falco and Perrings 2003; Abson et al. 2013). Underpinning these proximate drivers of landscape simplification, in turn, are value systems subscribing to economic growth, instrumentalism, utilitarianism and consumerism (Meadows et al. 1972; Fischer et al. 2014). Shaped by such value systems and at the same time reinforcing them, national and supra-national agricultural regulations further help to entrench structural changes in agricultural landscapes (e.g. Mikulcak et al. 2013). A potentially important but poorly understood consequence of landscape simplification is its effects on nature's contributions to people (NCP) (Díaz et al. 2019)—defined as "all the contributions, both positive and negative, of living nature to people's quality of life" (Díaz et al. 2018). The effect of landscape simplification is especially remarkable on non-material NCP that result from the relations between humans and nature (i.e. human–nature connectedness; see Ives et al. 2017) and on the relationships

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among humans that are fostered by nature (e.g. social relations, cultural identity; see Riechers et al. 2020b).

Research on human–nature connectedness is in need of a comprehensive understanding of what connectedness means and how to foster it. Connections between humans and nature are said to have positive influences on health (Maller et al. 2006; Shanahan et al. 2016), on the cognitive development of children (cf. Taniguchi et al. 2005) and overall happiness and well-being (Capaldi et al. 2014). Some scholars claim that we need a stronger connection with nature (Zylstra et al. 2014) because humanity's growing disconnection from nature exacerbates the global environmental crisis (Folke et al. 2011). As the literature is fragmented between disciplines, concepts and operationalization of human–nature connectedness (and related concepts/terms such as "connectedness to nature", Mayer and Frantz 2004; or "nature relatedness", Nisbet et al. 2009) are differently understood and applied with few overlaps across different research fields (Ives et al. 2017). Recent research differentiated five dimensions of human–nature connectedness: (1) a material dimension, such as food, fuel, or artisan goods; (2) an experiential dimension covering nature visits or specific activities in nature, (3) an emotional dimension including spirituality, aesthetics and sense of place, (4) a cognitive dimension which deals with knowledge and awareness, and (5) a philosophical dimension of connectedness that concerns normativity and values of a good life (Ives et al. 2017, 2018). Studying human–nature connectedness through such a comprehensive framework can provide insights about the diverse and multiple ways in which people connect with nature. Yet, empirical applications of multiple dimensions of human–nature connectedness are rare to date, despite their potential to provide insights on how to foster sustainability through (re)connecting humans with nature (Folke et al. 2011; Zylstra et al. 2014; Soga and Gaston 2016).

In addition to ecological changes, and changes to human–nature connectedness, landscape simplification can also impact the social relationships within landscapes—most notably because monofunctional landscapes often provide fewer NCP from which a small number of privileged actors benefit, thereby creating inequity and social conflicts (Fischer et al. 2017; Grass et al. 2019). To study environmentally mediated social relationships between individuals and groups of people, the lens of relational values has been proposed (Pascual et al. 2017). Relational values describe the "preferences, principles, and virtues associated with relationships, both interpersonal and as articulated by policies and social norms" (Chan et al. 2016). These include people's experiences, habits and actions with respect to nature and with respect to relationships of people in nature that are associated with a meaningful, ethically responsible and satisfying life (Himes and Muraca 2018). Since relational values can derive from physical, cognitive and emotional experiences of people in nature, this lens also embraces human–nature connectedness. In addition, relational values also include moral considerations regarding what is considered a good life (eudaimonic values) (Chan et al. 2018). Relational values thus acknowledge a plurality of sources of people's quality of life, heuristically divided into (1) the human collective, such as cultural identity, social cohesion, social responsibility and moral responsibility to non-humans, and (2) primarily individual values such as individual identity, values for a good life (stewardship eudaimonic) and the normative goal of protecting nature (stewardship principle) (Chan et al. 2016; Pascual et al. 2017). Despite the relevance of relational values for guiding policy-making and management towards a more sustainable world (Chan et al. 2018), empirical research on relational values remains scarce (but see exceptions such as Arias-Arévalo et al. 2017; Klain et al. 2017; Chapman et al. 2019; Topp et al. 2020).

Empirical research on the interplay between human–nature connectedness and relational values is lacking, yet a better understanding of such interplay could generate valuable insights for more sustainable landscape management (Stenseke 2018; Chapman et al 2019). In this explorative, empirical study, we combine a comprehensive assessment of human–nature connectedness with a relational values lens to understand how landscape simplification affects the interlinkages between humans and nature. We studied two agricultural landscapes in Lower Saxony, Germany, which experienced different trajectories of landscape simplification. We sought to (i) understand differences in human–nature connectedness, (ii) examine the interplay between human–nature connectedness and relational values, and (iii) compare how the two contrasting trajectories of landscape simplification affected the interplay between human–nature connectedness and relational values.

Methods

Study areas

In Lower Saxony, Germany, agricultural landscapes have been increasingly intensified. Especially the area used for maize cultivation nearly doubled from about 10% of the total agriculturally used land in the mid 1990s to about 20% in 2015 (area used for silage and grain maize; Landesamt für Statistik Niedersachsen 2018a,b), mainly due to a change in policies fostering biogas plants. We considered two study areas. The first was the commune of Bispingen (district Heidekreis), which is located in the south of the Lueneburg Heath (*Lüneburger Heide*) (Fig. 1b). The Lueneburg Heath is a natural park established in 1907 through the Federal Nature Conservation Act and is subject to specific environmental protection. With 6411 inhabitants in 2016 and ~ 128

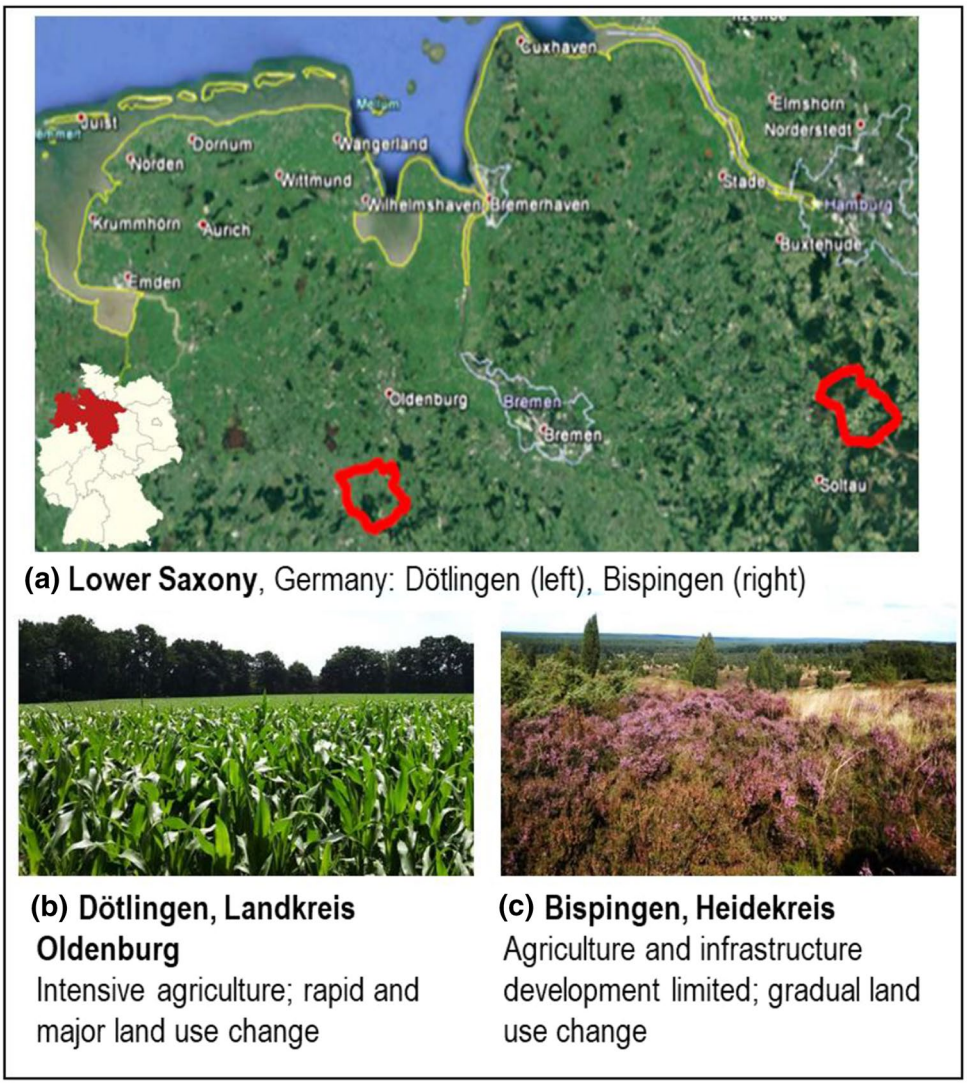

Fig. 1 Study areas situated in Lower Saxony (**a**), exemplary photos and short descriptions of the study area **b** Dötlingen (district Oldenburg) and **c** Bispingen (district Heidekreis)

km^2 of surface, Bispingen had a population density of 50 inhabitants/km^2 (LSN 2019a). As some areas of Bispingen are inside the natural park, various restrictions on land-use change, development and infrastructure exist. Apart from nature tourism, a newly gazetted commercial area includes tourist destinations. In 2017, 3865 ha (30% of the total land area) of Bispingen was used for agriculture (LSN 2019b).

The second study area, the commune of Dötlingen, lies in the district of Oldenburg, which is located to the South-East of the city of Oldenburg in the mid-western part of Lower Saxony (Fig. 1c), Germany. In the district of Oldenburg the number of biogas plants increased from the first one built in 1998 to 88 in 2017 (existing, in construction, and in process on 4 July 2017, Landkreis Oldenburg (2018)), leading to an increase in maize production in the area. The commune of Dötlingen covers an area of ~ 102 km and in 2016 had 6,217 inhabitants (population density of 61 inhabitants/km^2) (LSN 2019a). While it is part of the natural park Wildeshauser Geest, it is not subject to strong environmental protection regulations. Sixty-five percent of the total surface in Dötlingen (i.e. 6628 ha) is used agriculturally (LSN 2019b), predominantly as cropland.

Data collection

Data was collected using problem–centred interviews with a semi-structured interview guideline that was adjusted in parts to the interviewees' profession (Flick 2006). The guideline included sections on interviewees' material, experiential, cognitive, emotional and philosophical connectedness, which were assessed, among others, through questions on the use of local natural products, habits and frequency of nature visits, knowledge of nature and the landscape, perceptions of beauty, favourite places, and sense of place. For generating locally specific narratives, we provided landscape maps of the commune in which interviewees could mark,

for example, their favourite places or places that changed. We also used a ranking of photos with differing landscape features (natural spaces, monoculture, people in nature). Those methods were only used to stimulate the interviewees and keep their answers grounded in the local environment. Regarding landscape change, we asked for perceived changes in the last 20 years, how these influenced interviewees' lives, and how interviewees perceived the trajectory of changes for the coming 20 years. The translated interview guideline can be found in the supplementary material.

We interviewed a diversity of informed laypersons and experts who we expected to be connected to a given landscape (e.g. farmers, foresters, policy makers, long-term inhabitants, and clergy). These actors were identified through literature and online research on the given commune. We then used snowball sampling to reach possible interviewees and cover contrasting opinions (Flick 2006). Snowball sampling was especially necessary as contrasts in the communes led to mistrust against academic institutions, which we had to counter. This approach resulted in 34 interviews (Bispingen = 17, Dötlingen = 17). The interviews had an average length of 75 min. and were conducted in German by the first author. Our study did not aim to be representative for the chosen communes but instead provide in-depth understanding of the influences of landscape simplification on relational values and human–nature connectedness.

Data analysis

Interviews were transcribed literally and analysed with MaxQDR Plus 12 (VERBI GmbH). Data were analysed using qualitative summarizing content analysis (Mayring 2008). The coding sought to capture both human–nature connectedness and those relational values that refer to the human collective and individual values related with and fostered by landscapes. To this end, we used the following procedure for data analysis. In a first step, based on material, experiential, cognitive, emotional and philosophical dimensions of human–nature connectedness research (Ives et al 2017, 2018) (Table A1), we created a deductive coding tree which was iteratively adjusted inductively, driven by the narratives and topics raised by the interviewees. The initial deductive approach helped to focus on topics such as the dimensions of human–nature connectedness and relational values, while the subsequent inductive cycles ensured that the priorities and meanings of the interviewees were captured in detail. For the inductive approach, new codes were successively grouped together to form categories of an increasing level of abstraction. The resulting categories of this qualitative content analysis can be found in Table 1. During this process, we aimed at preserving the qualitative character of interviewees' statements.

In a second step, we analysed the results of the human–nature connections in terms of other relational values, based on Chan et al. (2016). We considered as relational values those referring to (1) the human collective (cultural identity, social cohesion, social responsibility, social memory), and (2) primarily individual values (individual identity, stewardship eudaimonic and stewardship principle, ecological literacy, sense of agency and sense of place) (Tables 1 and 2).

Finally, we coded interviewees' statements regarding their perceived land-use changes and whether these changes were associated with human–nature connectedness (Table 3). To assess relationships between dimensions of human–nature connectedness, relational values and landscape simplification we extracted stated relationships: for example, we may have coded an interviewee's statement into the category of emotional connectedness, such as sense of place; which is also a relational value; and an interviewee may perceive this to be impacted by landscape simplification.

Results

The interviews revealed a wide variety of human–nature connections and relational values. In the first section, we explain how the five dimensions of human–nature connectedness were perceived and influenced by landscape simplification (Table 3). In the second section, we present findings regarding the interactions between human–nature connectedness and relational values. Finally, we highlight the effects of landscape simplification on the links between human–nature connectedness and relational values.

Landscape simplification effects on human–nature connectedness

Different types of connectedness were influenced by landscape simplification in various ways—some types changed without fundamentally declining, while others were perceived to be declining.

Material connectedness was generally perceived to have declined, driven by an increase in industrialised food production. Due to the structural transformation in the agricultural system, which included a decrease of smallholder farms and intensification of agricultural production, local food, feed and fuel were often exported from the region. The size and use of home gardens used for growing food were perceived to be decreasing, as were the use and availability of local products supplied by small shops belonging to smallholder farms. These changes in material human–nature connectedness were perceived to negatively affect interactions with the local environment. In addition to associations with farming, material connectedness was

Table 1 Dimensions of human–nature connectedness (HNC) (sensu Ives et al 2017) and their definition stemming from the inductive data analysis

HNC	Definition of human–nature connections
Material	Local products with symbolic values
	Knowing where food comes from
Experiential	Passive and active recreation
	Social events in nature
	Childhood spent in nature
Cognitive	Knowledge on local culture and landscape
	Knowledge on sustainability topics
Emotional	Negative and positive emotions to nature
	Emotions regarding the trajectory of land-use changes
	Sense of place and regional identity
Philosophical	Treating nature appropriately
Relational values	**Definition of relational values**
Cultural identity	Identity of local culture linked with a landscape
Individual identity	Personal identity linked with a landscape
Social responsibility	Care for a landscape is seen as similar as caring for its people in the present and future
Social cohesion	Sense of belonging and equality in the commune regarding a landscape
Social memory	History of the commune and its people linked with a landscape
Social relations	People connect with each other while being in the landscape
Sense of place	Attachment to landscape or certain places
Sense of agency	Awareness to execute or control aspects of landscapes
Spirituality	Mystical or religious feelings stemming from a certain landscape or place
Stewardship principle	Taking care of the landscape is the right thing to do
Stewardship eudaimonic	Care for landscapes is necessary for a good life
Ecological literacy	Knowledge on ecological aspects and connections in landscapes

Relational values (sensu Chan et al 2016) and their definitions as stemming from the inductive data analysis

Table 2 General links between five dimensions of human-nature connectedness (HNC) and relational values based on the qualitative content analysis

HNC	Definition of HNC	Linked relational values
Material	Local products with symbolic values	Cultural identity
	Knowing where food comes from	Stewardship eudaimonic; Social responsibility
Experiential	Passive and active recreation	Stewardship eudaimonic
	Social events in nature	Social cohesion; Social relations; Cultural identity
	Childhood spent in nature	Individual identity; Social memory
Cognitive	Knowledge on local culture and landscape	Cultural identity; Ecological literacy
	Knowledge on sustainability topics	Stewardship principle; Ecological literacy
Emotional	Negative and positive emotions to nature	Individual identity; Social responsibility
	Emotions regarding the trajectory of land-use changes	Stewardship principle; Sense of place; spiritual values; sense of agency; Social cohesion
	Sense of place/regional identity	Cultural identity; Sense of place
Philosophical	Treating nature appropriately	Stewardship principle; Stewardship eudaimonic; Social responsibility; Sense of agency; Social cohesion

occasionally associated with local natural materials used for heating, building, decoration or collection of wild fruit or herbs.

In contrast to material connectedness, experiential connectedness was perceived to be stronger, and comparably less influenced by landscape simplification. Generally, interviewees spent a large amount of time in nature in

Table 3 Examples of the effects of landscape simplification and related drivers on human-nature connectedness and relational values in the two study areas

HNC	Main stated drivers of HNC loss	Main impacted relational values	Exemplary quotes
Material	Agricultural intensification; Global production of food; Subsidies for renewable energies	Cultural identity; Ecological literacy	Because they don't know anymore what meat actually means and what it is. And everyone is turned off when you see a slaughterhouse on TV. But the [agricultural] structure and how it reached the slaughterhouse [is not shown…]. That there has been a development [of disconnection; …] and this is not discussed (Bispingen, farmer about the disconnect from material HNC through spatial distance and lack of visibility)
Experiential	Agricultural intensification; Parents disconnected from nature; Multiple competing activities;	Stewardship eudaimonic Cultural identity Social cohesion; Social memory	This [nature experiences] also vanished through the parents. We don't have farms anymore; one doesn't really take the kids and go places to see what's creeping and crawling there (Bispingen, teacher on the disconnect from experiential HNC through lack of planned experiences)
Cognitive	Landscape simplification	Stewardship eudaimonic; Cultural identity; Ecological literacy	In the last 10 years, I would say, it [the blame towards farmers] increased. Farmers are polluters, farmers torment animals, farmers contaminate the groundwater, farmers are generally responsible for all bad things found in nature (Dötlingen, farmer about the biased knowledge on landscape simplifications)
Emotional	Agricultural intensification; Landscape simplification	Stewardship eudaimonic; Cultural identity; Social cohesion; Cultural identity	There are developments here in the landscape [landscape simplification], which I just don't consider aesthetic. Where I simply say that those disturbances bother me, and they hurt me (Bispingen, forester about the emotional impact of the amount of maize, and impacts of nutrients in the forests)
Philosophical	Agricultural intensification	Stewardship eudaimonic; Sense of agency; Stewardship principle/virtue	They really employ an [external] agricultural service to work the fields. Then there are young people sitting on the tractor, with no connection to the specific soil and they smash up everything that is not nailed down (Dötlingen, Environmentalist about the industrialisation of agriculture for economic gain)

Exemplary quotes are presented for the five dimensions of human-nature connectedness (HNC)

consequence of their profession, voluntary engagement or leisure activities. Due to the time constraints of daily life, many experiences in nature were unplanned or bound to the area close to people's work and living spaces. Hence, when interviewees' direct surroundings experienced rapid land simplification and agricultural intensification, experiential connectedness towards those spaces declined, and we observed a retreat of people into their own gardens or other spaces for nature experiences. While there was a trend that indicated hiking had increased, especially in the Lueneburg Heath, day-to-day nature experiences for most inhabitants were perceived as decreasing. Interviewees raised the issue of alienation from nature, stating that disconnected parents were unable or unwilling to experientially connect their children with nature. Further, the decrease of smallholder farms was perceived to negatively influence experiential

connectedness because of the lack of possible passive and active interactions with local farmers and their farms.

Cognitive connectedness, as knowledge and awareness of the natural environment, was related to the motivation to see and experience something new. Interviewees perceived it to be connected to stimulating experiences including animal sightings, special activities or memorable adventures. The new, unknown or attractive sights of historical, natural or aesthetically valuable places were a motivation to go out into nature. Environmental education was generally seen as very important, and both areas offered many possibilities for this. Using all five senses was highlighted as important for children's education and to sensitise children for nature. Overall, our findings suggest that cognitive connectedness was relatively high, despite ongoing landscape simplification. However, it was also discussed how knowledge and awareness about problems in the regions seemed not to lead to any significant behavioural change, and hence might not be enough to create meaningful change for sustainability.

Similarly to cognitive connectedness being fostered by stimulating experiences in diverse or structurally rich parts of the landscape, emotional connectedness also appeared to be related to biodiversity and landscape multifunctionality. Landscape simplification was generally perceived to have a negative effect on landscape aesthetics because monofunctional landscapes were seen as less beautiful. Through increasing monocultures, intensification and a general increase of infrastructure, inhabitants feared that the landscape's horizon may lose its sense of naturalness. We also found notions of anger and despair when it came to the topic of landscape simplification or the statement of general detachment from nature in society. One interviewee expressed the experience of watching the landscape simplification and growing disconnection between humans and nature with strong emotions: *"[…] a great, deep, fundamental pain, grief. Despair. Helplessness. Or often again a bewilderment about this state of semi-sleep [due to lack of agency]"* (Dötlingen, inhabitant). General love for nature was expressed with regard to old trees, special natural or historical sites, or animal sightings. Spiritual notions were linked to special or mystic atmospheres of places, such as early mornings in a foggy, calm heathland.

Finally, with respect to philosophical connections to nature, interviewees used a range of constructs, acknowledging the tensions between instrumental values of nature, such as the importance of nature for people's livelihoods, and values, such as the duty of care towards the environment. Interviewees frequently stated instrumental values when considering that nature's purpose was that it had to sustain livelihoods and could be used for recreational purposes. While environmental protection was seen as necessary, managing the land for humans was widely held as equally important. Many interviewees showed a feeling of unease and insecurity when it came to the current development of the landscape. Without being specifically prompted, interviewees often focussed on contrasts and tensions within the region as well as problematic narratives of (economic) growth when talking about landscape simplification. This discussion unravelled differing understandings of agriculture and environmental protection and often pointed to hardened ideological fronts—*"The facts are just created [felling of trees and ploughing up marshlands], and then it is destroyed. And you are standing there and you are thinking: yeah. And now it is broken, what should I do now?"* (Dötlingen, employee in local administration).

Interlinkages between human–nature connectedness and relational values

When interviewees discussed human–nature connections, they often also referred to relational values—focussing on their decrease as a result of landscape simplification. In terms of material connectedness, interviewees stated that the general notion of knowing where the food comes from is very important, and this was linked to values of a good life (stewardship eudaimonic, social responsibility). Similarly, some material goods had a symbolic character for cultural identity, such as regional specialty foods like certain types of potatoes or honey (Table 2).

Regarding experiential connections, especially passive recreation, respondents stated that they were very important for relaxation, solitude and quietness, and hence were linked to values of a good life (i.e. stewardship eudaimonic). Further, nature was valued as a backdrop for social events or as the focus for social gatherings, thus contributing to the quality of social cohesion and social relations. Such experiential connections also contributed to cultural identity in relation to their landscape, as one interviewee explained: "*[in former times] the whole village community always met and went to "entkusseln" [a type of landscape conservation which removes shrubs and young trees] in the heath land. So that the heath stays beautiful*" (Bispingen, inhabitant). Activities such as these strengthened the feeling of a shared cultural identity connected to "their" heathlands. Interviewees also drew on stories of their own childhood experiences in nature, which they believed led to a stronger connection to nature (i.e. individual identity, social memory).

Respondents often raised the relational value of cultural identity in regards to cognitive connectedness. Interviewees were concerned about the effect of landscape simplification on people's knowledge of nature, including formal knowledge through work and informal knowledge through inheritance and self-taught. Topics raised included knowledge of the landscape such as its cultural, historical and natural specifications. Further the interviewees' knowledge on environmental protection and sustainability was linked to

statements of how nature should be treated (i.e. stewardship principle), as stated by one interviewee: "*Only then [referring back to the co-creation of knowledge and awareness of nature], when there is a connection, then I feel responsible for something; or I consider something beautiful, or there is an effect of recognition with people that I meet. Only then, can I engage [in nature]*" (Dötlingen, environmentalist).

Emotional connectedness ranged from positive to negative emotions and respondents linked these with certain relational values. On the positive spectrum, both study areas had a very strong sense of cultural identity. Especially in Bispingen, the Lueneburg Heath was seen as a special area and its inhabitants often felt a sense of place or spiritual connections to certain places. Negative emotions towards landscape simplification were related to impacts on individual identity, diminished social cohesion and deteriorating social relations. In addition, the negative emotion of frustration emerged when interviewees considered simplification as an inappropriate trajectory of the landscape, expressing the relational values of stewardship principle and social responsibility. "*I am very very critical of this development [intensification/simplification]. And some things scare me. I am usually a positive person…or a positive thinking person… but some things really scare me*" (Dötlingen, forester).

In statements on philosophical connections, interviewees expressed opinions that nature was seen as fragile and it was deemed necessary to treat it well or give something back (stewardship principle) including the sense of agency to do so. Nature was also stated to be as essential for a good life (stewardship eudaimonic). This was, for example, stated by farmers with a high attachment to their own land and the future development of it, or related to the hunters' paradigms of "protection and care" (German: *Hege und Pflege*): "*We are a family business which grew decades, centuries. And we cannot leave this place, and hence we have to care for it, not emaciate and then move on. […] especially for older farms and heath farms, this [stewardship] is obvious*" (Bispingen, farmer).

Effect of landscape simplification on the interlinkages between human–nature connectedness and other relational values

While patterns in human–nature connectedness were broadly similar in both study areas, interviewees stated more negative influences of landscape simplification on relational values in Dötlingen (Table 3). By contrast, in Bispingen we observed fewer statements regarding the effect of landscape simplification on relational values and human–nature connectedness.

In Bispingen, the protected area status of the area constrained the growth of agriculture, leading to "smaller" farms with more livelihood diversity that included other experiences in nature, such as tourism and recreation. In fact, tourism in the Lueneburg Heath had long been a strong factor in the region for economic activities and for forming a cultural identity: *"this is what defines our commune, that we have this landscape, this heath"* (Bispingen, farmer). The diversity of experiences, in turn, was related to collaboration among local actors: *"Of course everyone has to look out for himself, but among farmers there is a real sense of unity, there are no animosities here"* (Bispingen, farmer). While conflicts and tensions existed, dialogue was seen as the best option to reach transparent decisions.

In contrast, the landscape in Dötlingen had seen uneven growth favouring a few, increasingly larger farms that focus in intensive agriculture. The growth of those farms had now reached limiting factors such as land availability and increased rents, as well as national emissions regulations that limit the construction of new mass husbandry stables. The growth of farm sizes seemed to be associated with a decline in people identifying with the surrounding landscapes. It also seemed to give rise to the alienation between fractions, such as smaller and bigger farmers and environmental protection groups: *"When you are constantly told that you are the bogeyman of the nation, you are not willing to voluntarily give in to anyone. You'd rather say: as long as you treat me like this, I won't do anything here"* (Dötlingen, farmer). One employee in the local administration in Dötlingen who works in environmental conservation expressed a similar sentiment, albeit directed against intensification: "*I just don't want this anymore. And I think: then just do your shit, just let it go your way. I don't want to say something against it all the time. You will see what the outcome is. […] and I am not the only one having this effect [i.e. no feeling this way]*". To continue working in agriculture, farms were increasingly pushed to focus on efficient production, which fostered instrumental values. This stood, in contrast, with the sense of place and cultural heritage inhabitants valued but felt disappearing through agricultural intensification of the landscape. In Dötlingen, a feeling of lack of agency and frustration with the current trajectory of land simplification emerged among interviewees. This led to people retreating into their own homes (where they had agency) or expressing anger (Table 3): *"I really think if we continue like this, with industrial animal husbandry and intensive agriculture, then our soil will be so damaged that nothing will grow, because that's it!"* (Dötlingen, tourism operator).

Discussion

Effects of landscape simplification on human–nature connectedness and relational values

Landscape simplification is occurring all over the world and increasingly shaped by global drivers rather than local ones (Foley et al 2005). Ecological effects of landscape simplifications are well known and studied, such as negative influence on wild biodiversity (Green et al 2005), farmland biodiversity (Tscharntke et al 2005), and the diversity of crop varieties (FAO 2011). Here, we highlight the impacts of landscape simplification on non-material NCP through the analysis of human–nature connectedness and relational values, particularly when the changes are rapid (Fig. 2). Our qualitative and explorative empirical work does not aim to give a representative overview of the two communes but rather highlight the various negative influences of landscape simplification of a small group of knowledgeable persons. Further research on quantifying HNC and other relational values and relating these to concrete landscape changes might be an interesting future endeavor.

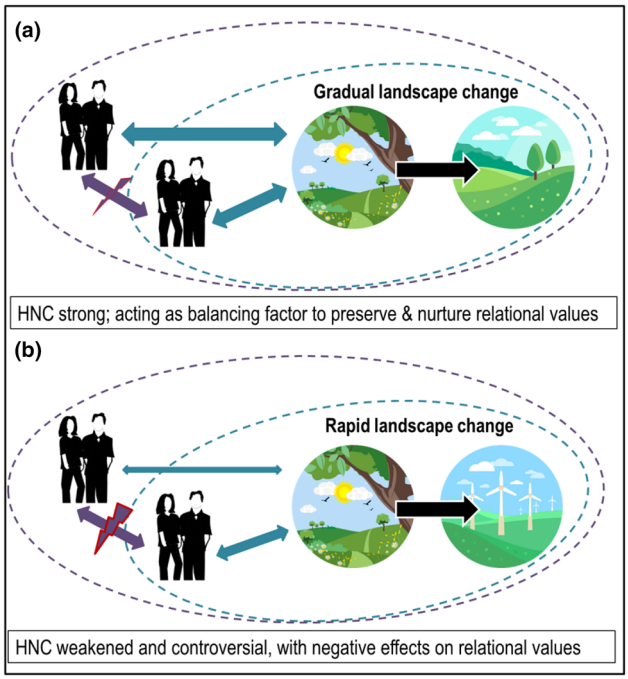

Fig. 2 Outer circle: relational values involving the human collective. Inner circle: primarily individual relational values. Blue arrows represent relations between humans and landscape = human–nature connectedness in different strengths and conceptualizations. Purple arrows show relations between people = social relationships. The width of the arrows denotes the hypothesized strength of a given connection; potential breakdown or conflict is indicated by a lightning symbol. Landscape pictograms show landscape change from gradual and minor (**a**) to rapid and major (**b**). *HNC* Human–nature connectedness. *Source: Landscape icons made by Freepik & Icon Pond from* www.flaticon.com

Our results, especially in Dötlingen, indicate a landscape under stress. With the influence of landscape simplification on inhabitants' sense of place and moral compass regarding "what kind of development is right for this area", contrasting ideological fronts have begun to diminish social coherence and social relations. Notably, the situation in Bispingen was less conflict-laden. Here, land-use change was limited due to the protected area status, and income diversification had been practiced for decades. Tourism activities in the area had strengthened regional identity and pride in those diverse landscapes. Collaboration among local government, farmers and tourism operators was high. Still the necessity to grow and intensify to allow an economically stable future, together with the restrictions imposed by the natural park, constantly challenged local farmers. This fostered disagreements and even caused a court case led by some farmers to reclaim land currently leased to the natural park. However, despite such challenges, the general understanding in Bispingen was not one of direct, personal blame but a sentiment of lack of ascribed responsibility and loss of agency. There was a feeling of an, often unidentified, outside force that was changing the system and making people behave in unsustainable ways.

Human–nature connectedness as balancing factor for preserving and nurturing relational values under Landscape simplification

Based on our findings, we argue that the multi-facetted dynamics in human–nature connectedness played a balancing role on the effect landscape simplification had on relational values. Relational values such as cultural or individual identity and social relations appeared to be partly mediated by human–nature connectedness (Fig. 2a). A strong emotional connection to the landscape expressed and shared by inhabitants may increase social coherence within the communities and strengthen social relationships. A similar effect may be hypothesized for a strong experiential connection, as many experiences in the landscapes are shared with family members, friends or other inhabitants (Balázsi et al 2019). However, groups may have different preferences and compositions of human–nature connectedness, i.e. a different understanding of what nature is, and what it should and could be used for. In gradually simplified landscapes, these differing understandings and connections can co-exist. However, when change becomes more rapid and natural spaces rarer, the contrasting preferences might lead to conflicts (Riechers et al 2018).

Rapid landscape simplification can decrease and change human–nature connectedness and, in turn, lead to starkly contrasting value preferences between actor groups (such

as prioritisation on instrumental values vs. sense of place or spiritual values) (Fig. 2b) (Riechers et al 2019a). The decrease of human–nature connectedness and the differing constitutions of those dimensions can lead to an erosion of certain relational values, such as cultural identity and social relations (Table 3). Hence, we postulate that landscape simplification is likely to have negative consequences for a broad range of relational values in many instances (Table 3), possibly even leading to a vicious cycle of disconnection and disengagement in the community. We also suggest that when landscape simplification affects relational values, it may lead to conflicts between individuals and actor groups (Fig. 2b) (Riechers et al 2019a). Our results contribute to current discussions on how relational values can build a better understanding of possible conflicts between social actors (Chapman et al 2019; Topp et al 2020). For example, Chapman et al. (2019) found that conflicts between farming and conservation programs could be meliorated by considering the relational values of farmers in terms of their identity.

A relational values lens highlights the links between humans and nature through tangible and intangible relationships. In our results, this is especially present in the emotional and philosophical human–nature connections as our respondents clearly highlighted the repercussions those have on (1) the relationships between community members and groups, and (2) the moral and ethical considerations of the inhabitants. The overarching normative questions of "where do we want to go" and "who owns a landscape" were addressed, as many interviewees wished for a system that allows a stable income in agriculture without focusing narrowly on profit maximisation with high economic risks, while also ensuring sustainable land use.

Activating the leverage point of human–nature connectedness

By highlighting the strong links between human–nature connectedness, relational values and landscape simplification, we emphasise the crucial role of connectedness to nature as a *leverage point* for sustainability (Abson et al. 2017; Fischer and Riechers 2019). Leverage points are places in a complex system in which small interventions can have wide-ranging influences to bring about system change (Meadows 1999), and intervening at key leverage points holds great potential for system transformation (Abson et al. 2017). Here, we defined leverage points as domains for interventions that can result in observable changes within a system (Manlosa et al. 2018). While most efforts to combat detrimental environmental changes have focused on changing specific parameters (e.g. the rate of land clearing) or relationships between parameters (e.g. increasing fines to prevent illegal land clearing), this often has not fundamentally changed the trajectories of the systems (Fischer et al. 2007). Addressing more deeply root causes of unsustainability in contrast, is more difficult to do but may hold greater potential for long-term system transformation (Fischer et al. 2012; Abson et al. 2017). Strengthening human–nature connectedness could be one potential leverage point to foster sustainability transformation (Riechers et al. 2020a) but is also deeply affected by landscape simplification (Riechers et al. 2020b).

Based on our analysis, we identified two domains for interventions seeking to enhance human–nature connectedness to improve sustainability. First, fostering collective knowledge generation to enable information flow and exchange can create mutual empathy and understanding, and thus combat slipping into unconstructive scapegoating (Riechers et al. 2019a). In Bispingen, collaborations between smaller and bigger farmers were strong, and while problems existed, communication and collaboration with environmental conservation groups and other inhabitants also flourished. Our research showed that there was an understanding that farmers are forced to grow and to intensify their agriculture due to national policies, however, anger and blame from both sides still emerged—often stating a lack of understanding of agro-political processes (see also Allen et al. 2018; Chapman et al. 2019). Our results support previous research that found that meaningful participatory processes would be favourable to stop a spiral of disengagement and apathy by strengthening information flow, creating knowledge and a sense of agency.

Second, the motivation and engagement arising from emotional discomfort could be harnessed to actively foster local transformational change as seen fit by the actors involved (Riechers et al. 2019a). Due to the intertwined and interlinked nature of human–nature connectedness and relational values such as social relations and eudaimonic values, we reason that interventions in these domains could nurture and foster a broad range of relational values (Capaldi et al. 2014; Riechers et al. 2019b). Especially interventions to strengthen emotional and experiential human–nature connectedness are pivotal, due to their multiple links to other dimensions of connectedness (Riechers et al. 2020a). This would lead to strengthening the overall human–nature connectedness and ultimately, may improve sustainability outcomes.

There is a clear need for transformative change that permeates entire social systems—from the emotions of individuals to attitudes of social groups, and ultimately to societal structures and processes. If state policies and interventions are to be effective in addressing landscape simplification and the far-reaching consequences, these will need to go beyond a focus on specific environmental parameters, and instead engage with deeper leverage points such as values and emotions (Riechers et al. 2020b). This will include confronting issues of changing and inequitable agency of residents, farmers and government

bodies. Many actors in a given landscape may wish for a transformational shift in the landscape trajectory, but a feeling of helplessness and inability to change existing economic and political systems often not adjusted to the landscape can substantially undermine their ability to actually work towards transformation (Chapman et al. 2019).

Conclusion

This study shows that landscape simplification can have far-reaching consequences on human–nature connectedness and relational values, fostering discomfort and concern in rural residents regarding future development pathways. Our study uncovers a nuanced perception of human–nature connectedness broadly distinguished into material, experiential, cognitive, emotional and philosophical dimensions. Further, we highlight the benefits of a relational values lens that combines human–nature connectedness with other relational values including those concerned with the human collective or primarily individual values. Human–nature connectedness and other relational values seem to be tightly interlinked and negatively impacted by increasingly rapid landscape simplification. We postulate that improved human–nature connectedness could buffer the negative impacts of landscape simplification on relational values, such as social relations and cultural identity. Based on our findings, we propose three domains of intervention that could act as leverage points to foster sustainability: (1) strengthening transparency and information flow and exchange, (2) tapping into the discomfort arising from landscape simplification as a source for motivating transformation, and (3) using meaningful participatory processes to stop a vicious cycle of disconnection and disengagement with a landscape and its people. The influence of landscape simplification on the relationship between human–nature connectedness and relational values deserves further research in different study areas to gain a deeper understanding on how the leverage point of human–nature connectedness may help to preserve and nurture relational values.

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Research

Reviewing relational values for future research: insights from the coast

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ABSTRACT

To create the science we need for the ocean we want in this UN Decade of Ocean Science for Sustainable Development and to support the IPBES value assessment, we systematically reviewed literature from the past 20 years (N=375) that used conceptualisations of relational values in coastal and marine ecosystems of the Global South. We found four clusters of research highlighting specific characteristics: Cluster 1 (Participatory and qualitative approaches) was defined by a focus on the relational value of cultural heritage and the production of qualitative social science data often with a participatory approach. Cluster 2 (Indigenous and local ecological knowledges hold by fishers and gatherers) linked to the explicit inclusion of Indigenous and local knowledges in the research and to aspects of biodiversity and marine resources. Cluster 3 (Ecological and environmental change), was determined by relational values of social relations and identity of residents and community members through the use of anthropological and ethnographic methods and linked to ecological and environmental change. Cluster 4 (Recreation and quantitative data) was characterized by a variety of relational values, such as recreation and enjoyment, aesthetics and inspiration or stewardship and based on quantitative empirical social research methods mainly elicited from coastal users (such as tourists). We highlight (i) the most prevalent relational values, (ii) the necessity to bridge dispersed research approaches and (iii) the possible negative impact of globalisation, market pressure and ecological degradation on relational values. Our lessons learnt are the challenge of conflating relational values with structures, institutions or emotions, the necessity of accounting for dynamic influences on relational values and finding ways to comparably quantify relational value categories. Our recommendations for future research are: (1.) specificity regarding relational values and their object of value; (2.) use of transdisciplinary and participatory approaches; and (3.) strengthening pro-environmental relational values for sustainability transformation.

Keywords: Biodiversity conservation; Fishing; Indigenous and local knowledge; Livelihood; Sense of place; Sustainability; Transdisciplinary

INTRODUCTION

Academics and practitioners increasingly articulate relational values to convey the importance of nature to decision-makers, especially in biodiversity conservation (Díaz et al. 2015, Pascual et al. 2017, IPBES 2019). Relational values are "preferences, principles, and virtues associated with relationships, both interpersonal and as articulated by policies and social norms" (Chan et al. 2016:1462). The "relational" refers to the focus on the relational *content* of valuation and not to the inherently relational *process* of valuation itself (Himes and Muraca 2018). The content of valuation refers to what is valued and how the value is attributed and articulated (Ibid, pg. 2) —in the case of relational values, this is our relationship with nature. Relational values focus both on human-nature connections (such as aesthetic or inspirational values, e.g., Badang et al. 2016, Mozumder et al. 2018), as well as human-human connections that stem from interactions within a social-ecological system (such as social relations or social memory, e.g., Hoque et al. 2017, Rojas et al. 2017) (Muraca 2011). Researchers proposed the framing of relational values as a "third type" of values, in addition to intrinsic values (i.e., the inherent value of nature as end in itself, regardless of any human experience) and instrumental values (i.e., the importance of nature as a means to achieve human ends or satisfy human needs) (Muraca 2011). Attention to relational values is said to help to foster inclusive conservation by acknowledging a plurality of values and increasing the options for how we discuss nature's meaning (Díaz et al. 2015, Chan et al. 2016).

Though the framing of relational values is new, the concepts of value on which this framing draws have a rich, diverse, and extensive research history. The framing of relational values builds upon decades of studies on topics such as sense of place (Trentelman 2009, Brehm et al. 2013), human-nature connection (Mayer and Frantz 2004, Dutcher et al. 2007, Nisbet et al. 2009), and experiential relations to nature (Keniger et al. 2013, Soga and Gaston 2016). Indigenous and local ecological knowledges (Berkes 1993, Bradley et al. 1999, Schultz 2001, 2002) and conceptions of humanity's place in nature (van den Born 2008, Raymond et al. 2013) are also foundational to relational values concepts. Hence, the literature about relational values is much older than the term coined by Barbara Muraca in 2011 (Muraca 2011). Yet these decades' worth of research on concepts that intertwine with relational values is dispersed across disciplines, which can make it challenging to get an overview of the information. A comprehensive summary of existing empirical research behind the new framing of relational values is missing. To further the concept of relational values and to learn from previous empirical research, in this review, we offer an overview of 20 years of dispersed research around relational values (by other names) in coastal ecosystems in the Global South.

Advancing this knowledge is especially relevant in the coastal ecosystems of the Global South. The high demand pressure on coastal ecosystems and the resulting rapid change is likely to impact relational values, and possibly erode pro-sustainability relational values (Riechers et al. 2020). Coasts are multi-functional

spaces in which many different demands meet the increasing impacts of global change (von Schuckmann et al. 2019). They are highly impacted by overexploitation through industrial and touristic development, overfishing, or mining which threaten the livelihood and food security of local communities (Mora et al. 2011, Hughes et al. 2017). Yet, many people, particularly in the Global South, are directly or indirectly dependent on coastal ecosystems through marine resources, agriculture, tourism, or recreation (IPCC 2019). This is especially true for Indigenous peoples and local communities (Cisneros-Montemayor et al. 2016). Combined, these pressures lead to a dramatic loss of biodiversity and ecological functions vital to the local communities (Millennium Ecosystem Assessment 2005, IPBES 2019), which is exacerbated by climatic stressors (Graham et al. 2015, IPCC 2019).

To create more sustainable livelihoods and conserve biodiversity, the complex societal challenges in coastal regions need to be researched comprehensively. To account for rapid and extreme environmental changes and to achieve the Sustainable Development Goals (UN 2015), coastal policy and management need to move away from sectoral approaches and instead adapt to the complexity of coastal social-ecological systems. The framing of relational values can help to foster a social-ecological perspective because it refers to the meaningfulness of relationships, such as those between nature and people and among people within or fostered by nature (Chan et al. 2016, 2018). This focus on relationships and interconnections is extraordinarily relevant to social-ecological systems research, and thus for building the science we need for the ocean we want in this current UN Decade of Ocean Science for Sustainable Development (United Nations Educational, Scientific and Cultural Organization 2020).

In this paper, we present the main findings from our systematic literature review of 20 years of research on relational values (by other names) conducted in coastal ecosystems of the Global South. To our knowledge, this is the first systematic literature review on the topic of relational values in general, and specifically with a focus on the Global South. Hence, in this paper we aim to: (i) give an overview of the relational values that we identified in the articles (as the articles may not use the term “relational values” explicitly); (ii) highlight methods used to elicit relational values; (iii) identify the biogeographical aspects to which relational values are linked; (iv) give an overview on the research clusters that have studied relational values; and (v) present connections between the people whose values were studied and the benefits and challenges in valuation as stated by the researchers.

We end our discussion with a section on lessons learned through our literature analysis, especially through empirical research papers. To further future research in this field we address questions on the relational values concept (what are relational values?), methods (how to assess them?), and topics (what is the object of value?). Based on these lessons learned, we offer three recommendations for further research on relational values: (1) specificity regarding relational values and the biophysical aspects to which they are linked; (2) use of transdisciplinary and participatory approaches; and (3) strengthening pro-sustainability

relational values for societal transformation (Box 1). Through this, we want to foster greater cross-disciplinary fertilisation of the new field of relational values and hope to enable a more comprehensive and applicable operationalisation of this framing.

METHODS

Data collection

Our systematic review followed the guidelines for the "Preferred reporting items for systematic reviews and meta-analyses" (PRISMA) framework (Moher et al. 2009) (Figure S2 in A2). We developed a search string to encompass the diversity of relational values and coastal ecosystems in the Global South (see search string in A1). In spring 2020, we applied our search string to the databases of Scopus including publications from 2000-2019. The search string was restricted to articles in English, including both conceptual and empirical observations, and resulted in 1,665 articles.

Articles had to address both relational values and coastal or marine ecosystems in the Global South to be included. We first screened the titles, abstracts, and keywords of these 1,665 articles and omitted 924 that did not meet these criteria (when in doubt, we maintained the article for full-text analysis). The remaining 741 articles were downloaded and analysed based on their full text. Since it was difficult to decipher the use of relational values within only the abstract, many articles were included in the full-text analysis which eventually had to be excluded for not using any concept that can be seen as similar to relational values (n=366). The final set of articles was 375 (Figure S2 in A2).

Data analysis

We partly based the coding scheme used in the systematic review on previous research. The categories of relational values were based on reports from the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES 2016, 2019) and related scientific studies (Arias-Arévalo et al. 2017, Klain et al. 2017) but adjusted inductively to highlight the focus of the articles. We adjusted benefits and management categories based on Tran et al. (2020). Finally, we tested and refined the coding scheme through 50 randomly selected articles before applying it to the full set. To ensure inter-coder reliability, tandems of two conducted preliminary coding separately. Each pair cross-checked and discussed their coding for consistency. The lead author spoke with each pair to ensure for consistency between them.

We analysed the data using SPSS 26 (IBM Deutschland GmbH, Ehningen, Germany). Data analysis consisted of qualitative and quantitative analyses. We analysed most variables using qualitative content analysis to summarise the results into distinct categories and groups (Mayring 2008). The overarching categories (e.g., relational values, biogeographical aspects) were used as numerical inputs into the statistical analysis. In addition to descriptive statistics, we conducted a hierarchical (agglomerative) cluster

analysis (HCA) using Ward's method (Ward 1963) and squared Euclidian distance on binary presence/absence data on the following: relational values, people whose values are elicited, inclusion of Indigenous ecological knowledge, presence of transdisciplinary processes and methods used. The HCA does not require a pre-specified number of clusters and the resulting clusters were chosen after multiple runs which were analysed with descriptive statistics on their coherence and explanatory power. We used the results from the HCA and correlated them with variables such as the ecosystem in which the study took place and the biogeographical components to which the relational values were linked (Cramer's V). To visualize the connections between the social groups whose values were elicited and the benefits and challenges mentioned in the articles, we created a directed tripartite network diagram using the R package 'igraph' (Csardi and Nepusz 2006, R Core Team 2019) (Figure 3).

RESULTS

Types of relational values used

Our content analysis resulted in 13 categories of relational values (Table 1). The most mentioned category of relational values was "Indigenous and local ecological knowledges" (n=267, 71.2%). Our classification of this concept included a collection of terms, as the current literature does not give a universal definition (Berkes 1993). Our definition is partly based on the work by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (Díaz et al. 2015), which includes the knowledge from Indigenous peoples and local communities such as traditional and Indigenous knowledge (Berkes et al. 2000, Mazzocchi 2006), local knowledge (Olsson and Folke 2001), local ecological knowledge (Crona 2006), and fishers' or farmers' knowledge (Leite and Gasalla 2013) (for a broader overview on these terms related to coastal ecosystems see Loch and Riechers 2021).

The second-most mentioned relational value was "Social relations" (n=86, 22.9%) which included aspects of sense of community and social cohesion as intertwined with or mediated by nature. The third-most mentioned relational value was "Recreation and enjoyment" (n=74, 19.7%) which comprised the sub-categories of recreation, enjoyment, and nature-based tourism. This was followed by the category "Identity" (n=70), which was made up of the sub-categories of cultural identity, individual identity, social and collective identity, and social learning (Table 1). Other categories of relational values that appeared with less frequency include "Stewardship", "Culture & heritage", "Spiritual", "Aesthetic & Inspiration", "Sense of place", "Empowerment & Autonomy", "Environmental awareness", "Educational", "Psychological", and "Well-being" (Table 1).

Regarding the people whose values were elicited, studies most often focused on artisanal fishers (n=182, 48.5% of all 375 articles) and residents or community members in general (n=138, 36.8%). Other articles

focused on “coastal users” (n=37, 9.9%), on Indigenous or Aboriginal Peoples (n=33, 8.8%), or government representatives (n=20, 5.3%).

Types of articles and methods used

Of the 375 articles included in our literature review, 93.3% (n=350) undertook an empirical, 5.3% (n=20) a conceptual, and 1.3% (n=5) a review research approach (Figure 1). Social science research methods dominated with 90.1% (n=338) of the articles using at least one method within this broad field (Figure 1). At least one natural science method was used by 26.7% (n=100) of the articles. Data was collected qualitative in 36.1% (n=137) articles, mixed in 36.1% (n=137) and quantitative in 22.7% (n=86). Over half of studies conducted interviews (59.7%, n=224), and roughly a third used surveys and questionnaires (33.6%, n=126). About a fifth of studies involved group discussions and workshops, (22.9%, n=86), and another fifth participant observation (19.5%, n=73). About a tenth of articles used spatial approaches (natural science methods such as GIS, geological mapping, and aerial photography) (10.9%, n=41). Transdisciplinary aspects, approaches, and processes were used in 7.7% (n=29) of the articles (Figure 1).

Biogeographical aspects

In this section, we focus on empirical studies to highlight the biogeographical aspects to which relational values were linked (Figure 1). Geographically, the study areas of the analysed articles were most often located in Asia (30.7%, n=115), South America (28.0%, n=105), and Africa (18.9%, n=71). Countries with the largest numbers of studies were Brazil (14.9%, n=56), Solomon Islands (6.9%, n=26), Indonesia (6.9%, n=26), Mexico (5.9%, n=22) and Bangladesh (5.3%, n=20). The most common scale was regional (37.6%, n=141), followed by the local (24.5%, n=92) and landscape (20.8%, n=79) scales. Most empirical studies did not name a specific coastal ecosystem in which they took place, but referenced coastal and marine systems in general (53.3%, n=200). The most commonly named ecosystems studied were coral reefs (12.8%, n=48), mangroves (10.9%, n=41) and lagoons (9.6%, n=36).

We further assessed biophysical aspects linked to the relational values studied (Figure 1). Many relational values were linked to marine resources in general and their protection (38.9%, n=146). A nearly equal proportion of relational values were linked to specific species (fish, marine mammals, invertebrates) and aspects of biodiversity (such as species abundance or diversity) (37.9%, n=142). Other relational values were linked to specific ecosystems (e.g., values related to mangroves or coral reefs) or nature in general (31.5%, n=118) . Almost 17% of studies linked relational values to ecological changes (16.8%, n=63), which included climate change, environmental degradation, and natural disasters.

Clusters of studies on relational values

Based on our analysis of specific study characteristics (whose values were elicited, methods used, biophysical

aspects, and ecosystems studied in), we found four clusters of research on relational values (Table 2, Figure 2). Cluster 1 (29.3%, n= 110), named “Participatory and qualitative approaches”, was defined by a focus on the relational value of cultural heritage and the production of qualitative social science data often with a participatory approach, and often in lagoons and estuaries (Table 2, Figure 2). Cluster 2 (24.8%) was named “Indigenous and local ecological knowledges held by fishers and gatherers” as it was linked to the relational values of Indigenous and local ecological knowledges (and related concepts such as traditional/environmental knowledges) of artisanal fishers and gatherers. Instead of being defined by specific research methods or data types, this cluster was linked to the explicit inclusion of Indigenous and local knowledges and aspects of biodiversity (e.g., species assemblages or links to specific fish, invertebrates, or marine mammals) and marine resources (e.g., ecosystem services, fishing, and marine conservation). Cluster 3 (26.1%), named “Ecological and environmental change”, was determined by relational values of social relations and identity. The relational values were often elicited from residents and community members through the use of anthropological and ethnographic methods. The relational values were linked to aspects of ecological and environmental change (such as climate change, disasters, coastal erosion, or degradation) and terrestrial aspects of coastal systems (such as farming, forestry, or land-cover). Cluster 4 (19.7%), named “Recreation and quantitative data”, was characterised by studies eliciting a variety of relational values, such as recreation and enjoyment, aesthetics, and inspiration or stewardship. Research in this cluster was based on quantitative empirical social research methods, including economic approaches, often elicited from coastal users (such as tourists) and carried out in the ecosystems of sandy beaches and coral reefs. The object of value were whole ecosystems and nature in general (such as mentioning nature, scenery, or seascapes).

Benefits and challenges of researching relational values

The most commonly noted benefit of studying relational values was the complementarity between scientific and Indigenous and local ecological knowledge (54.4%, n=204 of all 375 papers). Researchers also noted benefits for a more inclusive, informed government and management (35.5%, n=133) and advantages for the local economy and livelihoods (23.7%, n=89) (Table A2). Yet, research on relational values also involved challenges. The most commonly mentioned challenges in working with relational values were external influences, which challenged, eroded, or changed local values. These influences came from globalisation, development, and market pressure (22.9%, n= 86), and multi-scale environmental threats (13.3%, n=50), such as environmental hazards or ecological degradation. Another challenge often named was the difficulty of cross-cultural work to elicit locally explicit relational values (10.1%, n=38).

Our tripartite network shows the linkages, and strength thereof, between mentioned benefits and challenges in relation to the people whose values were elicited (Figure 3). The line thickness in figure 3 is proportional to the number of articles involved in each link. These thicknesses convey a suite of interesting relationships.

For instance, the connection between farmers, residents, and community members and the experienced challenge of the impact of multi-scale environmental threats is most prevalent in the reviewed articles. Further, research revealing relational values of artisanal fishers and gatherers was often linked to the complement ecological knowledge as well as to the support of local governance and management processes (Figure 3). Interestingly, we did not find connections between Indigenous and aboriginal peoples and complementing ecological knowledge.

DISCUSSION

Here we discuss (i) the most prevalent relational value categories in past research, (ii) the necessity to bridge dispersed research approaches, and (iii) the possible negative impact of globalisation, market pressure, and ecological degradation on relational values. Based on these specific findings, we highlight our general lessons learned from the research articles. These lessons are centred on conceptual and methodological aspects.

Prevalent relational values in past research

The vast majority of relational values in coastal ecosystems in the Global South fell within the category of "Indigenous and local ecological knowledges" (71.2%, Table 1), which includes the knowledge from Indigenous peoples and local communities (i.e., traditional and Indigenous knowledge [Berkes et al. 2000, Mazzocchi 2006], local knowledge [Olsson and Folke 2001], local ecological knowledge [Crona 2006], and fishers' or farmers' knowledge [Leite and Gasalla 2013]). The coding of this category was nuanced and broad, as the rationale is that traditional knowledge systems are almost always multifaceted: they often involve an intertwined mix of knowledges, practices, and values (Berkes 2017). The importance of Indigenous and local ecological knowledge as a virtue of a human-nature relationship in the assessed research articles thus likely stems from the myriad interlinkages to other relational values and institutions (e.g., norms, management approaches) (Sheremata 2018). Scholars have noted that Indigenous and local ecological knowledges have great potential to inform governance and management processes (Pellowe and Leslie 2021) as well as to complement existing scientific knowledge (Aswani and Lauer 2006, Silvano et al. 2006) (Figure 3). This suggests the importance of continuing to understand Indigenous and local knowledge, through relational values and other frames.

The second-most commonly named category of relational values was "social relations" (22.9%, Table 1). This category had many sub-categories and reflects human-human connections mediated through nature (Chan et al. 2016). Within this category, the most common sub-categories were sense of community and social memory. The sense of community could be strengthened through locally specific work with nature (Fröcklin et al. 2018) or through acknowledging traditions and local ecological knowledges (Outeiro et al. 2015). Another sub-category, valuing social memory, explicitly connects identity (social, collective,

or individual) and historical memory of a land-/seascape (often mediated through traditional practices and cultural heritage). In many of the assessed articles, this value category was linked to environmental and cultural changes (Gordon et al. 2003) caused by, for example, globalisation (Lauer and Aswani 2010).

Bridging dispersed research approaches on relational values

Our results showed that research that explicitly used transdisciplinary methods was scarce (6.9%, n=29). Additionally, our results highlighted a rather distinct subdivision of research approaches in eliciting relational values based on research methods and disciplinary fields. While about a third of the studies had a mixed-method approach, our cluster analysis highlighted methods-based distinctions. As an example, cluster 1 (participatory and qualitative approaches) showed a strong use of methods (primarily interviews) that produce qualitative data; cluster 3 (ecological and environmental change) highlighted anthropological and ethnographic approaches and cluster 4 (recreation and quantitative data) mainly applied social science research methods producing quantitative data done with surveys and questionnaires. In addition, clusters differed also by which and how many relational values were assessed. Cluster 1 used social science research methods to analyse mainly cultural heritage, cluster 2 studied Indigenous and local knowledges, whereas cluster 3 primarily assessed social relations and identity. Cluster 4, in contrast, analysed a broader range of relational values through surveys and questionnaires. Instead of reinforcing disciplinary methodological boundaries, we deem it important to combine a multitude of research methods, drawing on different disciplines and data types to capture and elicit a comprehensive set of relational values (Gould 2021).

To further the concept of relational values and to gain a more comprehensive understanding of the role they play in social-ecological systems, a broad range of different relational values should be assessed (Klain et al. 2017, Chapman et al. 2019, Mattijssen et al. 2020). Collaborations, both between disciplines and with non-academic actors who hold Indigenous and local knowledge will greatly facilitate this broader approach. As one example of what can be learned from working with non-academic actors, the IPBES Regional Assessment of Europe and Central Asia found interlinkages between the relational values of identity, security, and stewardship in narratives of Indigenous peoples and local communities (Schröter et al. 2020). Moreover, progress on relational values within the field of transformations and social-ecological research (Horcea-Milcu et al. 2019, Scoones et al. 2020) has the potential to inherently promote interdisciplinary research and unravel the relevance of relational values to foster sustainability transformation (Riechers et al. 2021b). To advance the field of relational values, future research should focus on multiple relational value categories, and their synergies and trade-offs as expressed by individuals but also between social groups.

Globalisation, market pressure, and ecological degradation affect relational values

This review shows that global environmental change can impact relational values. In our review, 16.8% of the relational values were negatively affected by the biophysical aspects of climate change, ecological degradation, or environmental changes in general and them (Marikandia 2001, Wiederkehr et al. 2019, Ratter et al. 2019). Additionally, globalisation, development, and market pressure as well as multi-level environmental threats were the most prevalent challenges regarding research on relational values in coastal and marine ecosystems of the Global South. Indeed, research on relational values, especially in the Global South, shows that the adherence to Global North development paradigms (Dacks et al. 2018) and the power dynamics inherent of a Western conservation ethic (Berkes 2004, Almudi and Kalikoski 2010) can endanger some relational values (Topp et al. 2021).

Global environmental change that leads to land-use management intensity can negatively impact inhabitants' sense of place and simultaneously foster contrasting ideologies that can diminish social cohesion and social relations (Riechers et al. 2020). Rapid simplification of ecosystems, in particular, can weaken or change certain relational values and, in turn, lead to starkly contrasting value priorities between groups (Okunoye 2008, Riechers et al. 2021b), which can possibly lead to social conflicts (Chapman et al. 2019, Topp et al. 2021). For example, resource scarcity can negatively affect social relations of small-scale fishers: scarcity hampers information-sharing on responses to resource fluctuations or uncertainties, which can lead to the erosion of relational values related to social capital (Ramirez-Sanchez and Pinkerton 2009). Yet, more research is needed to understand how land-use intensification may impact different relational values, in particular those related to social cohesion, cultural identity, and heritage. It is also interesting to consider whether intensification will lead to formation of new relational values, and whether those new values will be more or less sustainability-aligned than previous values (Hoelle et al. 2022). This is of special relevance in coastal ecosystems of the Global South, where global environmental change disproportionally impacts biodiversity and people's quality of life (IPBES 2019, IPCC 2019).

The global decline of Indigenous and local ecological knowledges is also intertwined with trends toward ecosystem simplification. The decline is mainly attributed to (i) the transition from subsistence-oriented economies to a market-oriented economy, (ii) changes in culture by which younger generations consider traditional practices as a symbol of poverty, (iii) rural abandonment, and (iv) land grabbing (Schröter et al. 2020) - all trends that often intersect with the intensification of land-use for commercial purposes. When Indigenous peoples and local communities are displaced from their customary territories, it jeopardises knowledge acquired through their relation with the land-/seascape and also other relational values such as sense of place, identity, heritage, and stewardship (Gordon et al. 2003, Dixon and Durrheim 2004, Sheremata 2018, Gladkikh et al. 2019). In addition, the loss of Indigenous and local ecological knowledges can lead to shifting baselines (Soga and Gaston 2018), which gradually increase tolerance for environmental degradation. That is, ongoing environmental degradation can change people's perception of desirable states and thus influence further management and conservation efforts (Papworth et al. 2009, Soga and

Gaston 2018) and impact local strategies of adaptation and resilience (IPBES 2019).

Knowing and strengthening people's pro-sustainability relational values, and more broadly human-nature and human-human connections (mediated through nature), may halt the current global environmental crisis (Nisbet et al. 2009, Folke et al. 2011). Articles in our review often stated that working with relational values can benefit governance and management of resources as well as strengthen partnerships and collaboration within and between communities, especially when including artisanal fishers and gatherers (see line thickness in Figure 3). Further, a strong sense of community as a virtue of a human-nature relationship could foster ecological restoration (Trialfhianty and Suadi 2017, Hein et al. 2019) and highlight power dynamics in land-use changes (Gasalla and Gandini 2016) and risk assessment (Hak et al. 2016).

That being said, two aspects of relational values need to be further considered: the fluid nature of relational values and the connections between relational values and sustainability-supportive behaviour. More research is needed to understand how relational values may change or possibly erode in response to globalisation, market pressure, and ecological degradation. Further, relational values may be transformed, both intentionally and unintentionally. Intentional environmental education efforts can change values that are, like those in our review, closely related to relational values (Britto dos Santos and Gould 2018). Relational values can also change along with shifting economic practices, political paradigms, or landscapes (Balázsi et al. 2019).

Moreover, relational values are not necessarily linked with sustainable or pro-environmental behaviour (Hoelle et al. 2022). Strong relational values may be used to argue for the maintenance of unsustainable practices due to claims of values for tradition, heritage, or continuity (Chapman et al. 2019, Hoelle et al. 2022). Relational values of stewardship or social responsibility may be used to support conservation actions and policies that could disenfranchise others who use and value nature differently (Sowman and Sunde 2018, Klain et al. 2018, Bennett et al. 2020). One example is marine protected areas that allow access for touristic purposes, including fishing, but not for local, often subsistence, uses (Lopes et al. 2017, Lopes and Villasante 2018, Bennett and Dearden 2018). Hence, relational values may or may not be associated with sustainable action, and we encourage future research to explore these interactions with ample attention to the local context (Hoelle et al. 2022).

Important considerations for empirical research

In our analysis of 375 articles, of which 350 were empirical studies, we noted several challenges that emerge when empirically working with relational values and related concepts. These challenges are based on study authors' own observations as stated in the reviewed articles, as well as our own discussions during the coding process. Here, we build on these challenges to highlight important considerations for future relational values research. These considerations centre on conceptual concerns (what are relational

values?) and methods (how to assess them?). In Box 1, we distill these considerations into recommendations for future research on relational values.

Relational values vs. structures and institutions

In our effort to determine if research was using what we today classify as relational values, we noticed the importance of distinguishing what relational values are not. In particular, we determined that social structures or other informal institutions are not relational values, though they are connected and could be conflated. Social structures and institutions are complex and multifaceted. They are interlinked with behaviours, practices, and values—these phenomena all shape and create each other (Mattijssen et al. 2020). A study in Zanzibar, for example, found that institutions that regulate small-scale fisheries and seaweed farming affect social cohesion (de la Torre-Castro & Lindström 2010). In future research, it will likely be helpful to draw differences between social structures and institutions that enable, support, or manifest relational values but are not relational values in themselves. These distinctions can be nuanced, as the same term may refer to different things: for example, the term "cultural heritage" can relate to buildings, traditions, norms, or relational values. Physical structures (e.g., traditional edifices or religious buildings) or informal institutions (e.g., traditions or norms) are not relational values, but may enable relational values.

Relational values vs. emotions

The same logic applies to links between emotions and relational values. Especially, when ecological degradation, biodiversity loss, or rapid change is part of the study, findings might highlight the feelings of loss, pain, and nostalgia (Riechers et al. 2019). Emotions - positive and negative - can indicate the existence of relational values and are strongly connected to them, but are not values themselves. A strong emotional attachment to nature could be further analysed to disentangle what relational value(s) might foster such emotional connections (Perkins 2010). Further, negative emotions such as expressed hurt, anger, loss, frustration, or pain, among others, might indicate a recent degradation of a social-ecological system due to, for example, ecological and environmental change. Here it also might be worthwhile to try to decipher when missing or changed relational values may cause these emotional responses. We emphasise that the lines between emotions and relational values may be quite imprecise (and possibly discipline-dependent) and see this topic as important for further exploration, especially concerning interdisciplinary understandings of both emotions and values (Hagen and Gould 2022).

Dynamism of relational values and their impact on human well-being

Individual and shared relational values can change due to ecological change or human migration, and these changes can impact human-well-being. First, many coastal ecosystems are changing rapidly, and this dynamism has at least two important effects associated with relational values. First, coastal degradation causes

many relational values to erode because biophysical aspects to which the relational value is linked are degrading or missing (Riechers et al. 2020). Second, erosion of relational values can decrease human well-being, as the loss of something that is valued has a negative impact (Ross et al. 2018). As an example, research on coastal degradation can detect a feeling of alienation by inhabitants, which may have replaced their relational values of sense of place (e.g., Okunoye 2008). Second, human migration can dramatically change relational values. Migration, both forced and voluntary, and both climate-related and otherwise, is likely to rise in the coming decades (IPBES 2019). This migration may lead to lost relational values, as people leave familiar landscapes and endure the trauma of change (Gordon et al. 2003). Migration may also, however, create new relational values (Gladkikh et al. 2019). These complex dynamics are ripe for future research.

Quantifying relational values and their loss

Another aspect that needs further research is the quantification of relational values and the loss thereof. To date no generally accepted quantitative relational value scale exists. Related research from multiple fields, however, suggests that understanding relational values with quantitative data is well within the realm of possibility (Schulz and Martin-Ortega 2018). Examples of scales with similar framing include nature-relatedness, connectedness to nature, and love and care for nature (Mayer and Frantz 2004, Nisbet et al. 2009, Perrin and Benassi 2009, Perkins 2010). Measuring relational values with quantitative data presents multiple important challenges. One is the underlying assumption that all respondents have the same understanding of the questionnaire items. For relational values, this might be difficult - especially across social groups, cultures, or those whom environmental change affects differently by. We do not see this challenge as insurmountable - research, however, needs to clarify what exactly was asked, and address multiple possible interpretations (e.g., rather than reporting only that spirituality is important, report exactly the language used to attempt to assess spirituality and what it likely meant in the study context). A related second challenge is that it may be difficult to parse relational values into separate distinct units, given that suites of relational values (and closely related concepts such as cultural ecosystem services) are often connected in complex ways (Klain et al. 2014, Gould et al. 2015). A third challenge is that the lack of relational values - i.e., “losing something” - may need to be assessed differently than “intact” values. Research suggests that this approach of asking about what is lost, in a hypothetical case in which an ecosystem or access to it changes, is an effective way to understand relational values that can be so ingrained in life as to be otherwise difficult to articulate. Understanding how questions about loss interact with actual biophysical change and consequent changing values, and determining how these phenomena may be assessed quantitatively, is a promising area for future research (Gould and Schultz 2021).

Conceptual and empirical clarity

Further, it is important to highlight that values, valued objects, benefits, and actions are often closely connected and can be difficult to disentangle (Schulz and Martin-Ortega 2018). “Recreation” provides an obvious and well-studied example. Many studies include recreation as a relational value, but it can also be considered a valued object (e.g. I value recreation in nature), a benefit that nature provides, or an action that allows the fulfilment of values (see a similar discussion around recreation as landscape value [Biedenweg et al. 2019] or as ecosystem service [Satz et al. 2013, Gould et al. 2015]). Concepts that confront similar complexity include “Well-being” and “Cultural” and “Symbolic” values. This complexity highlights that researchers needs to be clear about why and how focal topics are relational values.

Box 1:**Three recommendations for further research on relational values**

1. Specificity regarding relational values and the biophysical aspects to which they are linked

With a broad concept such as relational values, it is important to be conceptually explicit about what relational values are and which and whose relational values are being researched. Equally important is to specify to which biophysical aspects (element, structure, process of nature) the relational value is linked (Chan et al. 2018, Gould et al. 2020) in a way that can inform management. This broadens the approach to include those who need to change places (e.g. refugees, migrants or victims of segregation [Gordon et al. 2003, Dixon and Durrheim 2004, Gladkikh et al. 2019] or whose places are changing [Sheremata 2018]). This information can assist interdisciplinary work between social and natural scientists and enable a clearer formulation of environmental conservation measures with practitioners.

1. Use of transdisciplinary and participatory approaches

Transdisciplinary and participatory approaches can co-create new insights on relational values for research and practice through collaboration with diverse practitioners and researchers from different disciplines (Lang et al. 2012). Most of the research studies assessed did not explicitly acknowledge transdisciplinary and participatory approaches. Yet the few transdisciplinary and participatory studies we analysed make clear that these approaches can generate additional insights on how relational values can be understood and strengthened, and how they can be applied in conservation management and policy making. Especially if conducted in tandem with Indigenous peoples and local communities, such research can enhance social learning processes, empower actors and legitimise their knowledges or practices. Transdisciplinary approaches

are particularly likely to foster arts- and design-based approaches (Muhr 2020, Raatikainen et al. 2020), the assessment of poetry (Okunoye 2008), and other creative approaches, which may emphasise a different set of relational values and their connections to nature (Gould 2021).

1. Strengthening relational values for sustainability transformation

Relational values research has the potential to contribute to sustainability transformations. First, relational values may be linked to pro-environmental attitudes and behaviour and may influence policy interventions that aim to strengthen biodiversity and support citizens' contributions to environmental/biodiversity conservation (Mattijssen et al. 2020). Strengthening certain relational values might foster sustainability, so transforming social-ecological systems to allow pro-sustainability relational values to flourish might be a valuable goal for sustainability scientists (Folke et al. 2011, Abson et al. 2017). Second, eliciting how different relational values are interlinked and how they interact could help to find important nodes (i.e., relational values that are connected to many other relational values and could have synergising effects when strengthened). These nodes might act as enhancers and create stronger relational values overall through ripple effects in the value system.

CONCLUDING REMARKS

With the IPBES value assessment approved in July 2022 (IPBES 2022), understanding and operationalising relational values - in contrast to instrumental and intrinsic ones - will become increasingly crucial. Our paper presents a comprehensive systematic literature review of concepts related to relational values from coastal ecosystems of the Global South. We show how research over the last 20 years has used concepts closely related to relational values even before the term was widely in use in environmental spheres. Our lessons learned for empirical research are (i) specificity regarding relational values and the biophysical aspects to which they are linked, (ii) the use of transdisciplinary and participatory approaches for value assessment, and (iii) strengthening pro-sustainability relational values to foster sustainability transformation. With this article, we hope to contribute to strengthening empirical research on relational values across disciplines.

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Table 1. Overview of the relational values categories as resulted from the qualitative content analysis of N= 375 articles. The table shows the main category of relational values, their sub-categories (if existing) and the amount of articles in which these categories and sub-categories were mentioned (with the percentage of all papers N = 375).

Value category	**No. of papers (% of all N=375)**	**Values sub-category**	**No. of papers (% of all N=375)**
Indigenous/local ecological knowledge	*267 (71.2%)*		
Social relations	*86 (22.9%)*		
		Sense of community	23 (6.1%)
		Social cohesion	20 (5.3%)
		Social relations	18 (4.8%)
		Social memory	11 (2.9%)
		Kinship	6 (1.6%)
		Bequest	4 (1.1%)
		Sense of belonging	2 (0.5%)
		Conviviality	1 (0.3%)
		Reciprocity	1 (0.3%)
Recreation & enjoyment	*74 (19.7%)*		
		Recreation	65 (17.3%)
		Enjoyment	6 (1.6%)
		Nature-based tourism	3 (0.8%)
Identity	*70 (18.7%)*		
		Cultural identity	38 (10.1%)
		Individual identity	21 (5.6%)
		Social and collective identity	8 (2.1%)
		Social learning	3 (0.8%)

(con'd)

Stewardship	*68 (18.1%)*		
		Stewardship values	49 (6.1%)
		Social responsibility	13 (6.1%)
		Ethical values	4 (6.1%)
		Values of respect	2 (6.1%)
Culture & heritage	*62 (16.5%)*		
		Heritage values	27 (7.2%)
		Customary law	18 (4.8%)
		Traditional values	13 (3.5%)
		Cultural continuity	4 (1.1%)
Spiritual	*62 (16.5%)*		
		Spiritual values	49 (13.1%)
		Sacred values	7 (1.9%)
		Religious values	6 (1.6%)
Aesthetic & inspiration	*37 (9.9%)*		
		Aesthetic values	35 (9.3%)
		Inspirational values	2 (0.5%)
Sense of place	*36 (9.6%)*		
		Sense of place	25 (6.7%)
		Connectedness	11 (2.9%)
Empowerment & autonomy	*17 (4.5%)*		
		Security	12 (3.2%)
		Sense of agency	4 (1.1%)
		Social entrepreneurship	1 (0.3%)
Environmental awareness	*10 (2.7%)*		
Educational	*7 (1.9%)*		
Psychological	*6 (1.6%)*		
		Value of quietness	4 (1.1%)
		Therapeutic values	2 (0.5%)

(con'd)

Well-being	*3 (0.8%)*

Table 2. Results of the cluster analysis and the cluster's determining variables. Cramer's V shows the strength of the relationship in parenthesis. All coefficients shown are significant at p

	Cluster 1: Participatory & qualitative approaches n=110 (29.3%)	**Cluster 2: ILK held by fishers & gatherers** n=93 (24.8%))	**Cluster 3: Ecological & environmental change** n=98 (26.1%)	**Cluster 4: Recreation & quantitative data** n=74 (19.7%)
Relational values	Cultural & heritage (.24)	Indigenous/local ecological knowledges (.54)	Social relations (.32) Identity (.25)	Recreation and enjoyment (.59) Aesthetic & Inspiration (.50) Stewardship (.38) Educational (.23) Environmental awareness (.22)
People whose values were elicited		Artisanal fishers & gatherers (.48)	Residents and community members (.51)	Costal users (.53) other local experts (.19)
Methods used	Group discussions and workshops (.33) Single person interviews (.27) Participatory mapping (.25) Participatory approaches (.23)	Inclusion of ILK (.61)	Anthropological and ethnographical methods (.22)	Quantitative empirical social research methods (.23) Economic approaches (.20)
Biophysical objects of value (.45)		Biodiversity, Marine resources	Terrestrial, Ecological change	Ecosystems, Geodiversity
Ecosystem studied	Lagoons (.35) Estuaries (.22)	General (.55)		Beaches (.39) Coral reefs (.30)

(con'd)

Fig. 1. Descriptive proportion of selected variables indicating geographical, ecological and methods-related characteristics of the research on relational values in coastal and marine ecosystems in the Global South based on the qualitative content analysis of 375 articles.

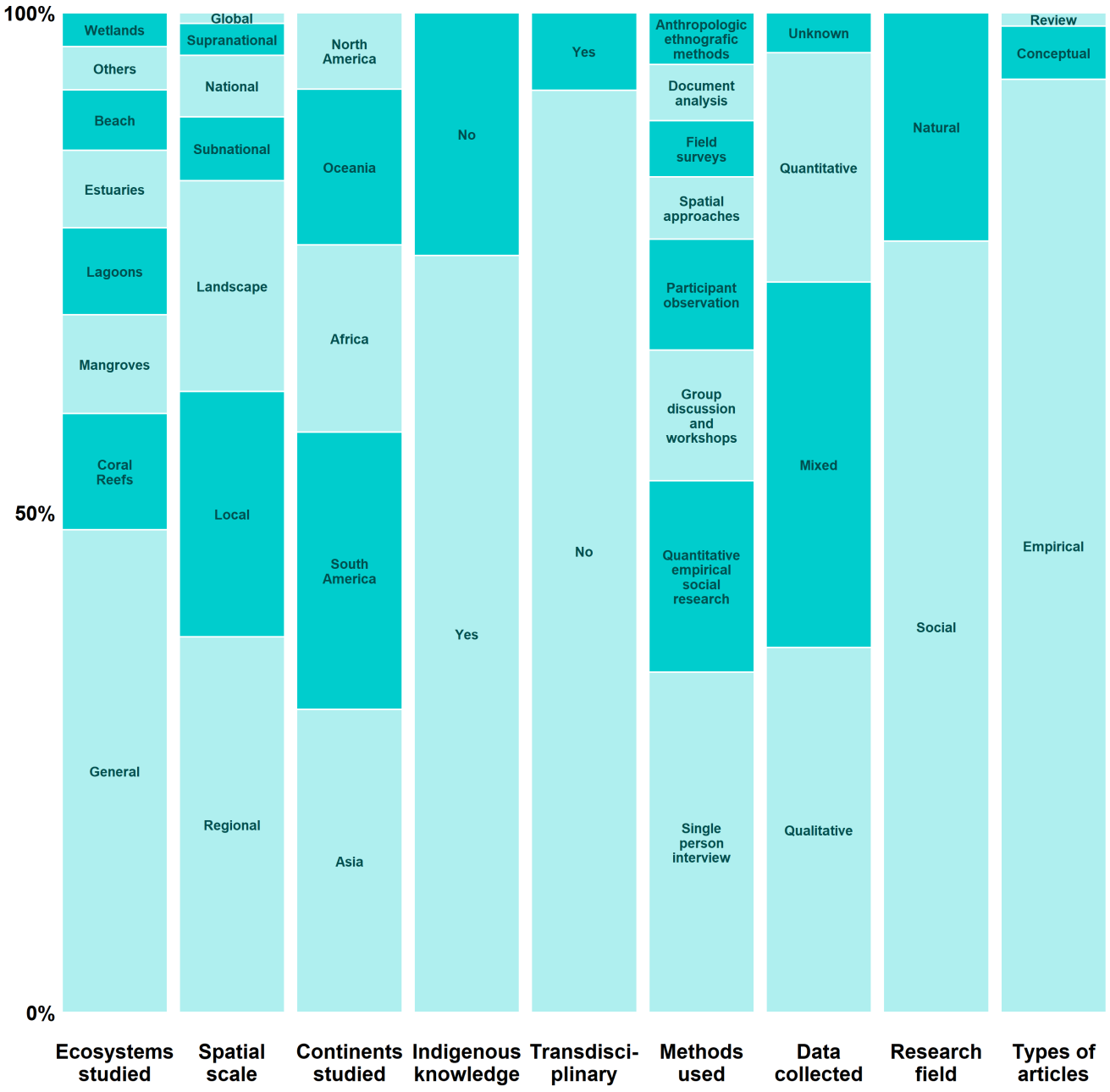


Fig. 2. Tripartite network showing the number of articles (N=375) linking each node of "challenge" (left, red dots) and "benefit" (right, blue dots) of studying relational values to the groups of people whose values were elicited (middle, yellow dots). Line thickness is proportional to the number of articles involved in each link. Only the five most often named challenges and benefits and the ten most often named value-holders are included to increase graphical simplification. The spacing between the nodes is used for readability and has no statistical meaning.

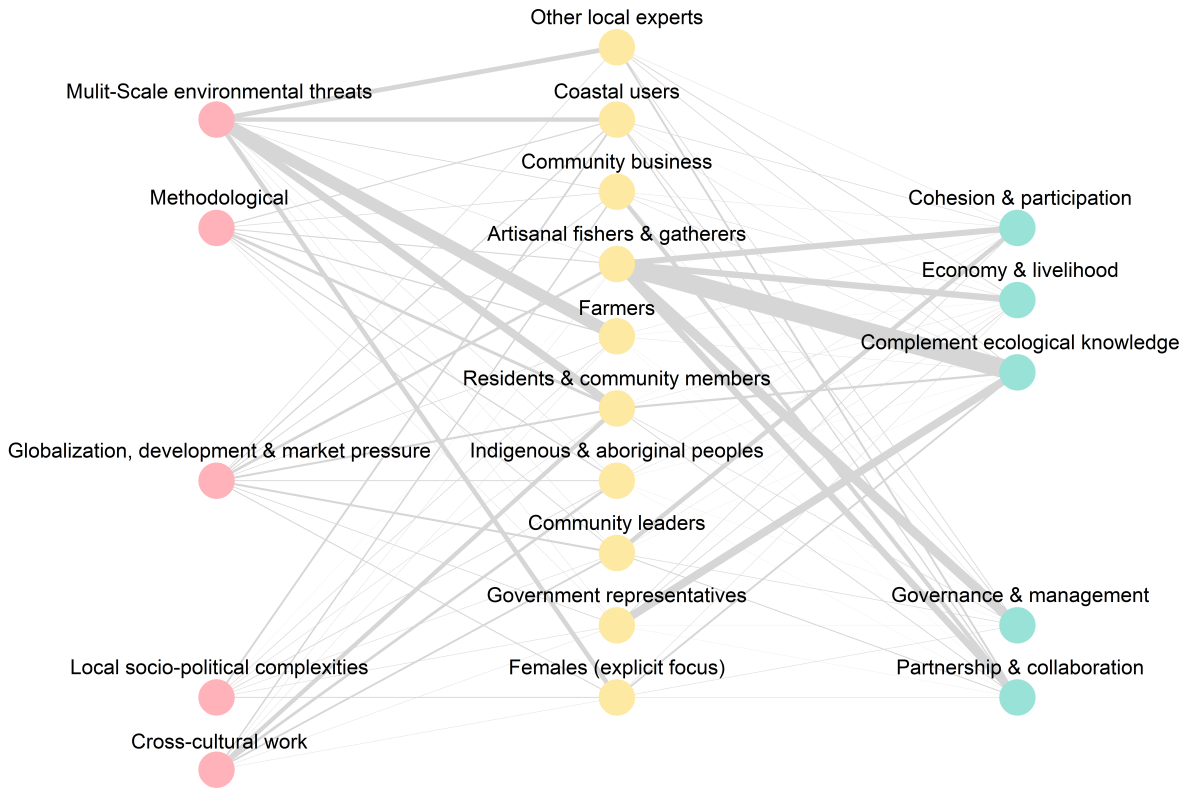
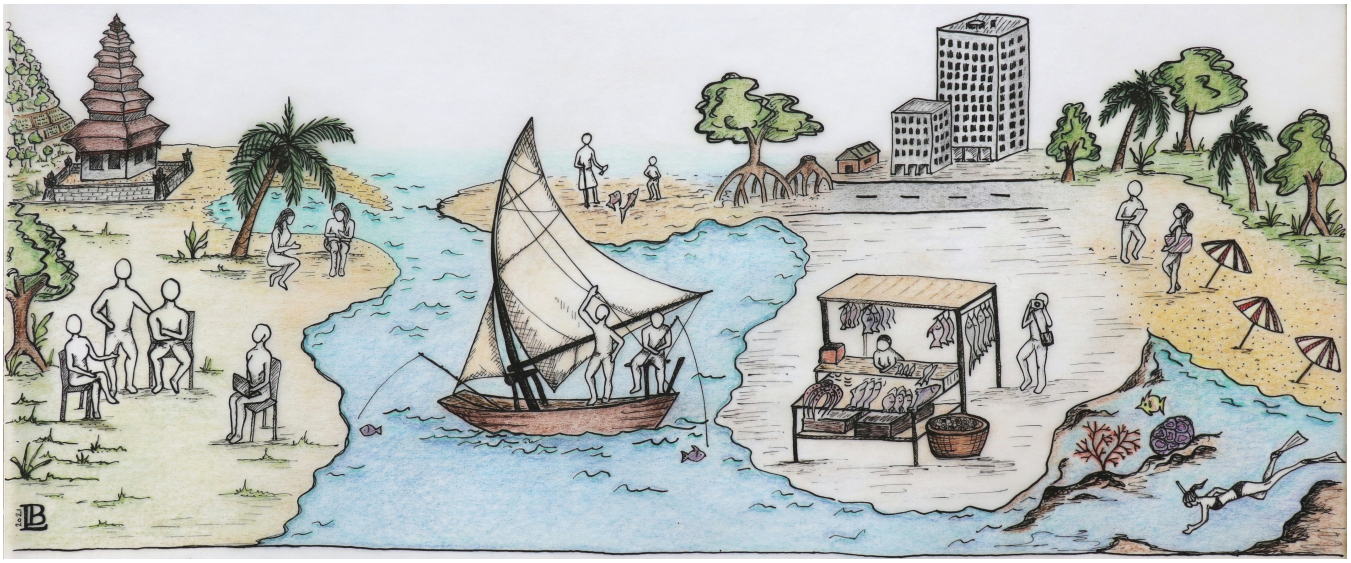


Fig. 3. Representation of the four clusters based on Table 2.



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RESEARCH ARTICLE

PEOPLE AND NATURE | BRITISH ECOLOGICAL SOCIETY

Understanding relational values in cultural landscapes in Romania and Germany

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Abstract

1. Relational values recently emerged as a concept to comprehensively understand and communicate the many values of nature. Relational values can be defined as preferences and principles about human–nature relationships and focus both on human–nature connections and well as human–human connections.
2. Here, drawing on 819 face-to-face questionnaires, we analysed relational, intrinsic and instrumental values across a total of six agricultural landscapes in Transylvania (Romania) and Lower Saxony (Germany). The landscapes described a gradient of land use intensity, within and across the countries.
3. Our results suggest a bundling of values into four groups: those concerned with individual cognition (including intrinsic values), those that focus on nature as a place for social interaction and relaxation, those that capture cultural identity and spiritual values and one bundle that only includes instrumental values.
4. These different values, in turn, were strongly related to (a) respondents' attitudes towards environmental conservation and the (b) frequency with which respondents used nature as a resource.
5. Instrumental values have the tendency to be inversely related to relational values and were found to increase with the land use intensity of the focal landscapes.

KEYWORDS

agricultural intensification, human–nature connections, land use change, leverage points, place attachment, sustainability

1 | INTRODUCTION

In environmental conservation, academics and practitioners articulate a wide range of values to convey attributes of nature to decision-makers. The diversity regarding theoretical conceptualisations related to values is high (Horcea-Milcu et al., 2019)—from individual, shared or social values to monetary values, or held and assigned values, as well as intrinsic or instrumental values (Dietz et al., 2005; Kenter et al., 2015; Rawluk et al., 2018). One debate stemming from this diversity is between the acknowledgement of intrinsic and instrumental values (Tallis & Lubchenco, 2014). To bridge intrinsic and instrumental values of nature, a new framing has emerged—relational values (Muraca, 2011). Relational values can be defined as preferences and principles about human–nature relationships (Chan

et al., 2016) and add to the vast body of research into related concepts such as sense of place (Brehm et al., 2013; Trentelman, 2009) or landscape (Barthel et al., 2013; ESF, 2010). This novel framing emphasises the relationships between people and nature, as well as environmentally mediated social relationships (Chan et al., 2016) and ways of living a meaningful, ethically responsible and satisfying life (Himes & Muraca, 2018).

The concept of relational values has facilitated growing recognition that landscape change influences human–nature relationships as well as human–human relationships (Chan et al., 2016; Sheremata, 2018). Rapid and intensive land use change, in particular, may be associated with the erosion of both types of relationships (Riechers et al., 2020). Focusing on the interlinked social–ecological dimensions of landscape change, in turn, could help to combat inequality regarding access to nature and its benefits (Berbés-Blázquez et al., 2016; Scoones et al., 2020), could counteract disconnection from nature (Miller, 2005; Pyle, 2003) and may also foster conservation and restoration initiatives (Bremer et al., 2018; Skubel et al., 2019).

Despite the relevance of relational values for guiding policy-making and management towards a more sustainable world (Chan et al., 2018; Sala & Torchio, 2019), empirical research into relational values remains scarce (with few notable exceptions Arias-Arévalo et al., 2017; Chapman et al., 2019; Klain et al., 2017). Especially cross-country quantitative comparisons to examine influencing factors and bundles of relational values are called for (Schulz & Martin-Ortega, 2018), but missing. To fill this gap, we studied six different agricultural landscapes spanning a land use intensity gradient in Transylvania (Romania) and Lower Saxony (Germany; Figure A1). We used a face-to-face questionnaire and surveyed the values of 819 respondents across 52 villages. Based on prior qualitative research (Balázsi et al., 2019; Riechers et al., 2019, 2020) and existing literature (Table 1), we sought to quantitatively (a) understand the perceived importance of various relational values—and their attributes—in contrast to intrinsic and instrumental values (see Table 1 for a list of the value categories and used questionnaire items; Arias-Arévalo et al., 2017; Himes & Muraca, 2018); (b) scrutinise how different landscape types—from less intensively to intensively used—might influence relational values (Riechers, Balázsi,

TABLE 1 Descriptions of value categories (relational, intrinsic and instrumental), questionnaire items constituting the respective values (assessed on a 6-point Likert scale) and related references

Value categories	Descriptions and questionnaire items	References
Aesthetic	Recognising the beauty of nature - I think nature is beautiful	Arias-Arévalo et al. (2017); Cooper et al. (2016); Himes and Muraca (2018)
Care	Feeling of concern or love for aspects in nature, that matter to someone - It makes me angry that humans treat nature so carelessly - I fear that for our children and grandchildren there won't be much unimpaired nature left	Britto dos Santos and Gould (2018); Jax et al. (2018); Klain et al. (2017)
Cultural identity	Identity of local culture linked to nature - Our landscape is a big part of our culture	Chan et al. (2016)
Concern for nature	Awareness and concern linked to the natural environment - I am very aware of environmental issues - I think a lot about how my behaviour affects the environment	Topp et al. (2021)
Individual identity	Personal identity linked to nature - I feel connected to all living things on earth - I think a lot about how much animals have to suffer because of humans - I am not separate from nature, but a part of it - Even if I am in a big city, I notice the nature around me	Chan et al. (2016); Klain et al. (2017); Nisbet et al. (2009)
Recreation	Nature used for passive and active leisure - In nature, I can relax and recover - I like to move outside and do sports	Arias-Arévalo et al. (2017); Chan et al. (2018)
Sense of place	Attachment to a landscape or certain places - Nature helps me to feel home - I have many memories with the landscape here	Stenseke (2018); West et al. (2018)
Spiritual	Mystical or religious feelings stemming from nature - In nature, I have the feeling there exists something mightier than me	De Vos et al. (2018); Nisbet et al. (2009)
Social relations	People connect with each other while being in nature - I like to meet people in nature or visit events	Britto dos Santos and Gould, (2018); De Vos et al. (2018); Klain et al. (2017)
Intrinsic	The value of nature is as ends to itself - All animals and plants have a right to live	Arias-Arévalo et al. (2017); Chan et al. (2018)
Instrumental	The relationship between human and nature is a means to an end - We humans have the right to use nature as we like - Using nature as resource for industry and economy is more important than nature conservation	Arias-Arévalo et al. (2017); Chan et al. (2018)

Betz, et al., 2020); and lastly (c) examine how aspects such as socio-demographics, use of products from nature and attitudes towards conservation might influence relational values.

2 | METHODS

2.1 | Focal landscapes

We compared a land use intensity gradient of three landscapes in Transylvania, Romania (Rupea area, Șoarș and Jibert Communes in Brașov County; Turda area, Mihai Viteazu and Moldovenești Communes in Cluj County; and Baraolt area, Brăduț Commune in Covasna County) and three in Lower Saxony, Germany (Bispingen, district Heidekreis; Bakum, district Vechta; and Dornum, district Aurich; Figure A1). In all six focal landscapes, prior research facilitated the contextualisation of the study and the data collection process. Results from the six focal landscapes were compiled to show overall influencing factors and bundles of values (relational, intrinsic and instrumental) across the countries.

The area of Baraolt is a smallholder-dominated cultural landscape with large patches of forests, grasslands and abundant wildlife. Driven by socio-economic and institutional change, land abandonment and intensification have increased, yet changes have been slow in Baraolt to date. The landscape in Turda is flat, crop-dominated and subject to strong urban influences due to its proximity to the cities of Cluj-Napoca and Turda, Câmpia Turzii and Aiud. Following Romania's accession to the EU in 2007, land use intensity has increased and smallholder vegetable cultivation has been increasingly replaced by industrial croplands. The area of Rupea is also a smallholder-dominated cultural landscape with croplands close to villages, while large areas of high natural value farmlands remain in the remote areas. In Rupea, due to socio-political influences during socialism (1947–1989), the local Saxon community emigrated and the area was repopulated by Roma and Romanian citizens.

The landscape in Bispingen (district Heidekreis) is located in the east of Lower Saxony and partly inside the Lueneburger heath nature park (protected under Germany's federal nature conservation act). This has slowed down the landscape change because of restrictions to agricultural intensification and large-scale infrastructure projects. The landscape in Bakum (district Vechta), located in the mid-west of Lower Saxony, has changed substantially over the last 20 years due to agricultural intensification. The region is known for the highest density mass husbandry in Germany (so called 'Pig belt'). Dornum lies in the north-east of Lower Saxony (district Aurich) in the landscape region of Eastern Frisia and is a coastal landscape at the North Sea. The landscape of Dornum is flat, dominated by often intensively used grasslands and a relatively high amount of wind parks to generate renewable energy.

2.2 | Data collection

Preparation for our quantitative survey included extensive theoretical and literature studies on relational values and human–nature relationships. Building upon prior empirical work in the region (see e.g. Balázsi et al., 2019; Hartel et al., 2016; Riechers et al., 2019), the questionnaire development included two focus groups with laypersons to improve structure and wording of the questionnaire and a pilot study with $n = 20$. The questionnaire contained parts on (a) utilisation of nature (visiting frequency of natural areas in the vicinity from 'daily' to 'never'; distance travelled to these places from 'up to 1 km' to 'over 10 km', use of different natural products such as water, wood, decorative material from 'always' to 'never'); (b) attitudes towards nature and nature conservation (importance from 'very important' to 'not important' of the conservation of specific natural attributes in the landscape); (c) relational, intrinsic and instrumental values; and (d) socio-demographic information (see Supporting Information S2 for the full questionnaire). In our study, we focused on nine relational values that were seen as important from our prior research, instrumental and intrinsic values. An overview of the values used in this paper and their description can be found in Table 1. Data were collected through face-to-face surveys, within randomly chosen villages within the focal landscapes. We used proportionate sampling based on the population density of the villages in the focal landscapes. Within the villages, the streets and households were sampled randomly. Surveys were conducted on various days of the week. After a second unsuccessful try, selected households were marked as dropouts. To decrease the dropout rate, we did not randomly select respondents within a given household. All respondents were asked for an oral consent to participate in this study, as a personal signature was deemed to create discomfort and increase dropout rates, especially in Romania. Data were collected between April and July 2017. This resulted in a total sample size of $n = 819$ across 52 villages (Romania $n = 22$ and Germany $n = 30$). The ethical approval of this research was granted by the Leuphana University.

2.3 | Data analysis

2.3.1 | Exploratory factor analysis

Our relational value data frame had a size of $N = 819$ observations of 18 variables (see Riechers et al., 2021). We imputed missing data with the method of predictive mean matching. Cronbach's α for these variables was 0.83, while Kaiser-Meyer-Olkin's measure of sampling adequacy was 0.93, well above the recommended value of 0.6, and Bartlett's test of sphericity was significant ($\chi^2(153) = 5{,}583.0$, $p < 0.001$). All of these diagnostics suggest reasonable factorability.

We considered three-, four- and five-factor models using oblimin rotation and a minimum residual factoring method. Associated scree plots and fit statistics indicated that the four-factor model was sufficient (RMSEA = 0.071, Tucker–Lewis index = 0.885). The four factors explained 29%, 7%, 5% and 4% of the variance, respectively, for a total of 45%. We refrained from removing items with factor loadings <0.4 because of our sample size of well above 300 (Stevens, 2002, 395). We provide the full loading matrix in Table 3. We created

composite scores for each factor by adding the scores of the items loading onto each factor for subsequent regression analysis.

2.3.2 | Candidate modelling

We modelled the response of the three latent factors to a set of socio-demographic variables using beta regression models (Cribari-Nieto & Zeileis, 2010; Grün et al., 2012) on the latent factor scores that we transformed to the open standard unit interval (0, 1). The transformation applied was the one recommended by Smithson and Verkuilen (2006), so that $y' = (y \times (n - 1) + 0.5)/n$, where y is the data of length n. We based the set of candidate models on grouping explanatory variables into three categories: personal characteristics of the respondent ('P': gender, age), nature-based variables ('N': distance travelled, attitude towards conservation, visiting frequency, frequency of use of natural products) and focal landscape ('L'). We constructed the following set of eight candidate models, which may be seen as our hypotheses regarding what variables might explain the latent factor scores observed: Null, N, P, L, N + P, N + L, L + P and N + P + L. We based model selection on AICc values and used the full average method where model averaging was required (Grueber et al., 2011; Nakagawa & Freckleton, 2011). We conducted our analyses using the R programming language (R Core Team, 2019). We present the coefficients of the best-fitting models for each latent factor in Tables 4 and 5 and in the supplementary Tables A1–A4.

3 | RESULTS

3.1 | Importance of relational values and landscape structure

All relational values and the intrinsic value were somewhat important to the respondents from Romania and Germany, as indicated by the mean score for each relational value being above the midpoint of the response scale (3.0; Table 2). Details on the respondents' socio-demographics can be found in the supplementary material (Box A1). In general, means were higher in Romania than they were in Germany. Respondents generally placed the highest importance on aesthetics (Romania: 6.0 and Germany: 5.7). In Romania, this was followed by the intrinsic value (Romania: 5.9 and Germany: 5.1). In

TABLE 2 Mean response for each questionnaire item for Romania (RO) and Germany (DE) on a 6-point Likert scale, where 1 = least important and 6 = very important

Value category	Questionnaire item	Mean RO	Mean DE
Instrumental	Using nature as resource for industry and economy is more important than nature conservation	2.1	2.5
Instrumental	We humans have the right to use nature as we like	2.4	2.6
Recreation	I like to move outside and do sports	5.1	4.4
Individual identity	I feel connected to all living things on earth	5.3	4.6
Individual identity	I think a lot about how much animals have to suffer because of humans	5.3	4.1
Concern for nature	I think a lot about how my behaviour affects the environment	5.4	4.4
Concern for nature	I am very aware of environmental issues	5.6	4.6
Spiritual	In nature I have the feeling there exists something mightier than me	5.6	4.9
Social relations	I like to meet people in nature or visit events	5.6	4.6
Individual identity	Even if I am in a big city, I notice the nature around me	5.7	4.4
Cultural identity	Our landscape is a big part of our culture	5.7	5.2
Care	I fear that for our children and grandchildren there won't be much unimpaired nature left	5.7	4.0
Individual identity	I am not separate from nature, but a part of it	5.7	5.0
Sense of place	Nature helps me to feel home	5.8	5.0
Care	I am angry about that humans treat nature so carefree	5.8	4.8
Recreation	In nature, I can relax and recover	5.8	5.4
Sense of place	I have many memories with the landscape here	5.8	4.9
Intrinsic	All animals and plants have a right to live	5.9	5.1
Aesthetic	I think nature is beautiful	6.0	5.7

Germany, the value for relaxation was placed second (Romania: 5.8 and Germany: 5.4). The least important values were the instrumental ones with both questionnaire items below 3.0 in Romania and Germany. Because the value for aesthetics was consistently high in all six focal landscapes, we excluded this variable from further analyses.

3.2 | Bundles of relational values

Our exploratory factor analysis resulted in four factors explaining 45% of the total variance in the value categories. Latent factor 1 (29%) comprised all items regarding individual identity, concern for nature, care, as well as one item for sense of place (regarding feeling home in nature) and hence was termed *individual cognition* (the process by which knowledge and understanding is developed in the mind). It also included intrinsic value. We termed latent factor 2 (7%) *nature as a place for social interaction and relaxation*, and it included values related to social relations, recreation and sense of place (having memories in the landscape). Latent factor 3 (5%) embodied *cultural identity and spiritual values*. Latent factor 4 (4%) was concerned only with *instrumental values* (Table 3).

Our results showed clear differences between the six focal landscapes regarding the stated importance of relational and instrumental values (Figure 1). The highest overall importance of the three latent variables concerning relational values was found in the Transylvanian focal landscapes in the Turda area, which has the highest land use intensity of the Transylvanian landscapes, but a relatively even spread of different land use types, and hence, a high level of overall landscape multifunctionality. Second highest ranked the landscape of Rupea, in which extensively used pastures and forest are the dominant land covers. The third highest values were found in the Baraolt area, in which forest and scrub vegetation are the dominant land covers. All German landscapes had lower overall values for the latent factors F1 to F3 than all Transylvanian landscapes. Latent factor F4—instrumental values—was highest in Dornum, in which over 90% of land was used agriculturally and with a high use intensity. Interestingly, Baraolt had the second highest value for latent factor 4, followed by Bakum, an area with a high percentage of agricultural land and high intensification.

TABLE 3 Factor loadings and communality of variables of relational, intrinsic and instrumental values. Loadings extracted through exploratory factor analysis with oblimin rotation and a minimum residual factoring method. The factors explained 29%, 7%, 5% and 4% (45%) of the variance. $N = 819$; h^2 = Communality; F1: individual cognition; F2: nature as a place for social interaction and relaxation; F3: cultural identity and spiritual values; F4: instrumental values

Value category	Questionnaire item	F1	F2	F3	F4	h^2
Individual identity	I think a lot about how much animals have to suffer because of humans	0.838				0.59
Concern for nature	I am very aware of environmental issues	0.714				0.59
Care	I am angry about that humans treat nature so carefree	0.707				0.51
Individual identity	I am not separate from nature, but a part of it	0.693				0.62
Individual identity	Even if I am in a big city, I notice the nature around me	0.687				0.47
Concern for nature	I think a lot about how my behaviour affects the environment	0.661				0.53
Care	I fear that for our children and grandchildren there won't be much unimpaired nature left	0.652				0.49
Intrinsic	All animals and plants have a right to live	0.626				0.39
Individual identity	I feel connected to all living things on earth	0.581				0.45
Sense of place	Nature helps me to feel home	0.544				0.46
Recreation	In nature I can relax and recover		0.578			0.41
Social relations	I like to meet people in nature or visit events		0.51			0.35
Sense of place	I have many memories with the landscape here		0.493			0.36
Recreation	I like to move outside and do sports		0.361			0.24
Spiritual	In nature I have the feeling there exists something mightier than me			0.596		0.46
Cultural identity	Our landscape is a big part of our culture			0.455		0.43
Instrumental	We humans have the right to use nature as we like				0.637	0.41
Instrumental	Using nature as resource for industry and economy is more important than nature conservation				0.425	0.27

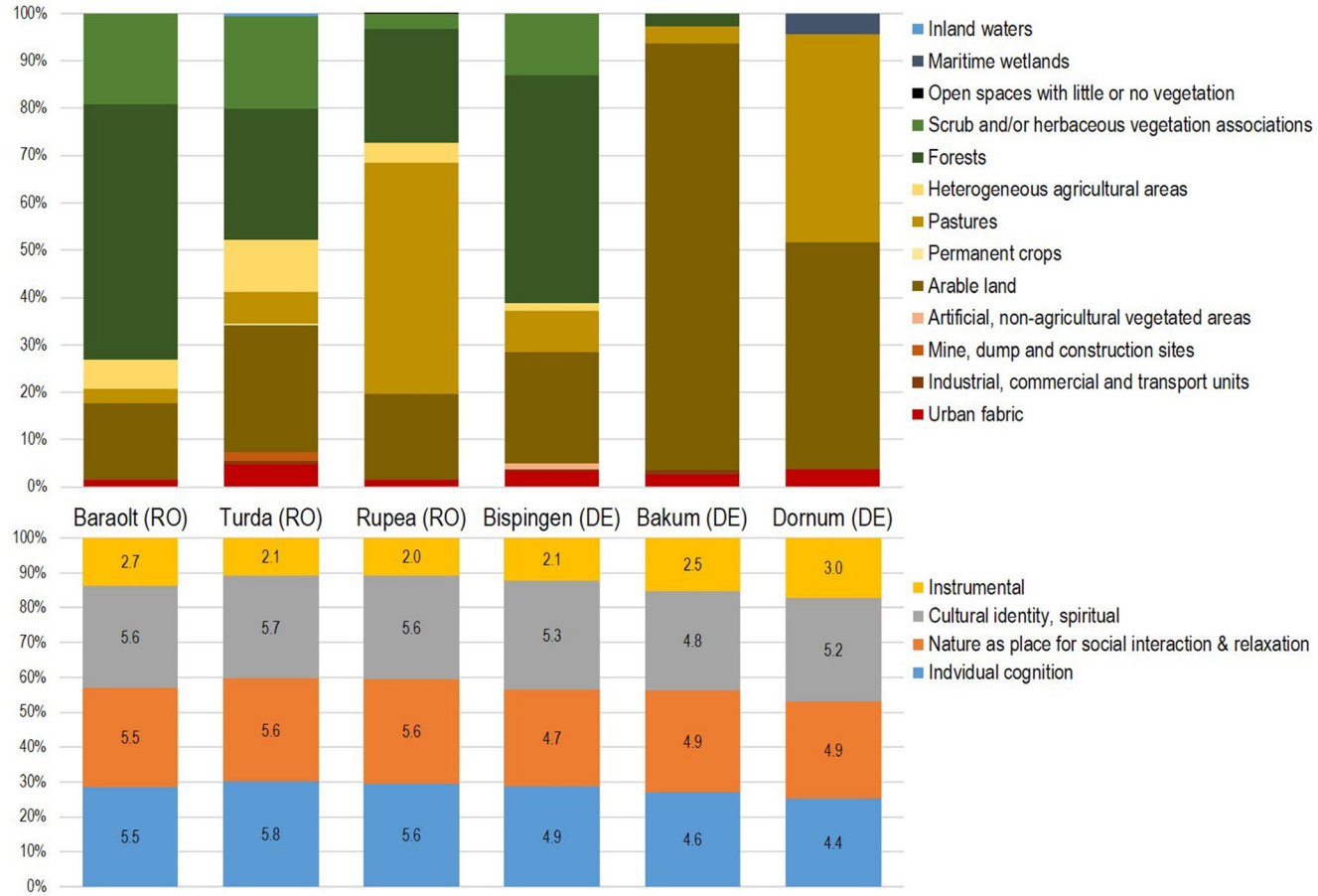

FIGURE 1 Means of the four latent factors by focal landscapes on CORINE land cover data in percentage of total land area. Range of $n = 819$

3.3 | Variables explaining relational values

The four latent factors were examined using regression analysis. For all factors, the confidence set of the best-fitting models always contained a model that included the focal landscape (variable group L), nature-based variables (group N) and personal characteristics of the respondents (group P; Tables A1–A3). These three groups of variables thus appeared to be particularly useful to explain our four latent factors.

Latent factor 1 (*individual cognition*) was most strongly related to a positive attitude towards conservation and a higher frequency of using products from nature in both countries. In Germany, *individual cognition* was further higher among older respondents (Table 4). Latent factor 2 (*nature as a place for social interaction and relaxation*) was only explained by the focal landscape in Romania (Table 5). In Germany, the latent factor was explained by a positive attitude towards conservation and a higher frequency of using products from nature. Latent factor 3 (*cultural identity, spiritual values*) was explained by increasing age of respondents in both countries and again, in Germany also by a positive attitude towards conservation and a higher frequency of using products from nature. Latent factor 4 (*instrumental values*), as shown also in Figure 1, was strongly related to a decreased appreciation towards nature conservation and showed a tendency to increase with higher land use intensity. In Germany, *instrumental values* were further explained by a less frequent use of products from nature.

In the combined model using the full sample for both countries (Table A4), country variance was captured by the focal landscapes playing a major role in explaining *individual cognition*, *nature as a place for social interaction and relaxation* and *instrumental* values—highlighting major difference between the six landscapes, especially between the two countries, as seen also in Figure 1.

The explanatory variables of attitude towards conservation and use of products from nature were included in each model in the German subset, as well as in the full sample. In Romania, these variables had less importance and explained *individual cognition*; only a negative attitude towards conservation was further explaining *instrumental values*. Other variables were generally less useful in explaining relational values. Even though they were included in some of the models supported by the data, distance travelled to nature, visiting frequency and gender consistently had a low effect size and were never statistically significant.

4 | DISCUSSION

To discuss our results, we will first focus on individual relational values in their relation to each other. We then discuss the connections

TABLE 4 Model coefficients for best-fitting models based on the German subsample ($N = 358$). Estimates with a p-value of <0.05 are marked with an asterisk and coloured grey

Predictor	Estimate	*SE*	*p*-value
(a) Individual cognition			
(Intercept)	−0.594*	0.225	0.008
Distance travelled	−0.049	0.033	0.131
Conservation attitude	0.434*	0.048	<0.001
Visiting frequency	0.048	0.040	0.236
Use of natural products	0.210*	0.059	<0.001
Gender	−0.048	0.052	0.359
Age	0.004*	0.002	0.010
Focal landscapes	0.022	0.033	0.514
(b) Nature as a place for social…			
(Intercept)	0.689*	0.295	0.020
Distance travelled	0.063	0.043	0.143
Conservation attitude	0.186*	0.065	0.004
Visiting frequency	0.026	0.051	0.611
Use of natural products	0.251*	0.075	<0.001
Focal landscapes	−0.066	0.056	0.239
(c) Cultural identity, spiritual			
(Intercept)	0.042	0.347	0.903
Distance travelled	0.017	0.053	0.748
Conservation attitude	0.349*	0.076	<0.001
Visiting frequency	0.103	0.066	0.115
Use of natural products	0.358*	0.097	<0.001
Gender	−0.148	0.084	0.080
Age	0.006*	0.002	0.010
Focal landscapes	−0.019	0.042	0.651
(d) Instrumental			
(Intercept)	2.114*	0.233	<0.001
Distance travelled	−0.047	0.036	0.195
Conservation attitude	−0.355*	0.055	<0.001
Visiting frequency	−0.051	0.044	0.248
Use of natural products	−0.146*	0.063	0.022
Focal landscapes	−0.219*	0.039	<0.001

TABLE 5 Model coefficients for best-fitting models based on the Romanian subsample ($N = 461$). Estimates with a p-value of <0.05 are marked with an asterisk

Predictor	Estimate	*SE*	*p*-value
(a) Individual cognition			
(Intercept)	1.273*	0.223	<0.001
Distance travelled	−0.027	0.047	0.559
Conservation attitude	0.251*	0.045	<0.001
Visiting frequency	−0.052	0.045	0.240
Use of natural products	0.175*	0.072	0.015
(b) Nature as a place for social…			
(Intercept)	1.972*	0.086	<0.001
Focal landscapes	0.109*	0.040	0.006
(c) Cultural identity, spiritual			
(Intercept)	2.015*	0.167	<0.001
Gender	0.076	0.076	0.316
Age	0.005*	0.002	0.026
Focal landscapes	−0.010	0.030	0.731
(d) Instrumental			
(Intercept)	0.808*	0.293	0.006
Distance travelled	−0.084	0.061	0.168
Conservation attitude	−0.243*	0.060	<0.001
Visiting frequency	−0.028	0.06	0.645
Use of natural products	0.001	0.072	0.985
Focal landscapes	−0.171*	0.052	0.001

between relational, intrinsic and instrumental values (aim 1). After this, we will go in detail into our further aims of research—the influence of land use intensity (aim 2) and other explanatory variables (aim 3) that may help to understand relational values in cultural landscapes of Romania and Germany.

In general, the consistently most highly valued relational value was aesthetics, emphasising the importance of including landscape aesthetical aspects in planning and decision-making. Further research could disentangle the meaning of 'beauty' for respondents further.

Bundling the items of the questionnaire through an exploratory factor analysis revealed how certain relational values are grouped together. Items regarding individual identity, concern for nature, care, as well as a feeling of home in nature created one bundle, which we termed *individual cognition*, because the focus of these items can be said to be the individual self of the respondents. Another bundle included values concerning social relations, recreation and having memories in the landscape, hence we termed it descriptively *nature as a place for social interaction and relaxation*. Interestingly, two questionnaire items that we initially classified as sense of place (Table 1) are split between those two bundles, showing the importance to further scrutinise this broad category in the future. We suggest that feeling home in nature might be an expression of respondents' individual cognition of themselves and their self-identification, whereas memories from the landscapes might be related to social interactions and moments of relaxation within nature—hence the split between the two bundles. A third bundle included the more collective, socially constructed relational values of *cultural identity and spiritual values*. This may show how the individual self-identification to nature, the social aspects of being in nature and the collective identity formed through culture and religion are also pronounced in the conceptualisation of relational values. This division highlights the importance of the individual sphere and inner motivations as connections to nature (Ives et al., 2020). Moreover, our exploratory factor analysis partly supports the conceptual classification by Chan et al. (2016)

of relational values involving the human collective (latent factors 2 and 3) on the one hand and relational values of a primarily individual nature on the other hand (latent factor 1).

With regard to our first aim, our findings help to understand relational values and how they relate to intrinsic and instrumental values in cultural landscapes in Romania and Germany. On the one hand, relational values and intrinsic values of nature were valued highly by most respondents and bundled together within the latent factor *individual cognition*. These results highlight how respondents' values for nature themselves might be related to their self-identification. Our results might suggest that intrinsic values and relational values are not inherently seen as connected by some respondents, and their differentiation thus deserves further research (Arias-Arévalo et al., 2017; Himes & Muraca, 2018).

Instrumental values, on the other hand, were much less pronounced and valued across all focal landscapes, that is lower than the mid-point of the response scale (3.0). Moreover, they had a tendency to be inversely related to relational and intrinsic values of nature. Our factor analysis clearly showed how instrumental values were understood differently than relational ones, forming a bundle of its own (latent factor 4). Instrumental values seemed to increase with land use intensity, a pattern that was most strongly apparent when comparing landscapes between the two countries (Figure 1; Tables 4 and 5).

Our second aim was to scrutinise how the different landscape types—from less intensive to intensive land use—might influence relational values. Based on prior qualitative research, we hypothesised an erosion of relational values with increasing land use intensity (Riechers, Balázsi, Betz, et al., 2020). Our quantitative results could not clearly confirm this hypothesis. Across the two countries of Romania and Germany and the six focal landscapes, we found that relational values were influenced in part by the landscape, however not in a clear-cut way. Instrumental values indeed seemed to increase with land use intensity, while relational values indeed seemed to decrease when comparing Romania and Germany. Yet, this trend did not hold at the landscape level, and especially not for the area of Baraolt, Romania (Balázsi et al., 2019). This might be due to the distance of the people from the goods and services provided by urban areas, which likely increased the self-sufficiency of inhabitants. In this landscape, biodiversity and land use diversity are still high, while the landscape also supports the needs and demands of the people living there (e.g. local economy based on forestry and animal husbandry). Agriculture and forestry are practiced extensively in the Baraolt area and nature might hence be valued and understood as multifunctional. In areas with higher landscape simplification, be it through intensification (Turda) or abandonment (Rupea), instrumental values seem to more strongly substitute relational ones.

Relational values were substantially higher in Romania than in Germany. This could be because of generally more intensive levels of land use in Germany, as well as fewer people engaged in semi-subsistence agriculture in Germany than in Romania (Balázsi et al., 2019; Hartel et al., 2014). In addition, within their given national context, landscapes with strong sociocultural links and a high degree of multifunctionality appeared to score highly with respect to relational values (Figure 1). Land use intensification is a potentially important issue in the context of relational values in both Germany and Romania. In Germany, the rise of intensive agriculture has already caused tensions and conflicts between different groups of stakeholders, such as smallholder farmers, industrial farmers and environmental conservation groups (Riechers et al., 2019)—who may all hold strong, but potentially contrasting relational values. Due to Romania's current development trajectory (Koranyi & Wittlinger, 2011; Milcu et al., 2014), however, it is possible that relational values will also decrease in Romania in the future (Hanspach et al., 2014).

A better understanding of relational values could be particularly important in a context of landscape change. Especially collective values may be vulnerable to landscape simplification (Riechers, Balázsi, Betz, et al., 2020), such that contrasting values among different clusters of people (e.g. sociocultural backgrounds) could lead to tensions (Riechers et al., 2018). Such tensions may arise because land use change can impact social relationships through creating inequity and social conflicts of the people living within a landscape (Chapman et al., 2019). Most notably, strongly simplified landscapes often provide fewer benefits and only to a small number of privileged actors (Fischer et al., 2017).

Our third aim was to identify other sociocultural factors which may explain relational values. We found that higher levels of relational values and intrinsic values were linked to a positive attitude towards environmental conservation, as well as more frequent use of local natural goods (Admiraal et al., 2017; Knippenberg et al., 2018; van den Born et al., 2017). This could suggest that people with higher relational values are more likely to support conservation agendas (Mattijssen et al., 2020; Topp et al., 2021). Our results showed that the involvement in environmental conservation groups or projects did not have any significant influence on relational values, suggesting that is it not the active involvement per se that is linked to stronger relational values, but rather that strong relational values underpin a positive perception of conservation. The frequent use of natural goods, such as home-grown food and other material connections to nature, was also positively linked to relational values. Interestingly, the frequency of visiting natural places did not have positive impact on relational values. Of the socio-demographic variables tested, only age was significantly related to relational values—with older respondents stating stronger values for *cultural identity and spiritual values* in Romania and Germany, as well as for *individual cognition* in Germany. This may be because older citizens' values were shaped at a time when the landscapes were still relatively more complex and multifunctional; and thus constitutes an example of the shifting baseline syndrome (Britto dos Santos & Gould, 2018; Soga & Gaston, 2018).

When quantifying relational values, much work still needs to be done. To date, no quantitative scale to measure relational values has been sufficiently tested to yield comparable results across different studies. This is a necessary step to be able to convey the importance of relational values without confusion—as one relational value category could be defined very differently across cultures and social

groups. For example, our relational value category of 'sense of place' consisted of two questionnaire items which were later split into two bundles of relational values (latent factors 1 and 2). Showing only the aggregated category of 'sense of place' might hide such nuances. Due to these findings, we decided to focus on the individual questionnaire items, instead of the categories in our further analyses. Especially in the context of dynamic landscape change, an erosion or change in relational values is difficult to assess in a questionnaire. Stating importance of a relational value does not show how prevalent these values still are in the landscape, especially when the landscape is currently experiencing rapid and extreme changes. More research into the quantification of relational values seems necessary to include spatially implicit aspects of these values, while also enabling a broader comparison (Schulz & Martin-Ortega, 2018).

In conclusion, our findings suggest that relational values can be a useful framing to understand how people relate to nature and to one another in different settings. We conducted a first exploration of the effects of rural landscape types in two European countries. Future studies could further disentangle the correlation between relational values and the structural complexity of landscapes. Moreover, further work on the effects of socio-demographic drivers of relational values will be especially useful in the future, as well as work on the conceptual and methodological application of relational values for comparable quantitative research.

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CONFLICT OF INTEREST

On behalf of all authors, the corresponding author states that there is no conflict of interest.

AUTHORS' CONTRIBUTIONS

J.F. and M.R. conceived the idea of this paper and all authors contributed critically to the design of the article; M.R. and Á.B. acquired the data; J.-O.E., G.S. and M.R. analysed the data; all authors interpreted the results; M.R. wrote the first draft of the manuscript and all authors contributed critically to subsequent drafts and gave final approval for publication.

DATA AVAILABILITY STATEMENT

Data deposited in the Dryad Digital Repository https://doi.org/10.5061/dryad.j3tx95xdx (Riechers et al., 2021).

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SUPPORTING INFORMATION

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RESEARCH ARTICLE

The erosion of relational values resulting from landscape simplification

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Abstract

Context The global trend of landscape simplification for industrial agriculture is known to cause losses in biodiversity and ecosystem service diversity. Despite these problems being widely known, status quo trajectories driven by global economic growth and changing diets continue to lead to further landscape simplification.

Objectives In this perspective article, we argue that landscape simplification has negative consequences for a range of relational values, affecting the social-ecological relationships between people and nature, as well as the social relationships among people. A focus on relational values has been proposed to overcome the divide between intrinsic and instrumental values that people gain from nature.

Results We use a landscape sustainability science framing to examine the interconnections between ecological and social changes taking place in rural landscapes. We propose that increasingly rapid and extreme landscape simplification erodes human-nature connectedness, social relations, and the sense of agency of inhabitants—potentially to the point of severe erosion of relational values in extreme cases. We illustrate these hypothesized changes through four case studies from across the globe. Leaving the links between ecological, social-ecological and social dimensions of landscape change unattended could exacerbate disconnection from nature.

Conclusion A relational values perspective can shed new light on managing and restoring landscapes. Landscape sustainability science is ideally placed as an integrative space that can connect relevant insights from landscape ecology and work on relational values. We see local agency as a likely key ingredient to landscape sustainability that should be actively fostered in conservation and restoration projects.

Keywords Agricultural intensification · Diversified farming · Human-nature connections · Landscape sustainability science · Smallholder farming · Social-ecological systems

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Introduction

Landscape sustainability science combines the insights from landscape ecology (Forman and Wilson 1995; Wu and Hobbs 2002) with the insights from sustainability science (Kates et al. 2001; Lang et al. 2012) in order to generate place-based solutions to interlinked environmental, social and economic challenges (Wu 2013). Through its focus on the landscape scale, landscape sustainability science provides a powerful and much needed space to integrate the insights from numerous scientific disciplines in ways that are of direct practical benefit to real-world actors and outcomes (Fischer et al. 2014b). In this perspective article, we use a landscape sustainability science framing to examine the interconnections between ecological and social changes taking place in rural landscapes. Throughout this article, we adopt a perspective of strong sustainability, that is, we recognize that ultimately, humanity is dependent on functioning ecosystems in order to maintain social well-being and economic activity (see, for example, Fischer et al. 2007; Wu 2013).

Landscape simplification—most notably for the expansion of industrial agriculture—has long been recognized as a key threat to terrestrial ecosystems, affecting wild biodiversity (Green et al. 2005), farmland biodiversity (Tscharntke et al. 2005), and the diversity of crop varieties (FAO 2011). Traditional agricultural landscapes often provide a balance of provisioning, regulating and cultural ecosystem services. Simplified agricultural landscapes, in contrast, largely supply the single provisioning service of crop production—at the expense of other types of services (Foley et al. 2005).

Despite these problems being widely known, status quo trajectories driven by global economic growth and changing diets continue to lead to further landscape simplification (e.g. Foley et al. 2011; Clapp 2015)—often fueled by misleading scientific or policy framings that pitch nature conservation and food production as incompatible (e.g. Vandermeer and Perfecto 2007; Grass et al. 2019). Some of the best known examples of landscape simplification are deforestation for soy production in the Amazon (Fearnside 2001) and Gran Chaco (Gasparri and Grau 2009), oil palm cultivation in Southeast Asia (Wicke et al. 2011). Less extreme examples of landscape simplification are far more widespread, and occur worldwide (e.g. Meehan et al. 2011; Jonason et al. 2013), for example agricultural intensification in Europe (Stoate et al. 2001).

While the destruction of ecological functions caused by landscape simplification is well documented, here we argue that in many cases, the effects on social-ecological aspects can be equally detrimental for sustainability. We draw on the relatively recent notion of *relational values* to provide a conceptual framework that hypothesizes ecological, social-ecological and social consequences resulting from landscape simplification. We suggest that landscape simplification has important but largely unexplored consequences for relational values. Neglecting such possible consequences, in turn, could undermine both present environmental management and future restoration potential in many landscapes.

Relational values have been proposed as a framing that can overcome the divide between nature having an inherent or intrinsic value, versus nature being of useful instrumental value to people (Muraca 2011). Relational values are defined as "preferences, principles and virtues about human-nature relationships" (Chan et al. 2018) and focus on the relational *content* of valuation (and not on the inherently relational *process* of valuation) (Himes and Muraca 2018). Instead of focusing on single value-providing entities and their beneficiaries, relational values emphasize the sum of collective values stemming from interactions within a social-ecological system (Muraca 2011). A key strength of a relational values perspective lies in the inclusion of environmentally mediated social relationships between individuals and groups of people (Chan et al. 2016), including elements of indigenous worldviews (Gould et al. 2019). Relational values acknowledge a plurality of sources of human well-being, and the concept is well equipped to include the diversity of inhabitants of places, including aspects of power and agency within their landscapes (Chapman et al. 2019). Relational values are heuristically divided into (1) the human collective, such as cultural identity, social cohesion, social responsibility and moral responsibility to non-humans; and (2) primarily individual values such as individual identity, stewardship eudaimonic (the care for nature fosters what I value as a good life) and stewardship principle/virtue (it is right to protect nature) (sensu Chan et al. 2016; Pascual et al. 2017).

The emergence of relational values (which adds to a vast body of research on related concepts such as sense of place (Trentelman 2009; e.g. Brehm et al. 2013) or landscape (e.g. ESF 2010) has facilitated growing recognition that landscape and environmental change influences human-nature connectedness as well as human relationships (Chan et al. 2016; Sheremata 2018). Here, we argue that landscape simplification can cause erosion of relational values. Leaving the links between the ecological, social-ecological and social dimensions of landscape change unattended could exacerbate a downward spiral of increasing inequality and disconnection from nature. Research shows that rapid landscape simplification can negatively influence inhabitants' emotional attachment to their 'home landscapes' as well as impacting the social interaction between those benefiting from the change and those that carry the (emotional) burden (Riechers et al. 2019). In this paper, we illustrate our perspective on relational values in the context of landscape simplification through four case studies from across the globe, and then discuss its implications for future research and practice in landscape sustainability science. We emphasize that our paper is not an in-depth empirical investigation, but rather a conceptual contribution, in which we draw on selected empirical insights to substantiate and illustrate our argument.

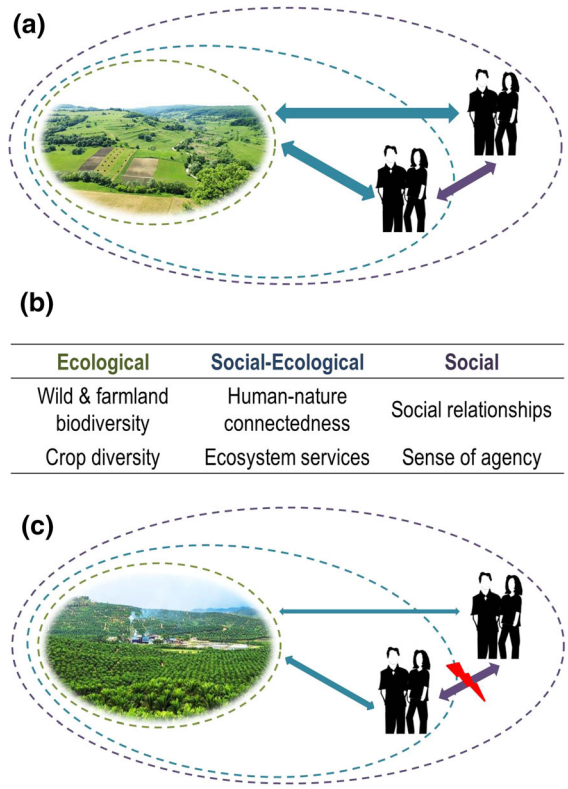

Fig. 1 Landscape simplification causes ecological, social-ecological and social changes. **a** Original landscape state (adapted from Chan et al. 2016). **b** Examples of ecological, social-ecological and social dimensions of landscape change. **c** Simplified landscape state. The width of the arrows denotes the hypothesized strength of a given connection; potential erosion or conflict is indicated by a lightning symbol. [Source Photo A: ©T. Hartel; Photo C: ©CEphoto Uwe Aranas]

A relational values perspective on landscape change

We propose that landscape simplification in rural landscapes—especially if it is rapid—can lead to the deterioration of ecological, social-ecological and social dimensions of the landscape's functioning. We acknowledge that urban or peri-urban systems could be equally interesting to examine from a relational values perspective, but in this paper, we choose to specifically focus on rural areas. We hypothesize that a typical diversified farming landscape has diverse ecological functions and strong relational values, such as strong human-nature connectedness and numerous values stemming from the flows of multiple types of ecosystem services. We further hypothesize strong relational values co-occurring with good social relationships and a strong sense of agency among resident groups in diversified rural landscapes (Fig. 1a). All of these relational values, however, can be eroded through simplification of the social-ecological system (Fig. 1b), causing, in extreme cases, severe flow-on effects on human–human relationships (Fig. 1c). We thus hypothesize that, from a landscape sustainability science perspective, ecological changes to landscapes are intimately connected with social-ecological and social changes.

As a starting point, to illustrate our perspective, we consider a diversified farming landscape. This could be a traditional landscape where culture and nature have co-evolved, but it could also be a modern diversified farming landscape (Fig. 1a). In a diversified farming landscape, ecological functions are relatively stable, supporting elements of wild and farmland biodiversity, and comparatively high crop diversity (Tscharntke et al. 2005; Kremen et al. 2012). Humans and the environment in such landscapes are

connected through a myriad of values, and inhabitants experience multiple benefits from a diverse range of ecosystem services (Horcea-Milcu et al. 2017). Regional identity and social relationships are often strong, and inhabitants actively exert agency to influence the landscape and its development trajectory.

We hypothesize that landscape simplification typically erodes various values associated with diversified farming landscapes (Fig. 1b). Around the world, landscapes are increasingly shaped by global (rather than only local) drivers (Wu 2013; Dorninger et al. 2017), including land use (Egli et al. 2018) and climate change (Mandryk et al. 2012; Prober et al. 2017), or questionable policy and scientific framings (Fischer et al. 2014a, b). These, in turn, stem from global population growth and changing consumption patterns, which foster massive geographically removed demand for agricultural goods, be they food, feed or fuel (Khoury et al. 2014). Landscape simplification is known to cause a loss of ecological functions—but there are also social-ecological consequences such as experiential, emotional and material disconnection of inhabitants from the landscape (Riechers et al. 2019; Balázsi et al. 2019). Moreover, cultural and individual identity and social cohesion can be partly mediated by human-nature connectedness (Chan et al. 2016). Hence, we postulate landscape simplification is also likely to have negative consequences for social relationships in many instances (Fig. 1c).

Last, there are likely flow-on effects on the sense of agency experienced by the inhabitants of a landscape undergoing structural simplification. Especially in landscapes with commodity crops, power relations play a major role in the distribution of benefits and burdens associated with landscape simplification (e.g. Berbés-Blázquez et al. 2016). Resources are often exploited by powerful (sometimes foreign) actors who leave locals with little economic revenue while shifting onto them the burden of provision and ecological impacts of the commodity crop. In this context, the sense of agency experienced by local people to meaningfully partake in the development of landscape trajectories can be expected to decline. Moreover, when access to land is restricted, or when land use strongly deviates from the ideals of inhabitants, a perceived loss of agency can go hand in hand with losses in regional identity and local ecological knowledge (Cundill et al. 2017; Chapman et al. 2019).

While we have separated ecological, social and social-ecological changes for simplicity in this paper, we are acutely aware that these spheres are intimately intertwined. Yet, we reason that certain aspects of landscape change are measurable entirely in ecological terms (e.g. biodiversity loss), while others are measurable entirely in social terms (e.g. loss of agency)—and yet others relate to links between the social and ecological realms (e.g. human-nature connectedness; ecosystem services). As such, we believe there is analytical value in not considering everything as "social-ecological", but rather noting that social-ecological change entails numerous interconnected dimensions.

Illustration of the perspective

We illustrate the plausibility of the perspective outlined above through four case studies. These describe a gradient from minor and gradual to major and rapid landscape simplification: Erdővidék (Transylvania, Romania), Landkreis Oldenburg (Lower Saxony, Germany), Wayanad (Kerala, India) and Abobo (Gambella, Ethiopia).

Erdővidék, as part of the Szeklerland, is a cultural landscape in southeastern Transylvania (Romania) that is dominated by smallholder farming. Studies in biophysically comparable landscapes in Transylvania have documented high levels of wild and farmland biodiversity and a wide range of ecosystem services (Hanspach et al. 2014). Changes in the last 100 years were driven by the socio-economic and political agenda of the central governance system, and rules that governed land use, management, property rights, local identity, social relationships, and in a broader sense the connection of communities to the landscape (Hartel et al. 2016). Three main periods can be distinguished that influenced landscape and value changes (Matei 2013): the pre-socialist (before 1947), socialist (1947–1989), and capitalistic/democratic period (after 1990). Historically, the Szeklerland was a privileged region of the Hungarian Kingdom with self-governed communities of peasants, where commons pool resources were regulated by village laws (Molnár et al. 2015). This medieval structure informally survived in Erdővidék until the newly formed socialist Romania reorganized its administrative divisions (1950–1968). This change influenced the local

social-ecological system, both directly and indirectly through an altered socio-economic and cultural context (Csergő 2002). Forest became state property (1948), agricultural land was collectivized (1949–1962), and industrialization increased (1920–1970). The synergistic effects of these events caused value changes (e.g. loss of family farming, mechanization of agriculture and forestry, creation of jobs in industry) and weakened the connection of locals to the landscape materially (e.g. growing less of their own food), cognitively (e.g. declines in traditional, place-based knowledge) and experientially (e.g. through loss of access to nationalized state property and suspension of social gatherings traditionally held outdoors). In the 1990s, Romania restituted the pre-socialist land ownership structure (Verdery 1994). Although this contributed to property and land use fragmentation and disadvantaged business farming, it stimulated a revival of smallholder farming. In Erdővidék smallholder farming gained prominence because of people depended on the benefits from nature, and many still had an emotional connection to traditional practices. Relational values linked to traditional practices (e.g. joint hay making, pasture and forest cleaning) were revived in the 1990s, but have declined again since then. Unemployment sharply rose following the collapse of communist industries in the 1990s (Sandu et al. 2018). Alongside the political shift to capitalism, unsustainable land management (e.g. forests, pastures) increased. Despite numerous historical shocks, the local community today is still connected to nature in many ways, and local identity and social relationships are strong. While Erdővidék has maintained many of its traditional values to date, ongoing governance challenges and socioeconomic changes could ultimately pose a risk to these values in the long run (Horcea-Milcu et al. 2017).

The district of Oldenburg (Landkreis Oldenburg) is located in the mid-western part of Lower Saxony, Germany. Dominant natural land systems are "geest" areas including heathland (with mostly nutrient-poor sandy soils) and marshlands along the rivers (with nutrient rich, clayey soils). The district covers approximately 100,000 ha, of which two thirds are used for agriculture (LSN 2018a). Almost the whole district is part of the "nature park" Wildeshauser Geest, one of the largest nature parks in Germany. However, the nature park incorporates areas of different levels of conservation status and in general offers only weak protection to biodiversity. Over the last two decades national and European Union subsidies, especially for renewable energy production, in combination with a paradigm prioritizing economic growth, have fostered landscape simplification. As one example, the percentage of maize production (silage and grain maize production) grew from $\sim$ 18% in 1996 to $\sim$ 33% in 2015 (LSN 2018a, b), as the number of biogas plants increased from the first one built in 1998 to 88 in 2017 (existing, in construction, and in process on 4 July 2017, LK Oldenburg 2018). In terms of the ecological consequences, other studies from similar landscapes suggest a likely loss in biodiversity (e.g. in birds Guerrero et al. 2012; Brandt and Glemnitz 2014; or in insects Hallmann et al. 2017) and decreases in water and air quality (e.g. Velthof et al. 2014). Natural conditions combined with economic incentives have enabled a small number of farms to grow into large enterprises, outcompeting many smaller family farms. Today, competition for land between agriculture, village development, industry and nature conservation limits further increases in the size of landholdings; and high costs of leasing agricultural land as well as strict emission regulations further constrain the ongoing growth of farms. However, overall, smallholder farming has become increasingly unviable. The rise of industrial agriculture has caused tensions and conflicts between different groups of stakeholders, such as smallholder farmers, industrial farmers and nature conservation groups. The term "maizification" (in German "Vermaisung") has a negative normative and emotional connotation and has become widely used in the media and in polemic debates to describe major losses in crop diversity and landscape simplification (e.g. Linhart and Dhungel 2013). Our recent work in the district has uncovered a widespread feeling of lack of agency and frustration with the current landscape trajectory among landscape residents (Riechers et al. 2019). Nature connectedness and ecosystem service provision have been influenced by landscape simplification. Some human-nature connections have changed while others are being lost. For example, directly used local provisioning services, such as timber or locally produced food, appear to be declining. Place attachment was often discussed by inhabitants in relation to a structurally diverse landscape, and, hence, is seen as being threatened by landscape simplification. Inhabitants perceived a loss

of agency regarding "their" landscape and home which was driven by, often unidentified, outside forces that seemed to be changing the local social-ecological system in unsustainable ways.

Wayanad District is located in the north of Kerala State, India. Wayanad is a biocultural hotspot (Pretty et al. 2009; Brosius and Hitchner 2010) and became a UNESCO World heritage site in 2012 (UNESCO 2012). While it is home to many threatened species and ecosystems (Myers et al. 2000), it also hosts a large indigenous population (Rath 2006). It is an undulating landscape, and approximately 97% of Wayanad are under agricultural use, mainly subsistence farming and smallholder plantations (Santhoshkumar and Ichikawa 2010). Beginning in the 1990s, agriculturalists all over India were hit by the agrarian crisis. In the case of Wayanad, the most important events were: (1) the rise and fall of pepper, vanilla and coffee cultivation and a coinciding ecological crisis (George and Krishnaprasad 2006; Münster 2012); (2) the reduction of import restrictions on agrarian products (Lerche 2011); (3) the impact of the Green Revolution (Pandey et al. 2010; Suma 2014); and (4) the commercialization of agriculture (Jose and Padmanabhan 2016). Due to agricultural intensification, Wayanad lost 160 rice, as well as several pepper, banana, and vegetable varieties (Kumar and Nair 2004; Suma 2014). The heavy overuse of chemicals, especially in pepper production, left the soil in many areas damaged beyond repair (Münster 2012). Furthermore, chemical use and land use change have resulted in a reduction of water and soil quality, and have been linked to a general decline in wild and farmland biodiversity (Kumar 2005). A poorly organized local rice market and the absence of rice mills in Wayanad have increased transaction costs for family farmers, making traditional rice cultivation increasingly unattractive (Jose and Padmanabhan 2016). The abolition of bonded labor increased expenses for laborers, and government schemes supporting the rural poor do not extend to agricultural laborers—which further aggravated the labor shortage, making traditional rice cultivation even less profitable. As a consequence, many rice farmers have converted their fields into cash crop plantations (Jose and Padmanabhan 2016). Intensified agriculture has created tensions between organic farmers and commercial farmers. Our studies in the area found that farmers perceived a link between increasing health problems and the use of agrochemicals. As a result, women are often prohibited from working in cash crop fields, and this has reduced their incomes and independence (Thottathil 2012; Betz personal communications during fieldwork in 2010 and 2011). Losses in wild and farmland biodiversity have also entailed nutritional changes. Especially the former forest nomads continued to collect edible plants and hunting game in the forest until recently (Suma 2014). Forest losses and a hunting ban, however, heavily restrict these practices now (Münster and Vishnudas 2012), increasing the economic burden of the locals (Betz et al. 2014). Yet, many local people still maintain sacred places in the forest and celebrate their religious ceremonies which are closely linked to rice cultivation (Betz et al. 2014; Suma 2014; Kunze 2017). Landscape simplification, access to higher education, different laws and regulations have changed the sense of agency perceived by local people. Moreover, gender relations, livelihood strategies and social order have changed (e.g. from matrilineal to patrilineal inheritance; from joint to nuclear families) (Suma 2014; Kunze and Momsen 2015; Kunze 2017), with likely negative repercussions for relational values.

Abobo district is located in Anuak zone, within Gambella region in western Ethiopia. Abobo district had long been known for its rich biodiversity, particularly of birds and mammals. The establishment of Gambella National Park in 1964 on approximately 5000 square kilometers along the Alwero River was intended to provide habitat to internationally important wildlife, and to act as a corridor for a major wildlife migration route between Ethiopia and South Sudan (Rahmato 2011). The Anuak people are the dominant indigenous agrarian community in the district. Smallholder agriculture is their dominant livelihood strategy, and the Anuak people are intimately connected with their land—which they consider a source of livelihood, and of cultural, ancestral and spiritual values (Horne et al. 2011). Moreover, water, wildlife and forest resources traditionally provided many ecosystem services to the Anuak people, including materials to build their homes, medicines and food, as well as providing a source of resilience against environmental shocks. In the last 15 years, driven by an agenda to stimulate economic growth, the government of Ethiopia has encouraged the expansion of large-scale private agricultural investors in Abobo district (Hussien 2004; Yasin

2010; Van der Wulp 2013). As a result, large areas of land, including farmland used by local people, communal land, and parts of Gambella National Park, were transferred to private investors such as the Saudi Arabia based "Saudi Star PLC" (10,000 ha) and Indian based "Karaturi PLC" (300,000 ha) (Abbink 2011; Rahmato 2011; Horne et al. 2011). Large-scale agricultural land acquisition has transformed the landscape into an intensive rice monoculture, forcefully removing local inhabitants, with numerous social, economic and ecological impacts (Rahmato 2011; Horne et al. 2011; Van der Wulp 2013; Baumgartner 2017). To the local Anuak people, land is closely tied to their identity and is an important spiritual asset, such that forced eviction has caused severe cultural and spiritual disconnection. Horne et al. (2011) suggested that the land transfer had robbed the community of their identity, created a disconnection from their ancestors, and from future generations to whom community values and traditions can no longer be readily transferred. Moreover, landscape simplification has caused conflicts: between the local people and the investors—leading to the violent destruction of infrastructure; between the local people and migrant workers coming from other parts of the country to work for the investors or on related infrastructure projects; and with adjacent pastoral communities, on whose traditional lands displaced Anuak people began to clear land for agriculture (Abbink 2011; Rahmato 2011; Horne et al. 2011). Although surplus food production was claimed to abate food insecurity, the crops grown are actually destined for international markets and therefore do not benefit local people (Horne et al. 2011). The loss of access to economically important ecosystem services (such as honey and fish), and livelihood assuring activities (such as gathering food, fuelwood, medicines, and occasional hunting of wildlife) have endangered the lives of the indigenous people (Horne et al. 2011; Rahmato 2011). Ecologically, landscape simplification has caused habitat loss and fragmentation, degradation of water resources, and clearing of forests (Abbink 2011; Horne et al. 2011; Rahmato 2011).

In combination, these case studies illustrate a gradient in ecological, social-ecological and social deterioration resulting from landscape simplification (Fig. 2). A key proposition is that all three dimensions of landscape change—ecological, social-ecological and social—appear partly predictable, and somewhat proportional to the speed and intensity of landscape simplification. We intentionally chose an extreme end point—Gambella—in our illustration, but we emphasize that the gradient of intensity of change is what is particularly interesting here, not the extremes as such. If what we propose here turns out to be generally applicable, it shows yet more trade-offs to landscape simplification than are typically recognized. Increasingly industrial crop production thus not only results in a loss of biodiversity and other types of ecosystem services (Foley et al. 2005), but landscape simplification also systematically and predictably undermines human-nature connectedness and social relations, that is, relational values. While one could argue this is a necessary trade-off in the face of a global increase in the demand for food, it is worth highlighting that most of the increase in global demand is related to increasingly meat- and oil-rich diets (Khoury et al. 2014), and landscape simplification thus is unlikely to improve access to food for those who actually need it.

Implications and future research

Landscape sustainability science encourages the simultaneous analysis of interconnected ecological, social and economic changes in a given place (Wu 2013). As our perspective has shown, this lens opens spaces for new types of landscape analyses—in this case, through using the concept of relational values. The perspective outlined above is based on myriad long-standing scientific traditions and disciplines (e.g. Déjeant-Pons 2006; Olwig 2007; ESF 2010) and is not an analytical endpoint, but should be seen as an empirically inspired proposition of how landscape simplification can erode relational values. Future research could further detail and unpack—or potentially refute—this perspective. We propose future research could examine: (i) interactions between social and ecological variables, (ii) time lags in changes in relational values, and (iii) implications for restoration projects.

First, focusing on interactions that alter relational values could help to scrutinize, for example, which types of agricultural system might best link ecological, social-ecological and social variables in desired ways. To comprehensively investigate interactions between those variables, we propose taking a "leverage points" perspective (Meadows 1999). This perspective seeks

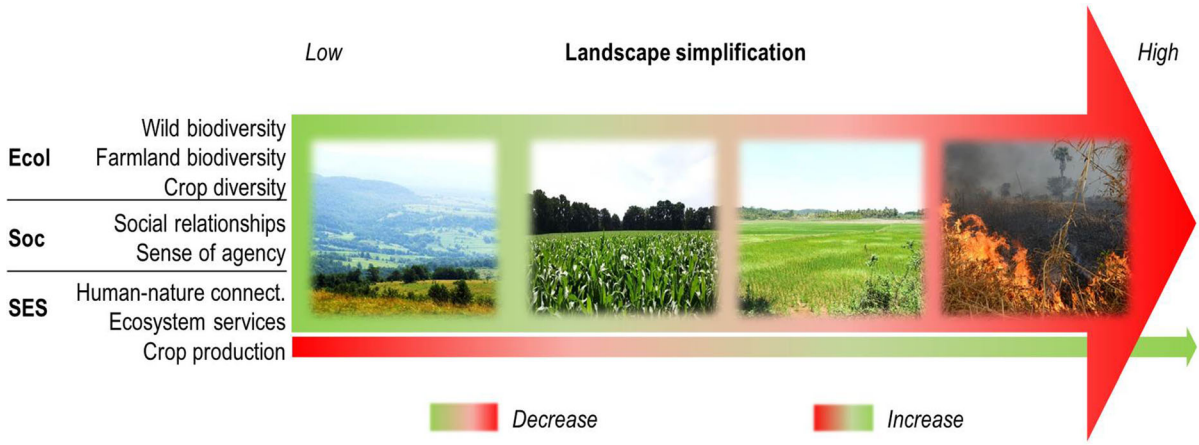

Fig. 2 Case studies describe a gradient from little simplification and slow landscape change to rapid, major landscape simplification (from left to right: Erdővidék, Landkreis Oldenburg, Wayanad, Gambella). Unlike the other variables depicted, the ecosystem service of crop production increases with landscape simplification. "Social relationships" = quality of social relationships; Human-nature connect. = human-nature connectedness (sensu Ives et al. 2018); Ecol = ecological dimensions of landscape change; Soc = social dimensions of landscape change; SES = social-ecological dimensions of landscape change. [Due to the conflicts in the area, picture of Gambella are difficult to publish. This photograph shown here depicts land-cover change through large scale burning. Source Photo D (on the right): ©Joerg Boethling/Alamy Stock Photo]

to identify strategic points to intervene in a system, ranging from shallow leverage points, such as parameters and feedbacks, to deep leverage points, such as worldviews and paradigms (Abson et al. 2017). A leverage points perspective helps to better understand how shallow and deep changes interact at different levels of systemic depth—describing how one type of change in a system precipitates another (Fischer and Riechers 2019). Deep leverage points for sustainability transformation are often neglected in research (Dorninger et al. 2020). Our preliminary analysis suggests that export-oriented, industrial systems erode landscape values at multiple levels of systemic depth, in at least three dimensions (ecological, social-ecological, and social).

Second, we believe it would be useful to study possible time lags in the impacts of landscape change on relational values. Some relational values, such as regional identity or a deep-rooted sense of responsibility for a region, may erode only slowly in response to landscape change (e.g. Horcea-Milcu et al. 2017). While in landscapes with more gradual and slower simplification, inhabitants might also change their values and start appreciating newly emerging landscape features (e.g. the beauty of rape seed flowers, or the wide view after a forest clearing) (e.g. Selman 2010), we hypothesize such adjustment to diminish the more rapid and extreme the landscape simplification will be. Studying such lag effects in responses to landscape change is important in its own right, but also because lag effects may provide institutional memory and a window of opportunity in which to restore social-ecological sustainability after the onset of landscape change.

Third, and following directly from the previous point, how could knowledge on relational values help with restoration projects? Relational values can have both positive and negative effects on the implementation and success of conservation and sustainability projects (Cundill et al. 2017; Klain et al. 2017; Jax et al. 2018). For example, drawing on local people's expressions of human-nature connectedness and social relationships could be a powerful way to tap into underlying motivation to help people restore 'their' landscape, drawing on, as well as strengthening, local identity and sense of agency (Chapman et al. 2019; Riechers et al. 2019). Moreover, the concept of relational values can help shed light on power relations between people and organizations regarding differential access to and distribution of benefits and burdens (Berbés-Blázquez et al. 2016), and could also help to foster a social-ecological approach towards ecosystem restoration (Fischer et al. forthcoming).

Although we caution that the ideas presented in this paper require further investigation, we propose an initial set of preliminary recommendations for policy

Box 1 Preliminary recommendations for policy and practice arising from a relational values perspective on landscape simplification

Landscape simplification is not just an ecological problem, and hence needs to be managed with attention to its social-ecological and social context. While biodiversity loss and a decrease in ecosystem services in response to landscape simplification have become common knowledge, social-ecological interactions demand more attention. Policy and management that target biodiversity conservation and ecological restoration should be aware of the interlinkages between a landscape and the people inhabiting it

Human-nature connectedness and social relationships need to be carefully considered in management plans, because they can work in favor of conservation outcomes, but could also undermine them. We expect strong associations between the multi-facetted experiential and emotional connections inhabitants have with their landscape, their regional identity, and their social engagement in the region. If these relations are strong, they can support conservation or restoration initiatives, but if they are weak, they could significantly hinder the effective implementation of new policies or management approaches

Local agency is a likely key ingredient to landscape sustainability, and should be actively fostered in conservation and restoration projects. Regional identity, solidarity with other local people, and the sense of responsibility for a landscape as 'home' can be seriously eroded as a result of landscape simplification, especially when powerful, external actors directly drive landscape change. A loss of agency could lead to apathy and might cause disinterest, disregard or even disrespect for local community and the landscape

and practice (Box 1). We emphasize these must not be implemented blindly, but should be carefully scrutinized on a case-by-case basis. In conclusion, we urge that it is time to look at landscape simplification more holistically than only from a biodiversity or ecosystem services perspective. Within the context of landscape sustainability science in particular, relational values may be a useful concept to facilitate such investigations.

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Leverage points for addressing marine and coastal pollution: A review

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ABSTRACT

Despite an increasing understanding of the issue of marine pollution, humanity continues on a largely unsustainable trajectory. This study aimed to identify and classify the range of scientific studies and interventions to address coastal and marine pollution. We reviewed 2417 scientific papers published between 2000 and 2018, 741 of which we analysed in depth. To classify pollution interventions, we applied the systems-oriented concept of leverage points, which focuses on places to intervene in complex systems to bring about systemic change. We found that pollution is largely studied as a technical problem and fewer studies engage with pollution as a systemic social-ecological issue. While recognising the importance of technical solutions, we highlight the need to focus on under-researched areas pertaining to the deeper drivers of pollution (e.g. institutions, values) which are needed to fundamentally alter system trajectories.

1. Introduction

Marine and coastal ecosystems are polluted at an alarming rate, degrading their ecosystems and biodiversity (Cole et al., 2011; Derraik, 2002). The negative effects of marine pollution on ecology also impacts human health (Carbery et al., 2018; Thompson et al., 2009) and well-being (Williams et al., 2016) and threaten food security and livelihoods (Hennessey and Sutinen, 2005; Possatto et al., 2011; Shahidul Islam and Tanaka, 2004). Some of the most prominent examples of marine pollution are the large-scale oil spills of the Exxon Valdez (Xia and Boufadel, 2010) and Deepwater Horizon (Beyer et al., 2016; Incardona et al., 2014) and the rising frequency of hypoxic dead zones in the oceans due to eutrophication (Diaz and Rosenberg, 2008). Furthermore, microplastics are accumulating even in remote regions (Lavers and Bond, 2017), such as the Arctic Ocean (Bergmann et al., 2017; Peeken et al., 2018) and deep seas (Peng et al., 2018; Woodall et al., 2014). The loss of iconic ecosystems such as coral reefs (Carpenter et al., 2008) and seagrass meadows (Orth et al., 2006) are accelerated by marine pollution. Additionally, climate change (Lu et al., 2018) and ocean acidification (Doney et al., 2009; Kroeker et al., 2013) alter biochemical processes and physical parameters, further increasing the pressure on marine and coastal ecosystems.

Knowledge of the quantification, characteristics and mechanisms of marine pollution (be it discrete or chronic, from a non-point source or point source) is increasing exponentially (Borja and Elliott, 2019; Lebreton et al., 2017). Further, high social awareness and knowledge about the problems at hand is available (Gelcich et al., 2014). Awareness is increasing, in part due to the Sustainable Development Goals that target responsible consumption and production (SDG 12) and life below water (SDG 14) (UN, 2015). For instance, in 2019 the European Parliament approved a law to ban single-use plastics by 2021 within the European Union (EU, 2019). Yet, projections still show an increase of plastic use driven by plastic production, with global production exceeding 350 million tonnes in 2018, of which about 62 million tonnes (17.7%) were

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produced in Europe (Jambeck et al., 2015; Plastics Europe, 2019). In the same year, 2018, 29.1 million tonnes of post-consumer plastic waste was collected (Plastics Europe, 2019). It was estimated that in 2010, about 5 to 13 million tonnes of produced plastics entered the ocean and this amount is likely to increase as it was estimated that about 12,000 million tons of plastic waste are likely to end up in the natural environment by 2050 (Geyer et al., 2017; Jambeck et al., 2015). With this paradoxical development of rising knowledge about the negative impacts of pollution and rising pollution, we have to ask ourselves: What drives this ongoing pollution and how can knowledge be more effectively deployed to address this problem?

One hypothesis is that interventions for sustainability have been primarily focused on "easy to fix" aspects and short-term interventions, which achieve a quicker but less transformative result (Fischer et al., 2012). Such a focus on "quick-fixes" prevents transformative systemic shifts (Sala and Torchio, 2019). Yet, such shifts are urgently necessary to combat marine pollution at its source. In this systematic review of scientific literature, we investigate this hypothesis of a focus on "quick-fixes" by extracting and evaluating interventions for cleaner marine and coastal ecosystems in scientific discourse. In this systematic review we aim to (i) determine the pollutants studied and their sources as named in the academic literature; (ii) focus on a subset of papers that state concrete interventions (as opposed to purely descriptive and monitoring approaches) and analyse the spatial distribution and characteristics of these interventions; and (iii) characterise the interventions according to the leverage points perspective, i.e. indicating their scientific approach or the type of framing used, identifying who is perceived to be responsible to intervene and the transformative potential of the interventions.

1.1. Leverage points perspective

We draw on the systemic leverage points perspective (Fischer and Riechers, 2019) as an analytical tool to scrutinise the transformative potential of interventions aimed at coastal and marine pollution in academic publications. The leverage points perspective is based on social-ecological systems thinking linking social and environmental phenomena (Berkes and Folke, 1998). To achieve a transformation to a more sustainable state, i.e. clean marine and coastal ecosystems, it is important to consider where to intervene in the system to attain the most transformative results. Meadows (1999) proposed a hierarchy of intervention points for leveraging change. These leverage points range from shallow interventions (e.g. changes in parameters or feedbacks) to deep and powerful interventions (e.g. changes in system intent, goals and paradigms) (Abson et al., 2017) (Table 1). The distinction between shallow and deep leverage points pertain to the depth at which a leverage point is located within a social-ecological system and the extent to which it can alter a system's trajectory. Following Meadows (1999), places to intervene include *parameters*, which are constants (e.g. subsidies or taxes as interventions), the size of buffer stocks and structure of material stocks and flows (such as transport networks or population age structures). In a marine and coastal context, an example of a parameter would be the concentration of a specific pollutant in a defined area. *Feedbacks* are leverage points that constitute the length of delay, strength of negative feedback and gain around driving positive feedback loops. Intervention in both of these system characteristics, parameters and feedbacks, has only a shallow leverage to transform a system. A deeper leverage point is the design of a system – defined by the structure of information flows (who does and does not have access to information), the rules of the system or institutions (e.g. incentives, punishments, constraints and other tools for regulation) and the power to add, change, or self-organise the system structure. The deepest leverage points consist of the system intent, i.e. the goal of the system or the mind-set/paradigm out of which the system arises (including value or beliefs systems). Based on the hierarchical structure from shallow to deep leverage points, changing the system intent would automatically influence the structure, rules, delays and parameters of a system (Abson et al., 2017; Meadows, 1999, 2008) (Table 1; see Table 3 for specific examples). Through this categorisation, we can use the leverage points perspective as an analytical tool to assess the transformative potential of interventions aimed to combat coastal and marine pollution.

Table 1
Twelve leverage points sensu Meadows (1999) and their corresponding system characteristics sensu Abson et al. (2017) from shallow to deep leverage.

Leverage points	System characteristics
12. Constants, parameters, numbers	Parameters
11. The size of buffers and other stabilising stocks, relative to their flows	
10. Structure of material stocks and flows	
9. Length of delays, relative to the rate of system changes	Feedbacks
8. Strength of negative feedback loops, relative to the effect they are trying to correct against	
7. Gain around driving positive feedback loops	
6. Structure of information flow	Design
5. Rules of the system	
4. Power to add, change, evolve, or self-organise system structure	
3. Goal of the system	Intent
2. Mind-set or paradigm that the system — its goals, structure, rules, delays, parameters — arises from	
1. Power to transcend paradigms	

Interventions at deep leverage points have greater power to influence and shift a system, while interventions targeting relatively shallow leverage points would produce smaller changes in the system as a whole. Many sustainability interventions target highly tangible but essentially weak leverage points, i.e. using interventions that are easy, but have limited potential for transformational change such as taxation on fossil fuels – instead of changing a fossil fuel based economy. Thus, there is an urgent need to focus on less obvious but potentially far more powerful areas of intervention (Fischer and Riechers, 2019). We do not want to suggest that interventions addressing more shallow leverage points are inherently and indiscriminately ineffective. They are both highly necessary and beneficial. Instead, we highlight that an intentional focus on deep leverage points and interactions between interventions is necessary and requires further attention. Key strengths of a leverage points perspective are (sensu Fischer and Riechers, 2019): (1) the explicit recognition of difficult to act upon but influential, "deep" leverage points (Dorninger et al., 2020) and enabling the examination of interactions between shallow and deep system changes (Manlosa et al., 2018); (2) the combination of causal (nothing can happen without a cause) and teleological modes (events and developments are meant to achieve a purpose and happen because of that) of research; and (3) the ability to function as a methodological boundary object for inter- and transdisciplinary research.

In the following, we present our findings on the concrete interventions suggested and deployed and how these can be analysed according to the leverage points perspective as described above. We then discuss the implications of our review according to the three key strengths of the leverage points perspective. We conclude by identifying opportunities for extending the transformative potential of the global fight against marine and coastal pollution.

2. Methods

2.1. Data collection

Our systematic review followed the guidelines for the "Preferred reporting items for systematic reviews and meta-analyses" (PRISMA) framework as described by Moher et al. (2009). We developed a search string, to encompass the diversity of marine pollution types and marine and coastal ecosystems (see S1). In September 2019, we applied our search string to the databases of Scopus (www.scopus.com) and the ISI Web of Science (www.webofknowledge.com). Our search string

includes publications from 2000 to 2018. The year 2000 is when the EU Water Framework Directive was adopted which changed the academic narratives towards a more comprehensive assessment. The search string was restricted to articles in English - including both conceptual and empirical observations, but excluding reviews – that focus on various forms of marine pollution and referred to interventions (see search string, Supplementary S1) in their title, abstract or keywords. After removing duplicates, the search string resulted in 4846 articles.

We screened the title, abstract and keywords of these 4846 papers (Fig. S1) based on our inclusion and exclusion criteria. Papers not concerned with marine and coastal ecosystems or the pollution thereof were excluded. Further, purely descriptive or evaluative empirical studies, i.e. with no reference to a possible intervention proposed or described in the abstract (or when a decision could not be made based solely on the abstract, based on reading the full paper) were excluded from the review ($n = 2492$). The goal was to include papers that describe a specific and intentional intervention targeting marine pollution. The remaining 2417 papers were downloaded and analysed full-text. These papers were included after screening because they mentioned either potential interventions in the title, abstract or keywords. A full text analysis revealed that interventions were not given substantive focus in all 2417 articles. Hence, for the in-depth coding on interventions, we included a total of 741 papers, which mentioned solutions and interventions to combat marine and coastal pollution.

2.2. Data analysis

Data were analysed using SPSS 26 (IBM Deutschland GmbH, Ehningen, Germany). Data analysis consisted of qualitative and quantitative analyses. The coding scheme used in the systematic review was partly based on Dorninger et al. (2020). It was tested and refined on 50 randomly selected papers before being applied. To ensure inter-coder reliability, tandems of two conducted preliminary coding separately. The results were crosschecked between the reviewers for consistency in the application of the coding scheme. We coded for 12 variables, each representing one question that was applied to the reviewed articles. The 12 variables filled in by the authors were standardised and turned into 96 distinct variables with a mostly dichotomous structure to account for the multiple occurrences of, for example, pollutants, ecosystems or spatial scale. The variables "sources of pollution" and "interventions against pollution" were analysed using a qualitative content analysis to summarise the results into distinct categories and groups (Mayring, 2008). The overarching categories were also coded numerically for further statistical analysis. To assess the leverage points or system characteristic of interventions, three experts on leverage points (IAD, AM, MR) first had a group discussion on the tasks, then separately grouped the interventions into the four system characteristic by Abson et al. (2017) and lastly compared and discussed their categorisation for more reliability.

The resulting codes were mainly analysed descriptively. Further, we conducted a hierarchical (agglomerative) cluster analysis (HCA) using Ward's method (Ward, 1963) and squared Euclidian distance to identify groups of papers that were similar with regards to the leverage points (i.e. the system characteristics of the named, often multiple, interventions: parameter, feedback, design and intent) addressed in the interventions. The HCA does not require a pre-specified number of clusters and the resulting clusters were chosen after a set of clusters from three to nine were analysed with descriptive statistics on their coherence and explanatory power. We used the results from the HCA to correlate the clusters with variables such as pollutants, scientific framing, spatial scale, reactive or proactive approach and agency for intervention using the standardised residuals of each correlation for graphical presentation.

3. Results

3.1. Foci of the academic literature on marine and coastal pollution

In total, our analysis of 2417 papers showed a research focus on chemicals (28% of the papers), followed by metals and metalloids (19%), nutrients (18%) and oil (14%). Microplastics (6%), plastics in general (4%) and a focus on the general topic of marine pollution (i.e. unspecified pollution, such as "marine litter" or "debris") (5%) received less attention ($n = 2417$). Other pollutants such as emissions, bacteria, noise and gas together accounted for 6% of all papers coded. Results also indicated a change of research foci over the last 20 years as, proportionally, research on pollutants such as chemicals, metals, nutrients and oil decreased over time, while studies on (micro)plastics increased (Fig. 1).

While our search string was designed to capture papers mentioning interventions for addressing pollution (see Supplementary S1) the vast majority of papers still described and measured pollution occurrences without naming any intervention to address it (53%). Around 16% of papers addressed pollution through monitoring, without suggesting further and more specific interventions to solve the problem. Almost a third of the papers (31%) named specific interventions. Of the interventions stated in these papers, 61% were reactive, i.e. dealing with the pollution when it had happened and 39% had proactive elements, i.e. aiming to prevent the pollution from happening.

For the subsequent stages of analysis, we excluded papers that did not cover concrete interventions beyond monitoring activities and we focused exclusively on the 31% of the 2417 papers that proposed clearly defined interventions ($n = 741$).

3.2. Interventions to combat marine pollution

While the proportion of papers with a focus on reactive interventions has grown over time, the percentage of papers stating proactive interventions to prevent pollution does not show a clear trend (Fig. S3).

The sources of pollution named in these papers (Table 2, $n = 1362$) were predominantly oil spills (18.4%) and wastewater (14.5%), followed by agriculture (11.8%), but also often left unnamed (general 10.2%). To address these pollution sources, research on concrete interventions were mostly lab studies (46.1%), with 11.9% papers having a regional (sub-national) spatial focus, followed by the smaller spatial scales of studying pollution at the landscape scale (9.6%) and in locally specific areas (9.3%). Most interventions were proposed (76.2%) and fewer were implemented (23.8%) (Fig. 3).

Using qualitative content analysis, we classified the interventions into 44 categories, of which the top 20 cover over 75% of interventions named for each pollutant. The main intervention categories to combat marine pollution were (bio)remediation (incl. (bio)sorption), followed by more and/or improved cleaning strategies, technologies and mathematical models to increase the effectiveness and speed of responses after a pollution event. The third most frequently mentioned intervention to combat marine pollution was the call for stronger and/or better regulations and laws to prevent pollution from happening in the first place, as well as the coordination of clean-ups (Table 3).

3.3. A leverage points perspective on interventions against marine and coastal pollution

Using the leverage points perspective as an analytical tool to categorise the interventions, we found that most interventions addressed parameter system characteristics (51.3%) (Table 3). Feedback system characteristics were addressed in 4.6% of interventions. The system design was addressed in 34.6% and the system intent in 9.1% of the interventions.

When analysed in relation to the pollutant (Fig. 3), results showed that at least half of the papers on interventions against chemicals, oil,

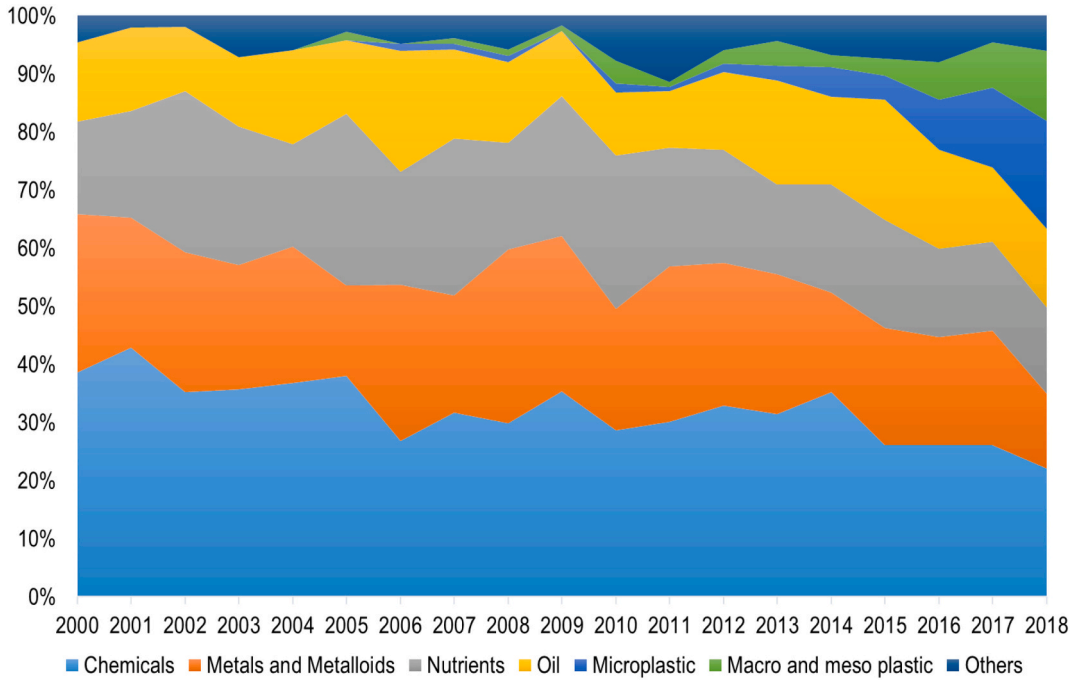

Fig. 1. Proportion of pollutants studied by year. To account for the general increase in academic papers (Fig. S2 shows the increase of papers from 37 in 2000 to 359 in 2018) data are shown in proportion to the papers published the respective year (n = 2417).

Table 2
Pollution sources and major subcategories as resulting from the qualitative content analysis of n = 741 papers. Total number of source statement = 1362, multiple sources can be named in one paper.

Pollution source	Largest subcategories (% of total poll. source)	Percentage of total
Oil spills		18.4%
Industry	Dyes (7.1%) Nuclear energy (5.8%) Tourism (4.9%) Military (3.1%) Flame-retardants (1.8%)	16.5%
Wastewater		14.5%
Agriculture	Pesticides (2.5%) Fertiliser (1.9%)	11.8%
General	Land-based (14.4%)	10.2%
Shipping	Anti-fouling items (21.3%) Fishing (15.7%) Harbours (11.1%)	7.9%
Domestic items	Plastics (26.6%) Single-use items (23.4%) Pharmaceuticals (17.0%) Cosmetics (9.6%) Domestic solid waste (5.3%)	6.9%
Urbanisation		3.3%
Runoff		2.6%
Aqua/ mariculture		2.5%
Emissions		2.4%
Mining	Drilling (11.4%)	2.6%
Others		0.5%

nutrient and metal pollution addressed system parameters (see also Fig. S4). System design (mainly an intervention addressing laws and regulations regarding pollution) was the focus of 59.4% of the interventions in papers addressing pollution in general and 54.8% and 55.4% of those against macroplastics and microplastics pollution, respectively. With 13.6%, system feedbacks were most commonly addressed in terms of interventions against oil pollution. Of the interventions against macroplastics and microplastics pollution, 16.1% and 15.7% respectively focused on the system intent, followed by papers on nutrient pollution (13.7%). Fig. 3 shows the distribution of the intervention categories by pollutant and classified according to the leverage points perspective, highlighting the dominance of individual interventions in the scientific discourse on pollutants.

Further, we looked at the scientific approaches taken in the research papers (multiple approaches within one paper are possible). Fig. 4 highlights that more than half of the papers (53.6%) used a technical framing for their interventions, followed by a political framing (18.6%). Agency for interventions was framed to be mainly with scientists (44.3%) and national politicians (22.6%), while 14.9% of the papers stated that companies and businesses are responsible for the interventions.

Our cluster analysis resulted in three distinct clusters: 1) Parameters, 2) Feedbacks, 3) Design and Intent. Fig. 5 shows that the system characteristic of parameters was mainly addressed by studies on chemical and metal pollution through lab studies. The interventions named in these studies tended to be reactive, have a technological and ecological framing and consider scientists to be responsible for the interventions.

Interventions that address the system characteristic of feedbacks have a focus on metal pollution and covered predominantly a regional (sub-national) scale. The interventions tended to be reactive, framed technologically and scientists were identified as being responsible for interventions.

The design and intent system characteristics were addressed by studies on general pollution; plastics, microplastics and nutrients tended to be done on a national scale. Interventions in this cluster were mainly proactive, have diverse scientific framings and named a wide range of actors for the intervention.

4. Discussion

Whereas there exists a large amount of scientific knowledge on the problems and sources of coastal and marine pollution (Lebreton et al., 2017; Löhr et al., 2017), the problem itself is still as prevalent as ever. The current sustainability crises are not “fixed” by more research or better technology (Orr, 2004) but through agency and action in real-

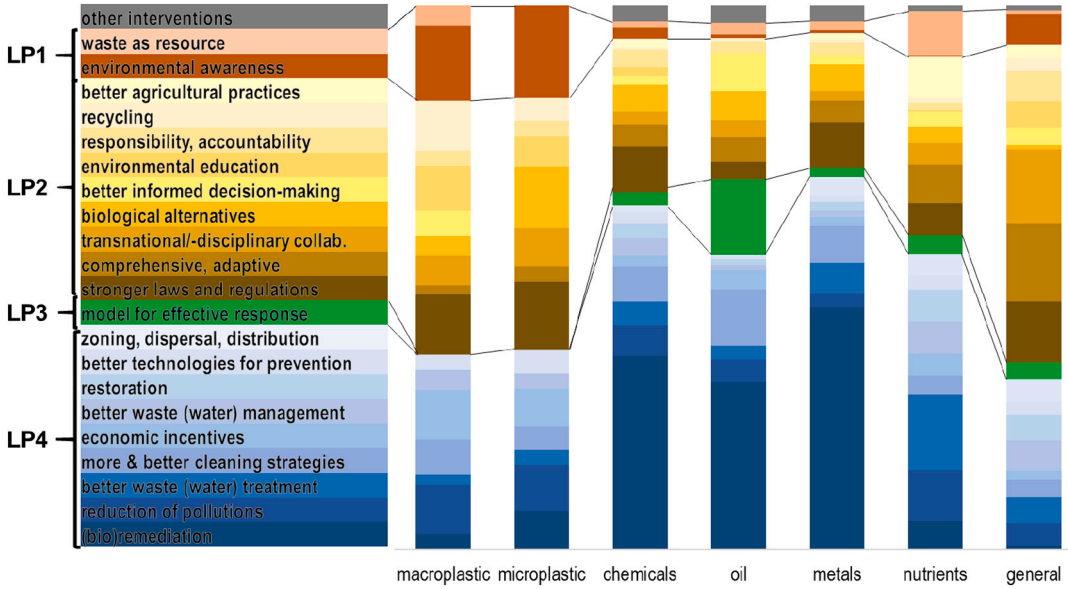

Fig. 3. Distribution of the 20 most named interventions against marine pollution classified by the system characteristic they address: LP4 = system parameters (blue), LP3 = system feedbacks (green), LP2 = system design (orange), LP1 = system intent (red). Remaining interventions were grouped into "others" and not classified according to the leverage points perspective. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 3
Percentage of the four system characteristics according to Abson et al. (2017); percentage of interventions named in the literature; categories as resulting from the qualitative content analysis. Interventions named less than 1.5% have been excluded from this presentation for simplifications.

System characteristics	Specific interventions identified from content analysis	Percentage of all interventions named (n = 1171)
System parameters (51.4%)	(Bio)remediation, incl.(bio) sorption;	22.9%
	More & better cleaning strategies;	11.6%
	Better waste (water) treatment;	6.8%
	Reduction of pollutant;	4.4%
	Economic incentives;	3.4%
	Better waste (water) management;	2.9%
	Restoration;	2.8%
	Better technologies for prevention;	2.1%
	Zoning, dispersal, distribution	2.1%
System feedbacks (5.0%)	Model for effective response	5.5%
System design (34.6%)	Stronger laws and regulations;	7.9%
	Comprehensive, adaptive and/or spatial management;	4.8%
	Stronger transnational, transdisciplinary collaborations;	4.4%
	Biological, non-toxic, alternatives;	4.3%
	Better informed decision-making, incl. risk assessment/ inclusion;	3.7%
	Responsibility, accountability for polluters;	2.1%
	Better agricultural practices;	2.1%
	Recycling;	1.5%
	Environmental education	1.5%
System intent (9.0%)	Waste as resource;	3.8%
	Environmental awareness	2.8%

world settings (Colloff et al., 2017). It is important to note that the research on plastics (micro-, meso- and macro-) increased significantly from the first study in 2005 to 122 in 2018, both in proportion and in absolute numbers. In 2018, nearly 31% of all marine pollution studies were researching plastics. No other pollutant picked up research interest so fast in our record, showing the agility of science to re-focus on emergent threats.

We showed that oils spills were mentioned most often as source of pollution, followed by different industrial sources, waste water and agriculture. The most often named interventions for these particular sources were framed around cleaning (e.g. remediation/absorption, waste water management) and were rarely concerned with interventions for oil-alternatives or more sustainable industrial production processes. Indeed, even though our search string was designed to include interventions, over half of the papers were purely descriptive and did not mention clearly defined intervention strategies. Of those papers that suggested interventions, the majority focused on reactive (mainly cleaning up), rather than on proactive, preventive ones. Based on our stated hypotheses regarding a scientific focus on "quick-fixes", which are most often related to reactive interventions and cleaning up measures, our findings highlight a diversity of reactive and proactive approaches showing 61% of the named interventions to be reactive, while 39% were proactive. The interventions mentioned to address marine pollution are mostly technological advancements – often based on studies done in the lab - with the agency of intervention in the hands of scientists, which is a general bias of science (Dorninger et al., 2020). We, however, also showed the existence of a more social-ecological approach in which articles mentioned the agency of multiple actors (e.g. politicians, society and business) to intervene to combat marine pollution. Beyond our focus on academic papers, a leverage points analysis of interventions against marine and coastal pollution in other sources such as government and non-government reports to enable a comparison between science and policy foci. In addition, further research could focus on characterising and comparing interventions to combat pollution from point and non-point sources and chronic and discrete types. A leverage points perspective could help determine whether interventions for chronic pollution from non-point sources differ from interventions from an oil spill and whether interventions for the former will tend to focus on deep leverage points. However, due to limitations in our data, this

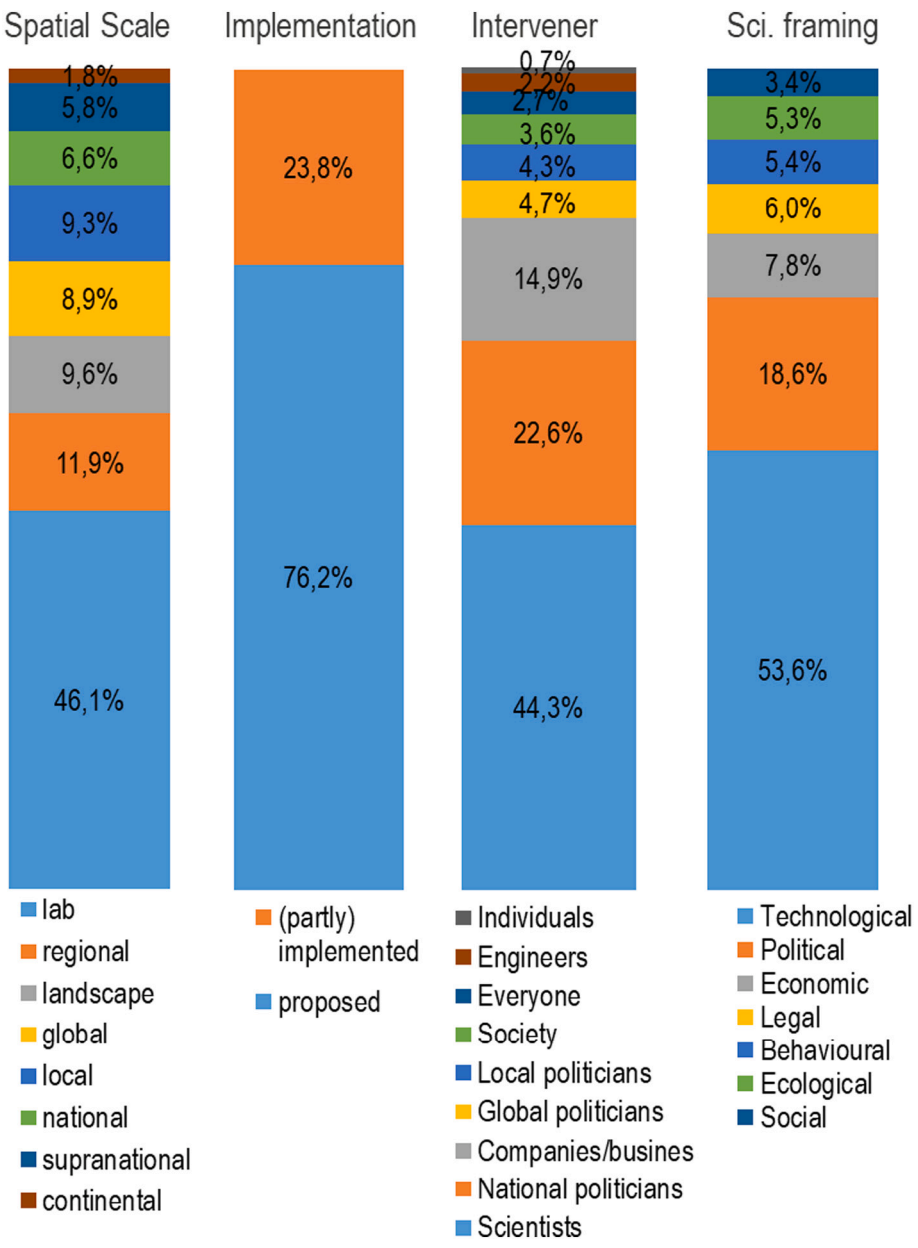

Fig. 4. Categorisation of 741 papers (in percentage) regarding the spatial scope of study, whether interventions are proposed or implemented, whose responsibility it is to act and the scientific framing of the intervention. One paper can use several scientific framings, refer to multiple agents for intervention and use multiple scientific framings.

question was not covered by this study.

In the following, we synthesise lessons learned from applying a leverage points perspective to interventions against marine pollution, drawing on the three key strengths of this perspective: 1) focusing on deep leverage points and links between them, 2) the combination of causal and teleological approaches and 3) how the leverage points perspective can be used as a practical and methodological boundary object. Based on these insights we identify opportunities to develop and implement interventions to address the issue of marine and coastal pollution more effectively.

4.1. Operationalising the leverage points perspective for cleaner marine and coastal ecosystems

4.1.1. Focus on deep leverage points and interactions

Our review of the literature demonstrated that interventions, which take a rather short amount of time to be implemented are common in research on marine pollution. This, however, eludes a transformative shift. The lack of research on deep leverage points is not uncommon (Dorninger et al., 2020) as technocratic approaches have a longstanding history in science and are currently being critically scrutinised (Bäckstrand, 2003; Rametsteiner et al., 2011). An intentional integration of deep systemic transformation is needed (Meadows, 1999). Interventions that were classified as deeper leverage points are related to, for example, a change towards a low-impact (Ehrenfeld, 2005; Liu et al., 2012) or circular economic paradigm (Löhr et al., 2017; Penca, 2018) and a strengthening of the precautionary principle (Liu et al., 2012; Udovyk and Gilek, 2013). These proposed interventions are not bound to one pollutant or pollution source and instead focus on transforming the underlying intent of the system which generates pollution towards more sustainability. Another example of a deep leverage point in relation to nutrients from agriculture is the suggestion to change agricultural practices (McLellan et al., 2015). This entails political changes from global (e.g. curbing the increasingly distant supply chains, Khoury

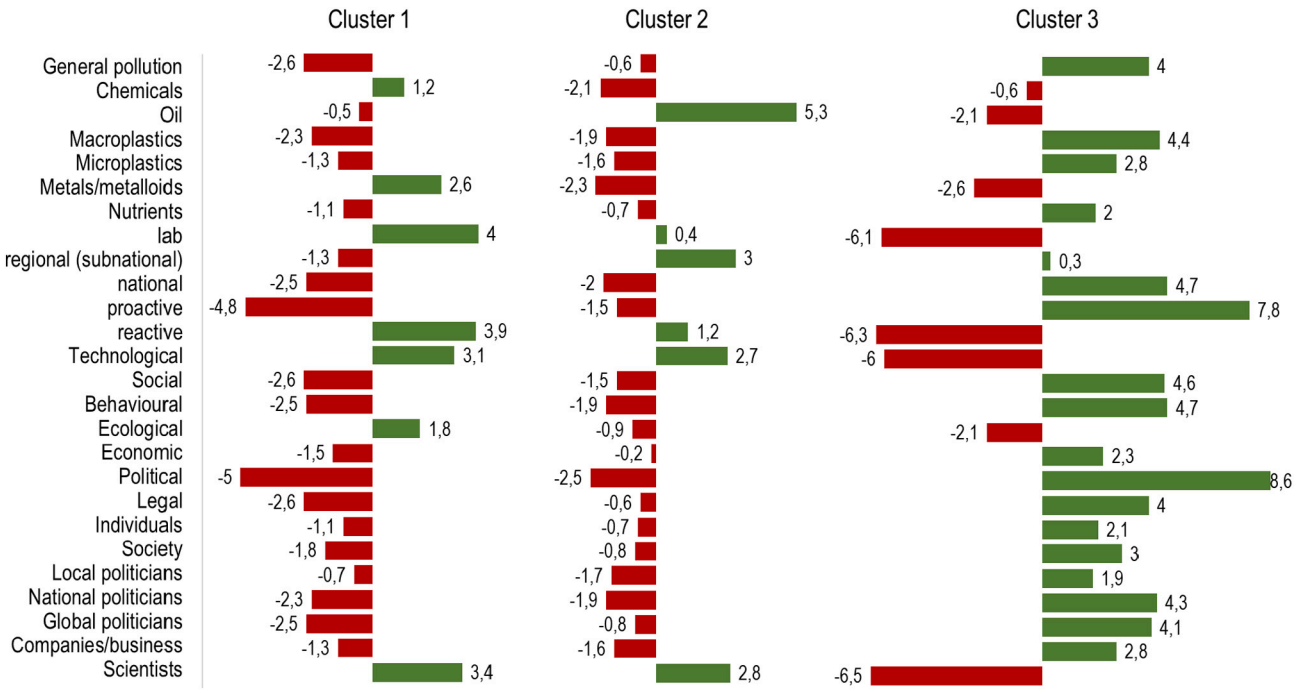

Fig. 5. Results from the HCA of 740 papers. Only correlations with $p = 0{,}000$ are shown. Bars show the standardised residuals of each correlation; negative residuals are shown in red, positive residuals are shown in green. Cluster 1 = Parameters, Cluster 2 = Feedbacks, Cluster 3 = Design and Intent. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

et al., 2014) to local levels (e.g. supporting organic farmers, Loizidou et al., 2017).

As mentioned earlier, the distinction between relatively shallow and deep leverage points does not mean that interventions, which can be classified as shallow are unnecessary and ineffective. It means rather that certain interventions, while effective for their particular purposes, have little power to fundamentally alter system dynamics and trajectories. Moreover, if research related to marine pollution continues to focus on shallow leverage points, the concomitant public policies developed will be ineffective, avoiding real and necessary transformation. For instance, cleaning up after an oil spill is highly necessary (Beyer et al., 2016; Incardona et al., 2014). Such highly visible spill incidents can lead to a proliferation of research in advancing clean-ups (e.g. Bernabeu et al., 2009; Sueiro et al., 2011) and more effective response categories (Melaku Canu et al., 2015; e.g. Poje et al., 2014; Qin et al., 2017). However, discussions about fundamentally preventing another oil spill through changed, stricter legislation are less prevalent. Hence, we highlight that an intentional focus on deep leverage points and links between leverage points (i.e. addressing both deep and shallow leverage points) is necessary to expand the focus beyond leverage points that are insufficient for systemic change to sustainability. Our cluster analysis showed that interventions addressing the system characteristics of design and intent occur together – yet discussions around the linkages between shallow and deep leverage points remain missing. An example of this from our findings relate to plastics (micro-, meso- and macro-). Our results showed that 15% of interventions focused on system intent (e.g. raising awareness and education), ~55% on system design (e.g. stricter rules and regulations) and ~30% on parameters (e.g. finding more biological-friendly alternatives). Given the rise of research on plastic pollution, this could suggest a potential shift of focus towards a social-ecological perspective which considers links between leverage points.

4.1.2. Causal and teleological focus on interventions

Research on marine pollution is relying on finding principles of causality, as our results point out. This focus on causality has, for example, led to strong predictive models on clean-ups and response efficiency. These interventions use the dominant scientific mode of forecasting, where known causalities are extended into the future. Scientific forecasts, regardless of whether they are on anthropogenic climate change, demographic change or biodiversity loss, are extremely useful tools in decision-making (IPCC, 2018). Taking a leverage points perspective, we underscored that these models and forecasts target parameters and feedback system characteristics. The hierarchy of leverage points proposed by Meadows (1999) and Abson et al. (2017) spans a range of considerations from causal to teleological – providing a place where fundamentally different modes of thinking can be bridged.

We argue that cleaner marine and coastal ecosystems are not only achieved by better predicting when pollution events might happen and how to respond to them. Instead, one should also proactively aim to change the system intent towards healthy and clean marine and coastal ecosystems (such as the “intents” of above named circular economy or the precautionary principle). For instance, this shift could promote the modification of our ways of being in the world, our production and trading systems and the ways in which we relate to each other and to the rest of nature. The system goals and especially the power to transcend the paradigm underpinning a system acknowledge that human agency, its normative direction and thus teleology fundamentally shape outcomes. An example of an approach that lends itself to this kind of research is backcasting. Backcasting is a strategic planning tool, which is designed to envision a desired future (e.g. in 20 years). This vision is the starting point to discuss and design concrete steps to materialise this vision (Dreborg, 1996). Backcasting, hence, includes a focus on the design and intent system characteristics and strengthens the focus on proactive interventions. With the system intent set on healthy and clean marine and coastal ecosystems, the causal relationships will act within these teleological boundaries and serve its overall purpose and goal. There are other methods which include a teleological approach (see e.g. Three Horizon in Sharpe et al., 2016) and we argue that their inclusion can have great merit for transformative action. Such methods can also engage scientists from various disciplines and non-academic actors that rally behind a common vision.

4.1.3. Inter- and transdisciplinary solution-oriented research

Preventing marine pollution is a practice as much as it is a science and hence the scientific approach needs to be more solution-oriented. Three-quarters of the interventions considered in this literature review are only proposed and not (yet) implemented. To develop and implement more effective interventions that address the root causes of marine pollution, we suggest the application of inter- and transdisciplinary approaches, which engage with plural scientific perspectives and a diversity of stakeholders (Riechers et al., 2021). Environmental conservation and management have traditionally been addressed within disciplinary boundaries and on a sectoral basis (Coppolillo et al., 2004; Simberloff, 1998). This fragmentation results in science providing advice, instead of co-producing knowledge between actors (Kirchhoff et al., 2013). Transformative interventions to combat marine pollution cannot be answered from within the natural nor the social sciences alone. Instead, they require inter- and transdisciplinary approaches that facilitate collaboration between a diverse group of scientists and non-academic actors (e.g. industry, policy, affected locals; see Sala and Torchio, 2019 for a discussion on these issues). To jointly develop more transformative interventions, researchers may enter unfamiliar grounds of knowledge co-creation, facing the complexity of the issue on purposive, normative and pragmatic levels of societal problem solving (Hirsch Hadorn et al., 2006). Concomitantly, researchers can engage in a discussion on the role that science, technology, industry, policy and society could play to accomplish the challenge of reducing pollution and its impact on humans and the environment around the globe.

Such a discussion may also venture into the debate on the values we hold for nature as done in sustainability transformation (Horcea-Milcu et al., 2019). Meadows (1999) highlights 'values' as deep leverage points and current debates highlight the necessity to include the relationship between humans and nature, including relationships between people mediated by nature (Chan et al., 2016; Riechers et al., 2020), as being emphasised by the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) (Díaz et al., 2015). This discussion of values of the oceans goes beyond instrumental values (Himes and Muraca, 2018), instead aiming for meaningful relationships and responsibilities established between humans and nature through concepts such as stewardship (Bieling et al., 2020; Cockburn et al., 2019; West et al., 2018).

Finally, we recommend that all actors that endeavour to clean our ocean – science, policy and economics – conduct a leverage points assessment of their specific interventions against pollution. Such assessments should collect social-ecological information on a wide range of issues and sources including consideration of the systemic depth of the interventions proposed or implemented and actively engage in the difficult questions concerning the root causes of pollution and how these can be effectively transformed in the long run.

With social-ecological links recognised in the Sustainable Development Goals (UN, 2015) and by the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES, 2018), we see great potential to incorporate a leverage points perspective based on social-ecological system thinking into research on marine pollution to move towards a more sustainable trajectory for the marine and coastal ecosystems. Likewise, we see how our recommendation can underpin the objectives set out in the agenda of the United Nations Decade of Ocean Science for Sustainable Development (2021–2030) – such as adaptation strategies and science-informed policy responses to global change.

5. Conclusion

By 2025, the Agenda 2030 for Sustainable Development aims to prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution. Despite existing global efforts, current trends show an ever-increasing marine and coastal pollution. The amount of papers published each year on marine pollution gives a good impression of the astounding level of information achieved already. Humanity, however, has not been able to significantly alter the trajectory on increasing pollution of our marine environment.

Based on the seminal work by Donella Meadows, we use the leverage points perspective, a hitherto under-recognised heuristic and practical tool, for an extensive systematic review to classify different interventions according to their potential for system-wide change and sustainability transformations. Our results highlight (i) that chemical pollution is the most studied area, followed by metals and metalloids and nutrients ($n = 2417$ papers). The most frequently mentioned sources of pollution in the papers were oil spills, industry and wastewater ($n = 741$ papers); (ii) while the amount of papers is increasing, a solution-orientation is limited throughout the years (i.e. around 30% focus on interventions to marine pollution). (iii) These 30% were analysed in depth, showing diverse solutions proposed to minimise marine pollution. More articles focus on reactive interventions, such as cleaning up, instead of proactive, pre-emptive interventions at the source. In this paper, we have shown that deep leverage points related to changing the system's intent and paradigms are rarely addressed. The interventions mentioned to address marine pollution are mostly technological advancements with the agency of intervention in the hands of scientists. A smaller cluster showed a more social-ecological approach with studies done at the national level which identified multiple actors – politicians, society, business – as having roles to intervene in order to foster cleaner oceans. We propose that for initiating system-wide transformative change towards clean and healthy marine and coastal systems, deep leverage points, that is, the goals of a social-ecological system, including its intent and rules, need to be addressed more directly. These priorities, we argue, can provide useful guidance for how to make marine pollution agendas around the world more effective.

CRediT authorship contribution statement

Maraja Riechers: Conceptualization, Writing – review & editing, Investigation, Data curation, Writing – original draft. **Benedikt P. Brunner:** Investigation, Data curation, Writing – original draft. **Jan-Claas Dajka:** Investigation, Data curation, Writing – original draft. **Ioana A. Duşe:** Investigation, Data curation, Writing – original draft. **Hannah M. Lübker:** Investigation, Data curation, Writing – original draft. **Aisa O. Manlosa:** Investigation, Data curation, Writing – original draft. **Juan Emilio Sala:** Investigation, Data curation, Writing – original draft. **Tamara Schaal:** Investigation, Data curation, Writing – original draft. **Sabine Weidlich:** Investigation, Data curation, Writing – original draft.

Declaration of competing interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.marpolbul.2021.112263.

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PERSPECTIVE

PEOPLE AND NATURE | BRITISH ECOLOGICAL SOCIETY

A leverage points perspective on sustainability

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Abstract

1. Drawing on seminal work by the late Donella Meadows, we propose a leverage points perspective as a hitherto under-recognized heuristic and practical tool for sustainability science. A leverage points perspective focuses on places to intervene in complex systems to bring about transformative change.
2. A leverage points perspective recognizes increasingly influential leverage points relating to changes in parameters, feedbacks, system design and the intent encapsulated by a given system. We discuss four key advantages of a leverage points perspective.
3. *First advantage*: A leverage points perspective can bridge causal and teleological explanations of system change – that is, change is seen to arise from variables influencing one another, but also from how human intent shapes the trajectory of a system.
4. *Second advantage*: A leverage points perspective explicitly recognizes influential, 'deep' leverage points – places at which interventions are difficult but likely to yield truly transformative change.
5. *Third advantage*: A leverage points perspective enables the examination of interactions between shallow and deep system changes – sometimes, relatively superficial interventions may pave the way for deeper changes, while at other times, deeper changes may be required for superficial interventions to work.
6. *Fourth advantage*: A leverage points perspective can function as a methodological boundary object – that is, providing a common entry point for academics from different disciplines and other societal stakeholders to work together.
7. Drawing on these strengths could initiate a new stream of sustainability studies, and may yield both practical and theoretical advances.

KEYWORDS
backcasting, scenario planning, social–ecological system, system change, transformation, transition

1 | INTRODUCTION

Despite intensifying efforts in both science and society, numerous indicators of social and biophysical unsustainability continue to exponentially increase (Ripple et al., 2017). Of course, there has been progress in some locations and for some indicators – gross domestic product per capita has increased substantially in many countries over the last decades (World Bank, 2018); renewable energy

sources, and especially solar energy, are rapidly expanding (IEA, 2017); and charismatic species such as the wolf (*Canis lupus*) have returned to locations from which they had been extirpated (Wagner, Holzapfel, Kluth, Reinhardt, & Ansorge, 2012). Notwithstanding the significance of such progress, the global picture is far from encouraging. To list just a few examples, anthropogenic climate change is ongoing (Pachauri et al. 2014), human population growth remains high in many of the world's poorest countries (United Nations, 2017), the global number of undernourished people is rising rather than declining (FAO, IFAD, UNICEF, WFP, & WHO, 2017), girls in many countries still have little opportunity to obtain a good education (Global Education Monitoring Report Team, 2018), consumption changes towards processed foods and diets rich in animal protein are driving massive rises in demand for commodities such as palm oil and soy (Khoury et al., 2014), and partly as a result of the above, global species extinction rates are up to 100 times higher than background rates (Barnosky et al., 2011; Millennium Ecosystem Assessment, 2005).

Humanity is living in overshoot, beyond the biophysical limits of the planet (Rockström, 2009; Steffen et al., 2015), and yet still below the provision of a basic socio-economic foundation for billions of people (Raworth, 2012). Despite global agreements on various iterations of well-intended goals (most recently, the Sustainable Development Goals), humanity has not managed to fundamentally change the trajectory of the global coupled human–environment system. Many indicators suggest an ever-growing rather than shrinking 'sustainability gap' – that is, a growing discrepancy between the actual state of the global human–environment system relative to what would be sustainable (Fischer et al., 2007).

Finding approaches that can effect transformative change, bringing about a biophysically sustainable and socially just world, thus becomes the holy grail of sustainability science. Without doubt, there is no panacea (Ostrom, Janssen, & Anderies, 2007). However, this humbling realization should not take away from cautious enthusiasm for those ideas that do have genuine potential to make a positive difference, and bend back down the 'hockey

TABLE 1 Four realms of leverage as proposed by Abson et al. (2017), their relationship to the 12 leverage points originally postulated by Meadows (1999) and examples. Increasingly influential (deep) leverage points are listed towards the bottom of the table

Realm of leverage	Leverage points	Example
Parameters	Constants, parameters, numbers	Average fuel consumption of a car
	Size of buffer stocks, relative to flows	Amount of total standing timber in a production forest
	Structure of material stocks and flows	Run-off dynamics of nutrients from agricultural fields into adjacent water bodies
Feedbacks	Length of delays, relative to rate of system change	Time it takes for the ozone hole to close after harmful emissions seize
	Strength of negative feedback loops	The extent to which a lake can absorb nutrients and thus remain clear
	Gain around positive feedback loops	The extent to which poverty leads to population growth, which may further exacerbate poverty
Design	Structure of information flows	Consumer knowledge about where certain products come from
	Rules of the system (incentives, constraints)	Policies governing natural resources, including among others taxes and regulations
	Power to change system structure or self-organize	Ability of farmers to organize the sustainable use of a communal pasture
Intent	Goals of the system	Organization of global institutions to support free trade versus global equity
	Paradigm underpinning the system	A 'green revolution' paradigm underpinning agricultural policies
	Power to transcend paradigms	The conscious shift from a growth-based economy growth to a steady-state economy

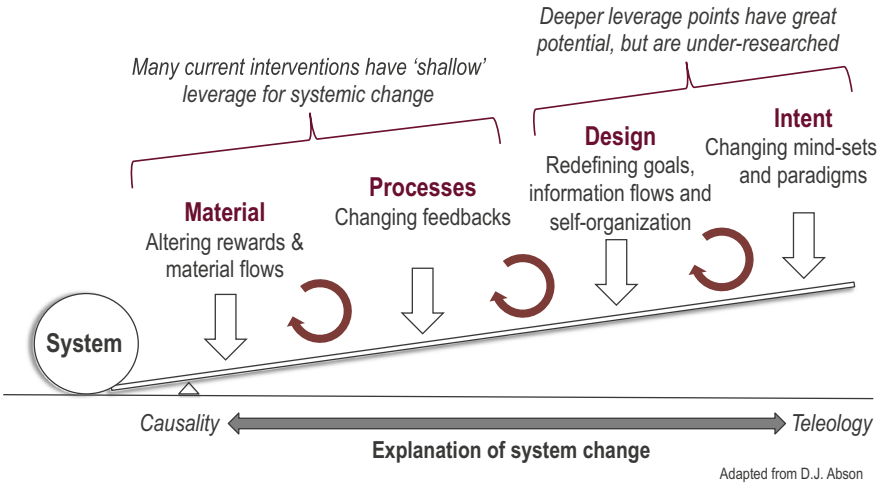

FIGURE 1 Schematic illustration of four realms of leverage (Abson et al., 2017) showing a gradient from shallow leverage points to deep leverage points (see Table 1 for details and examples); and the position of those realms of leverage regarding their explanation of system change in terms of causality or teleology. Round arrows indicate stylized interaction that may occur between any combination of leverage points. (Figure is adapted with permission from an earlier version by D.J. Abson.)

stick' patterns of out-of-control exponential growth, which characterize The Great Acceleration (Steffen, Crutzen, & McNeill, 1989, 2007; e.g. climate change Pachauri et al., 2014; biodiversity loss Millennium Ecosystem Assessment, 2005). In this paper, we argue that a leverage points perspective on human–environment systems deserves greater attention, because it holds substantial promise to inspire new directions in sustainability science and practice. We briefly summarize what we mean by a leverage points perspective, and then highlight four key advantages of such a perspective that suggest it might be well placed to stimulate much needed progress.

2 | ORIGIN AND RECENT REVIVAL

Leverage points are places in a system where relatively minor interventions can lead to relatively major changes in certain outcomes (Meadows, 1999). The concept is not new to systems thinking, nor is its application to human–environment systems. Based on years of experience, in 1999, Donella Meadows –one of the world's pioneers in research on coupled human–environment systems (Meadows, Meadows, Randers, & Behrens, 1972) – postulated a hierarchy of 'places to intervene' in complex systems (Meadows, 1999). She distinguished between leverage points at which interventions are easy but limited in their potential to bring about transformative change (here, termed 'shallow') and leverage points where interventions are difficult but have great potential to bring about transformative change (here, termed 'deep'). Recently, Abson et al. (2017) simplified the 12 leverage points postulated by Meadows into four 'realms of leverage'. Increasingly deep (i.e. powerful) realms of leverage, according to Abson et al. (2017), related to changes in parameters, changes in feedbacks, changes in system design and changes in the intent encapsulated by the system (Table 1, Figure 1). Abson et al. (2017) provided a detailed discussion of the nature of different realms of leverage, and especially focused on examples of deep leverage points. Unlike Abson et al. (2017), here we specifically focus on four general advantages of taking a leverage points perspective.

3 | KEY ADVANTAGES OF A LEVERAGE POINTS PERSPECTIVE

3.1 | Combining causality and teleology

Traditional science is strongly rooted in finding principles of causality. Finding cause-and-effect relationships (including feedbacks) is in fact a critical part of systems thinking. A focus on causality has, for example, led to strong predictive models. Such models, in turn, relate to the dominant scientific mode of forecasting – where known causalities are extended into the future. Scientific forecasts, either for anthropogenic climate change, demographic change or biodiversity loss, are extremely useful tools in a decision-making context.

However, as aptly summarized by Dreborg (1996), there is a second, far less widely used mode of engaging with the future – namely that of backcasting. In backcasting, a desired ('normative') endpoint is defined, and then the means to reach such an endpoint are determined in response. Probably the most famous example of backcasting in practice was United States President Kennedy's decision to put a man on the moon 'before the decade is out' (Kennedy, 1962; Manning, Lindenmayer, & Fischer, 2006). The actual means by which this became reality were only systematically worked out after this bold (and at the time 'unrealistic') decision had been made. Causal relationships of course still exist when operating in backcasting mode, but causality is drawn on within firmly defined bounds of teleology – that is, 'the explanation of phenomena in terms of the purpose they serve rather than of the cause by which they arise' (Oxford Dictionaries, 2018). Backcasting thus allows for the creative pursuit of truly bold goals that will routinely fall outside the bounds of what forecasts based on current systems understanding predict.

How does this relate to leverage points? The hierarchy of leverage points proposed by Meadows (1999) and Abson et al. (2017) is unique in that it spans the full range of considerations from deeply causal to deeply teleological. Parameters, buffers and feedbacks among parameters thus fall firmly within the scope of causality;

whereas the goals pursued through a system, and especially the power to transcend the paradigm underpinning a system acknowledge that human agency, its normative direction and thus teleology fundamentally shape outcomes (Table 1, Figure 1). This, in turn, means that two frequently conflicting perspectives (causality and teleology) are integrated within one meta-perspective (leverage points) – providing a place where quite fundamentally different modes of thinking can meet.

Routinely integrating causal and teleological explanations of system change could lead to major breakthroughs in sustainability. Countless well-intentioned targets have been articulated in political documents – on climate change, biodiversity loss or sustainable development more broadly – but these often do not translate into sufficient action. Focusing solely on teleological means of bringing about change thus appears to be insufficient – concrete steps, based on an understanding of system causalities, need to be taken for an intended system trajectory to actually manifest. Put bluntly, rhetoric and targeted action (teleology and causality) need to be linked. A leverage points perspective provides a coherent framework that recognizes the joint importance of both teleology and causality as mechanisms of change.

3.2 | Digging deep

A second major benefit of a leverage points perspective is its explicit distinction of shallow versus deep types of interventions. Abson et al. (2017) emphasized the importance of deep leverage points, arguing that interventions at shallow leverage points had been used much more frequently for the pursuit of sustainability, but in many cases had evidently been insufficient by themselves. Three deep leverage points were specifically highlighted by Abson et al. (2017): (a) to restructure institutions so as to create conditions that favour sustainable behaviours by relevant societal actors (e.g. Ostrom, 2009); (b) to reconnect humans with the natural environment (e.g. Folke et al., 2011); and (c) to rethink how different types of knowledge interact and need to be drawn on to foster sustainability (e.g. Cash et al., 2003). While these three deep leverage points provide valuable starting points in many social–ecological systems undergoing change, there are countless other truly deep leverage points that are worthy of investigation. Examples include the notions of different worldviews (de Vries, 2013) or value orientations (Schwartz, 1992) and their influence on sustainability, the role of spirituality (Tolle, 2005) and religion (Pope Francis, 2015), or of compassion (His Holiness the Dalai Lama, 1999) and love (Fromm, 1956) as guiding principles for a sustainable future. Indeed, it is questions around worldviews and values that have recently stirred new discourses in the ecosystem services arena (Masood, 2018). Where these discourses lead remains to be seen, but a key point is that open discussions about worldviews and values are needed, since these shape and constrain interventions deemed plausible at more shallow levels of leverage (Fischer et al., 2012). Increased recognition of the importance of deep leverage points could help to facilitate such discussions in constructive ways.

3.3 | Recognizing interactions across leverage points

A leverage points perspective postulates that transformative change is unlikely if only shallow leverage points are acted upon; but it also recognizes that acting on deep leverage points (e.g. altering worldviews) is difficult in practice, even if the benefits could be substantial. Based on this, it may be particularly interesting to learn how shallow and deep interventions interact in different situations (Figure 1). For example, a recent study in Ethiopia showed that changes to rules related to the rights of women (a relatively deep leverage point) had led to changes in parameters (a relatively shallow leverage point) describing women's increased presence in public life, thus paving the way for men to gradually adjust their attitudes about women (a deep leverage point) (Manlosa, Dorresteijn, Schultner, & Fischer, 2018).

Interactions between leverage points such as in the example above suggest that there are 'chains of leverage' that can be studied; describing how one type of change in a system precipitates another, across different depths of leverage. A working hypothesis is that if such chains do extend to deep leverage points, then a given chain of leverage has the potential to bring about transformative change. In contrast, a chain that only involves shallow leverage points is unlikely to effect transformation. This framing provides a new lens for how to study change in systems, and provides new impetus to connect different bodies of empirical and theoretical work – linking, among others, changes in institutions, practices and values in new, largely unexplored ways.

3.4 | Providing a methodological boundary object

There are three primary modes in which sustainability science might generate insights – through conceptual work, qualitative empirical work or quantitative empirical work. The integration of these modes benefits from boundary objects – that is, perspectives or concepts that facilitate inter- and transdisciplinary communication and collaboration by offering a shared vocabulary and narrative (Star & Griesemer, 1989). Prominent examples of boundary objects in sustainability science include resilience (Folke, 2006) and ecosystem services (Costanza et al., 1997; Daily, 1997), which have been successful partly because they have functioned at multiple levels, for multiple users (Strunz, 2012). Both ecosystem services (Ehrlich & Ehrlich, 1981) and resilience (Holling, 1973) started out as concepts or even metaphors, but quickly opened up to increasingly sophisticated qualitative and quantitative applications (e.g. Bateman et al., 2013; Carpenter, Walker, Anderies, & Abel, 2001).

A leverage points perspective also can be engaged from multiple methodological angles. This, in turn, generates the potential to attract numerous different scholars, and importantly, creates the potential for different types of scholars to collaborate by using a leverage points perspective as a boundary object. For example, conceptual work might examine how different potential changes in a system may translate to interventions at shallow or deep leverage

points (e.g. Ives et al., 2018), thus using leverage points largely as a metaphor. Qualitative methods may be used to elicit narratives of system change, tracing for example, how chains of leverage may unfold in a given system. Various quantitative methods could also be used, including in a process modelling context (e.g. Meadows et al., 1972) but also in the context of statistical analyses of relationships among different variables denoting a given system's state with respect to different realms of leverage.

Finally, our personal experience in a transdisciplinary context has shown that a leverage points perspective has considerable appeal to non-academic audiences. This is critical because decision-making power usually does not reside with scientists – narratives that also speak to other stakeholders are therefore critical to generate sustainability 'ripple effects', where different actors learn from and inspire one another (Everard et al., 2016). Especially at a metaphorical level, the notion that we need to look more deeply for what needs to change speaks to the growing sense of dissatisfaction felt by many people in increasingly modernized societies (Eckersley, 2016). Developing and using methods and communication tools, in turn, that different audiences can relate to is a critically important priority for sustainability science (Fazey et al., 2018). Like other successful boundary objects such as resilience and ecosystem services, a leverage points perspective could be valuable because it has both heuristic and practical appeal.

4 | CONCLUSIONS

We argued that a leverage points perspective holds considerable potential as a boundary object for sustainability science. We reiterate that no single silver bullet, conceptual or otherwise, will be able to turn around the self-destructive trends that have led to the proclamation of the Anthropocene. But still, history has proven that major changes in human behaviour do occur – the end of slavery or racial segregation, and increasing equality of women and men being examples of major changes that at some point would have seemed utterly unthinkable to contemporary analysts. Paradigm shifts and societal transformation are possible, arguably when the desire for change coincides with practical means to enact concrete measures. Through spanning the broad range of considerations from simple parameters to shifts between paradigms, a leverage points perspective might hold considerable promise for sustainability science.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

J.F. and M.R. conceived the ideas and wrote the manuscript. Both authors contributed critically to the drafts and gave final approval for publication.

DATA ACCESSIBILITY

This paper does not include any data.

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Current Opinion in Environmental Sustainability

Operationalising the leverage points perspective for empirical research

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Strategies to address the current unsustainable trajectory of our planet require deep transformations. The leverage points perspective can support such efforts for transformative change by motivating more research combining empirical and theoretical frameworks to understand the dynamics of complex social–ecological systems. We argue that the leverage points perspective can foster (i) a stronger engagement with plural ways of knowing (i.e. diverse epistemologies) and diverse, potentially divergent paradigms; (ii) a combination of methods to achieve a more comprehensive understanding of system dynamics; (iii) special attention to possible interactions between leverage points within a given system to design more effective interventions and (iv) the recognition of power imbalances and differing values to reach agreements, shared visions and codesigned actions.

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Advantages of the leverage points perspective

Despite global efforts, the current trajectory of our planet is unsustainable [1] — making it necessary to focus on a deep transformation of Earth's social–ecological systems [2–4]. Yet, deep transformation has been hindered by the difficulty to tackle underlying or indirect drivers of this unsustainable trajectory, as well as a focus on 'easy to fix', short-term solutions [5]. One approach to foster system transformation is Donella Meadows' seminal work on places to intervene in complex systems that bring about transformative change (i.e. leverage points) [4]. In recent years, the framing of 'leverage points' has gained increasing attention in sustainability and transformation discourses. It has been used to engage with policy [6,7], biological conservation [8], Indigenous and local knowledge [9], gender-transformative changes [10] and climate-change adaptation [11], and has been taken up by the IPBES [12], especially in its currently ongoing assessment on transformative change.

Leverage points are places to intervene in a system (Meadows 1998). They are parts of complex, social–ecological system that can be acted on in order to induce change. Leverage points can be classified into fundamental (deep) and superficial (shallow) ones. Interventions at deep leverage points have greater potential to change a system, while interventions targeting shallow leverage points have minor influences on the system as a whole. The distinction between shallow and deep leverage points, hence, describes the extent to which it can alter a system's trajectory and transform it. Following Abson et al.'s classification [5], more shallow places to intervene include parameters and feedbacks (see Table 1 for details). Deeper places to intervene include the design and the intent of a system, not least because changing system design and intent automatically has repercussions for feedbacks and parameters of a system [4,5] (see Table 1). The specific leverage points depend on the type of system, the system boundaries, goal and aim of the research and so on. As a novel approach that has only started to receive increasing attention in sustainability research, questions of how leverage points operate, are linked or acted upon, are important questions that future research should examine.

Building on this work, a leverage points perspectivehas emerged as a new, epistemological view of systems and fostering system transformation [13], which complements, rather than substitutes, other systems' approaches [14]. It provides a new lens for how to study change in

Table 1

Glossary of terms used regarding the leverage points perspective as defined in references [4,5,8].

System transformation	Radical change of systemic interlinkages and systems behaviour with fundamentally different sustainability outcomes
Leverage points perspective	A leverage-point perspective recognises increasingly influential leverage points from shallow to deep within a given system, with the advantages to act as analytical tool, metaphor and methodological boundary object
System characteristics	The four system-characteristic parameters, feedback, design and intent are a nested hierarchy and tightly interlinked. Changes to parameters and feedbacks are seen as relatively shallow interventions for system transformation, whereas changes to design and intent allow for deeper system change.
Intent	1. Power to transcend paradigms 2. Mindset or paradigm that the system — its goals, structure, rules, delays and parameters — arises from 3. Goal of the system
Design	4. Power to add, change, evolve or self-organise system structure 5. Rules of the system 6. Structure of information flow
Feedback	7. Gain around driving positive feedback loops 8. Strength of negative feedback loops, relative to the effect they are trying to correct against 9. Length of delays, relative to the rate of system changes
Parameters	10. Structure of material stocks and flows 11. The size of buffers and other stabilising stocks, relative to their flows 12. Constants, parameters and numbers
Leverage points	Places in a complex system where small interventions can have wide- ranging influences to bring about system change and where the right kinds of intervention hold great potential for system transformation
Interventions	Concrete actions taken. The outcome of appropriate interventions can foster sustainability. The phrases 'levers' and 'interventions' are sometimes used interchangeably in the literature

systems and provides new impetus to connect different bodies of empirical and theoretical work [1]. The key strengths of a leverage points perspective [13,15] are, among others, (i) the explicit recognition of difficult to act upon but influential 'deep' leverage points [16,17], (ii) a focus on interactions between shallow and deep system changes that can strengthen the transformative potential of interventions [9,10], (iii) the combination of causal explanations and goal-oriented, purposeful action research [18,19] and (iv) the ability to foster inter- and transdisciplinary research [20–22].

In this paper, we will not focus on how leverage points can be identified in specific systems, but rather discuss how this emerging epistemological view of systems can be operationalised in the empirical research process — from (i) navigating diverse scientific paradigms in the design of research projects; (ii) choosing research methods; (iii) gauging the likely transformative potential of interventions; to (iv) possibly implementing interventions.

Operationalising the leverage points perspective

Setting up the empirical research: navigating scientific paradigms

To solve complex social–ecological problems, diverse ways of knowing and different knowledges (i.e. plural epistemologies [23,24] such as scientific knowledge, Indigenous or local knowledges) and different paradigms need to be brought together. As a contrast and example, environmental conservation and management have traditionally been performed based on disciplinary or sectoral understandings [25–27], instead of taking into account interactions among ecosystem elements or stakeholders [25,28,29]. Such forced fragmentation, symptomatic of a 'normal science paradigm' [30,31], can lead to a focus of science on external advice and the reinforcement of top-down interventions, rather than coproduction of knowledge [32,33]. This, in turn, can create conflicts if various initiatives such as conservation projects are implemented without the full understanding of the knowledge, values or perspectives of diverse stakeholders [34,35]. To counter such fragmentation and focus on scientific advice, calls have emerged for a democratisation of science, such as 'postnormal science' (in which "facts are uncertain, values in dispute, stakes high and decisions urgent" [30:744]), or 'mode 2' research (i.e. research based on nonlinear, transdisciplinary knowledge coproduction by heterogeneous groups (e.g. [36,37]).

The leverage points perspective can assist in combining different scientific paradigms (see Table 1) with the aim to foster a sustainability transformation. To create a more comprehensive understanding of a system, including the type and direction of transformation desired by stakeholders, the leverage points perspective allows

Table 2

System characteristics, examples of the scientific paradigm with which they are usually researched, and examples of research methods.

System characteristic	Examples of science paradigms	Examples of methods
Parameters	Mono- and multidisciplinary, *a posteriori* ethics [31]	Statistical modelling Causal-loop diagrams [2]
Feedback	Causal explanations	Red-loop green-loop model [39]
Design	Inter- and transdisciplinary [28] Ontological and epistemological pluralism [38,40]	Institutional analysis and development framework [41] Three-Horizon [42]
Intent	*A priori* ethics [31] Relational thinking [16] Teleological focus [19]	Participatory Geographic Information Systems [43] Ontological encounters [44] Backcasting [45]

to combine the paradigms of normal and postnormal science. The analysis of parameters and feedbacks, for instance, is often based on paradigms in 'normal science' and explains causal and historical relationships [31]. The study of a system's design and intent, by contrast, draws on 'postnormal science paradigms' [31,38] with a more normative, solution-oriented (instead of a problem-oriented) focus. For an overview, Table 2 shows examples of scientific paradigms that are often linked to specific system characteristics (see [32] for an in-depth discussion on this). By using the leverage points perspective to design a research project, various scientific paradigms can be bridged between, for example, different actors (that engage with one specific scientific paradigm), different stages of a research project (starting with a normal science approach and then venturing into postnormal science) or between different methods (see below).

Conducting empirical research: combining methods

The leverage points perspective deals with multiple parts and characteristics of a system, therefore, the approach entails the use of plural methods that could be suitable for such a comprehensive understanding. The perspective thus functions as an umbrella under which different methods based on different scientific paradigms can be combined in complementary ways. This aligns with the nature of sustainability science, which spans multiple scientific communities, providing many methodologies and methods to draw upon. As we will show, some methods can be modified and adopted to incorporate deep and shallow leverage points, as well as connecting causal, past relationships with present interventions for a desirable future.

Tools in the realm of shallow leverage points focus more on past and present system states and often involve quantification of system elements. Yet, many methods that have their primary focus on explaining causalities, can be modified to include a deep leverage points perspective. One example is the 'red-loop green-loop model', which focusses primarily on causal relationships to understand systems [39], but can be adopted to include a focus on deep leverage points. Highlighting feedbacks can be a tool to focus on how system variables influence each other, but can also help to identify influential domains of leverage. When identifying feedback loops in a coral reef social–ecological system in Jamaica [46] caused by an unsustainable trajectory of overfishing and reef degradation, the leverage points perspective helped to identify possible interventions in the country. By analysing past trends of the social–ecological systems, the authors identified that a value change of the local population regarding Jamaican fish species through Eco-Labels or implementing export bans for fish could strengthen the local markets and alleviate food insecurity and may create a more sustainable future for the Jamaican coral reef social–ecological system.

Tools in the realm of deep leverage points often use participatory and transdisciplinary approaches across different academic disciplines and sources of knowledge, while also applying other methods to identify causal links. A common example is participatory scenario planning [47]. This method enables engagement with diverse stakeholders to identify plausible future trajectories that are not bound by present limitations [42]. To create a shared understanding of the past and a shared vision for the future, projects can rely on methods primarily linked to 'normal sciences' such as causal-loop diagrams [48], participatory modelling [49,50] or Participatory Geographic Information Systems [43] (see Table 2). Another example of using methods, which aim for causal explanation to uncover deep leverage points, can be gender-transformative approaches that engage with deep social and gender norms that drive social practices [10]. Household methodologies such as the Gender Action Learning System developed by Oxfam Novib and implemented in sub-Saharan Africa [51] are examples of interventions that work with deep-seated gender beliefs, relations and norms with the aim of transforming these to promote gender equality [52].

Such combinations of methods, which uncover different leverage points, from shallow to deep, may help facilitate knowledge coproduction while including a focus on situated, lived experiences of places and land-/seascapes. Further, using the leverage points perspective can enable

researchers across different disciplines as well as nonacademic actors to come together to work in disciplinary, inter- or transdisciplinary ways, while working for a shared goal of finding leverage points for sustainability transformation.

Transformative potential of interventions: combining leverage points

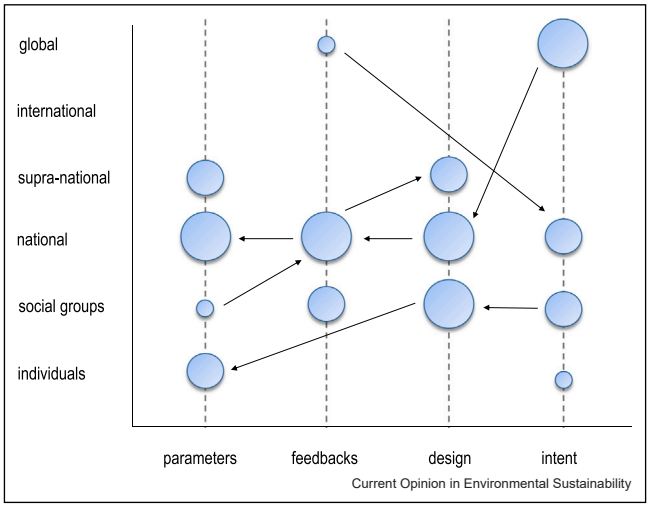
Having engaged with diverse scientific paradigms and methods, it becomes possible to analyse how certain proposed interventions might interact to transform a system.

Because social–ecological systems are complex [53], interventions can have unintended consequences if the system is not well understood [3,4]. Likely interactions among leverage points make it necessary to describe how one type of change in a system precipitates further changes, across different systemic depths (i.e. at the levels of parameters, feedbacks, design and intent) [18].

In social–ecological systems, it is likely that paradigmatic change — a dialectical change of worldviews, mindsets and beliefs — precedes changes in system feedbacks and parameters (deep-to-shallow change). Alternatively, changes in parameters could also pave the way for a questioning of system goals and paradigms (shallow-to-deep change). Work on gender in a rural landscape, for example, showed that changes to rules related to the rights of women (a relatively deep leverage point) led to changes in parameters describing women's increased presence in public life (a relatively shallow leverage point), thus paving the way for men to gradually adjust their attitudes about women (a deep leverage point) [10].

Within the leverage points perspective, such 'chains of leverage' — that is, sequences of how shallow, mid-level, and deep systemic changes flow on from one another (see Figure 1) — can highlight possible mismatches or inadequacies of interventions at different levels of systemic depth. Research on formal and informal agricultural institutions in Ethiopia, for instance, showed a clear mismatch between the system goals and intent at the national level versus the goals and intent in specific rural landscapes [7]. The national government used formal institutions to intervene in the social–ecological system with the goal to strengthen agricultural production and efficiency. Existing local informal institutions, however, focused on strengthening trust, collaboration and shared labour. Our initial analysis suggests that formal and informal institutions pursue the same overarching goal, namely to increase food security. However, the intent encapsulated in formal institutions prioritises cash flow and monetarised productivity, while the system intent encapsulated in informal institutions prioritises shared and secure local livelihoods. Different intents are thus pursued at different levels of the system, by different actors, causing mismatches and leading to sub-optimal sustainability outcomes. In this case, because the national government is more influential than local people, informal institutions are gradually being eroded by formal institutions (and their encapsulated intent) [7].

Figure 1



Graphical representation of possible interactions among leverage points. Different, multifaceted system elements (circles) interact across multiple levels of systemic depth, that is, leverage points (system parameters, feedback, design and intent) and scales (individual to global). In addition, there are possible interactions among multiple levels and scales that can shape the trajectory of the system. Some of these interactions can create chains of leverage, that is, nested elements influencing each other. The size of the circles illustrates the strength of the influence of a particular element. The bigger the circles are, the more influential a particular element is. For example, a global system intent of economic growth (represented by global players) may have a stronger influence on the system trajectory and thereby override a local system intent carried by social groups, who may wish to pursue alternative economic paradigms. Arrows indicate links and directionality of influences — for example, a global intent can influence feedbacks and parameters on different scales. 'Chains of leverage' can unfold from deep to shallow, but also from shallow to deep. The figure is adapted from unpublished text by J. Hanspach. (unpublished).

Interactions among leverage points thus exist both in the form of 'chains of leverage' (e.g. shallow to deep vs. deep to shallow, see above), but also through possible contradictions within the same level of system depth. A leverage points perspective can help to unravel — and ultimately resolve — such inconsistencies (Figure 1). Key research questions are which actors are influential for which level of system depth and how well the different system levels align across multiple system levels and actors.

Implementing interventions: addressing differences in values and power imbalances

Not least because of the complex interplay among diverse actors and potentially conflicting agendas at

different scales, researchers have to be mindful of differences in values and power imbalances in decision-making structures. A leverage points perspective can help navigate differences in vision and codesign of interventions for transformation, as well as foster dialogue between divergent understandings of system intents and definitions of parameters and feedbacks. Such a dialogue can reveal different values and assumptions about entities and their constitutive relations (i.e. different 'ontologies' [44]).

Without such dialogue, the implementation of interventions might lead to inconsistencies, or to conflicts and coercion among actors with asymmetric power-relations [44]. Instead of promoting solution-oriented deliberations based on diverse, coexisting values, implementations can result in the imposition of a single perspective and dominance of a single interest [54] (see previous section for an example). Creating concrete interventions, hence, requires researchers and decision-makers to develop an openness towards the dialectical processes of the implementation of action concerning different understandings of types of knowledge and policies [31]. Values and assumptions about entities and their constitutive relations influence the system design and intent and directly shape parameters and feedbacks. Thus, the dialectical process of defining leverage points and interventions influences the interpretation of the social–ecological system (and its boundaries) and affects the implementation of results.

Moreover, there could be a power imbalance between the actors involved and the agency to act upon identified interventions. For example, an analysis of chains of leverage might identify transformative potential in a shift to alternative economic paradigms, yet, local individuals might lack the agency to intervene in this leverage point. A mismatch between the scales of interventions (i.e. changing the design of a system on a global scale) and the actors involved (i.e. local farmers) might not conduct itself to foster transformative interventions but only highlight potential leverage points. For example, research in Germany showed that rural inhabitants and farmers were often aware of the unsustainability of intensified agriculture that came with the pressure to grow and intensify their family farms. However, this pressure stemmed from system dynamics they felt unable to change — neither individually nor as a group [55]. Research needs to create space and time for iterative cycles of feedback and dialogue about the diversity of stakeholders, their perspectives and power-relations that otherwise would be overlooked [56]. Stimulating the dialogue about underlying values and assumptions of social–ecological systems can strengthen the implementation of interventions by increasing participation and social legitimacy [54]. This must necessarily be accompanied by a change in the way scientific research is funded, allowing the process of long-term social–ecological research.

The leverage points perspective has great potential for bridging differing values and assumptions by acknowledging that the limits of a system are subjective and negotiable [31]. It can promote more transparency in the underlying assumptions about constitutive relations influencing the dynamics of social–ecological systems and the values about which relations are important and morally right [13,17]. The definitions of the system's boundaries and domains of leverage reflect these types of assumptions. Recognising this as a dialectic entanglement can be the basis for guiding possible agreements on interventions for sustainability transformation.

Conclusion

When operationalising a leverage points perspective, it is important to make clear decisions about scientific paradigms, methods and ways to foster meaningful sustainability transformation. With this paper, we aimed to highlight the new lens that a leverage points perspective can provide in studying system changes. We provided pointers and examples on how the leverage points perspectives can be operationalised in research — from reflecting on scientific paradigms to implementing interventions. The integration of plural ways of knowing and different paradigms can better inform the assessment of consequences of interventions, trajectories of the system and relevant domains of leverage to intervene in. This can be useful to analyse chains of leverage and understand how interventions work on parameter, feedback, design and intent level, and how contrasting system intents can hinder the successful implementation of interventions. By building on multistakeholder collaborations, interventions can gain genuine agility and flexibility to bridge approaches that focus on causal and shallower leverage points, and those that focus more on purposeful and deep leverage points. This operationalisation can lead the leverage points perspective towards more democratic, scientific paradigms based on pluralistic dialogues from which innovative solutions for sustainability transformation can emerge.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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PERSPECTIVE

Leverage points to foster human–nature connectedness in cultural landscapes

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Abstract Calls for a reconnection to nature and the biosphere have been growing louder over the last decades. Cultural landscapes are rapidly changing, posing a threat to ecosystems and biodiversity, but also to human–nature connections. Human–nature connectedness may be a potential lever to shift the unsustainable trajectory that we are currently proceeding, but is also negatively influenced by it. To concretize the call for a reconnection to nature, we used the leverage points perspective on five empirical case studies with focus on human–nature connectedness. Based on the synthesis of our yearlong work, in this perspective paper, we propose four leverage points to foster a sustainability transformation: (1) maintain and enhance the structural diversity of landscapes, (2) maintain and enhance economically and ecologically sustainable small-scale agriculture, (3) strengthen sense of place and (4) strengthen sense of agency in actors. Intervening in these leverage points could be effective to foster human–nature connectedness and ultimately contribute towards a sustainable trajectory. We further argue that the interconnection between leverage points is equally important as their systemic depth.

Keywords Human–nature relations · Land use change · Sense of agency · Sense of place · Sustainability · System change

INTRODUCTION

Cultural landscapes are currently under change—be it through agricultural intensification and building activities or abandonment—posing threats to ecosystems (Young et al. 2005; Bürgi et al. 2017) and biodiversity (Green et al. 2005; Tscharntke et al. 2005), including the diversity of crop varieties (FAO 2011) and therewith food security (Fischer et al. 2017). Apart from ecological degradation, landscape change can negatively affect the local community structure and traditional cultural heritage of a landscape (Riechers et al. 2020a, b). We have already crossed planetary boundaries (Steffen et al. 2018) creating a sustainability gap (Fischer et al. 2007). Despite all global efforts, this sustainability gap is rather growing than closing (Fischer et al. 2007) making it necessary to focus on a deep transformation of our social–ecological systems (Meadows 1999). Yet, deep transformation has been hindered by the difficulty to tackle underlying drivers of landscape change and a focus on "easy to fix", short-term solution (Fischer et al. 2012).

One of such transformative shift could come through the reconnection with nature (Abson et al. 2017) because it may halt the current global environmental crisis (Nisbet et al. 2009; Folke et al. 2011). While a reconnection with nature could be a remedy for an unsustainable landscape trajectory, connections to nature are also influenced by it. Recent studies have facilitated a growing recognition that landscape change erodes human–nature connectedness (HNC) (Chan et al. 2016). Many calls for 'reconnection' have remained vague and lack concrete insights about how to strategically foster comprehensive HNC (Ives et al. 2018) on a landscape level. In this paper, we address this research gap by presenting leverage points to foster HNC.

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Leverage points are places in a complex system where small interventions can have wide ranging influences to bring about transformative system change (Meadows 1999). Leverage points have been categorized into 12 places to intervene in a system (Meadows 1999) and clustered into four system characteristics namely (1) parameters (e.g. constants, buffer stocks), (2) feedbacks (length of delay, strength of feedback), (3) system design (information flow, rules) and (4) the system intent (goals, paradigms) within which different interventions may be made (Abson et al. 2017) (see Box 1 for glossary). One of the main arguments is that these four system characteristics are encapsulated by the system with increasing order of effectiveness (from shallow to deep) for a system transformation. Therefore, interventions at deep leverage points have greater power to influence the system, while interventions targeting shallow leverage points would produce smaller changes in the system as a whole.

We used the leverage points perspective (Fischer and Riechers 2019) as an analytical tool to illustrate four leverage points with promising potential to cause positive ripple effects across five different cultural landscapes. In this paper, we aim to understand different leverage points that foster human–nature connections, and secondly, we explore which interventions may have positive flow-on effects on the overall landscape trajectory with regard to sustainability. This perspective paper is structured as follows: First we explain the theoretical background to classify dimensions of HNC (material, experiential, cognitive, emotional, philosophical) as seen in Ives et al. (2018), and how it relates to the case studies we draw upon in the paper (Tables 1, 2). Second, we summarize the empirical background of this perspective paper (details found in supplementary S1 and S2). Third, we discuss four leverage points that may foster HNC in the five different cultural landscapes, for which we refer to the system characteristics of parameters, feedback, design and intent by Abson et al. (2017). Fourth, after this discussion, we focus on the interlinkages between those leverage points to highlight the necessity to address relationships and interdependencies of leverage points to achieve the greatest leverage potential.

Box 1 Description of terms used regarding the leverage points perspective. These descriptions are partly direct quotes from the sources named below, partly defined or edited by the authors

- *System transformation* radical change of systemic interlinkages and systems behaviour with fundamentally different sustainability outcomes.
- *Leverage points perspective* a leverage points perspective recognizes increasingly influential leverage points from shallow to deep, encapsulated by a given system that can be used as analytical tool, metaphor and methodological boundary object.
- *Realms of leverage* overarching 'thematic areas' which have the influence to transform the system across all four system characteristics.
- *System characteristics* The four system characteristics parameters, feedback, design and intent are a nested hierarchy and tightly interlinked. Parameters and feedbacks are seen as shallow for system transformation, design and intent allow for a deeper system change.
- *Leverage points* places in a complex system where small interventions can have wide ranging influences to bring about system change and where the right kinds of intervention hold great potential for system transformation.
- *Levers* interventions that can foster change. Levers are often intuitive, but the direction in which such levers should be 'pulled' may not be.
- *Interventions* Concrete action taken improves situation and fosters sustainability. Levers and interventions are sometimes used interchangeably in the literature.

Sources Meadows (1999), Abson et al. (2017), Fischer and Riechers (2019), Dorninger et al. (2020)

THEORETICAL BACKGROUND

Human–nature connectedness as realm of leverage

European landscapes are rich in culture as well as biodiversity with connections between humans and nature playing critical roles (Hartel et al. 2014; Elands et al. 2018). Studies show that, for example, emotional and experiential connections with nature may have positive outcomes for human well-being (Capaldi et al. 2014) or pro-environmental behaviour (Hedlund-de Witt et al. 2014), promoting in turn environmental and heritage conservation initiatives (Miller 2005). In this perspective paper, we will be using the term human–nature connectedness (HNC) to describe a myriad of connections between humans and their natural environments.

We operationalized HNC by using a multi-dimensional conceptualization (Ives et al. 2017, 2018): A material dimension, including food, fuel, and other natural goods; an experiential dimension relating to activities in nature; a cognitive dimension capturing awareness and knowledge; an emotional dimension, including spirituality, aesthetics and sense of place; and a philosophical dimension relating to conceptions of humanity's place in nature (Table 1). We are aware that the literature of this topic is based on decades long research in various, often fragmented, disciplines, such as studies on the 'connectedness to nature scale' (Mayer and Frantz 2004), 'nature relatedness' (Nisbet et al. 2009), 'connectivity with nature' (Dutcher et al. 2007) or 'relational values' (Muraca 2011). In this paper, we do not aim to give a literature review or an in-depth analysis of those categories but give balanced and therefore simplified overarching connections of these dimensions with the leverage points perspective. For a

Table 1 Dimensions of human–nature connectedness (HNC) with exemplary conceptual background and example references, and relating broad summary of the empirical results. For a more detailed description of the five dimensions of human–nature connectedness, see Ives et al. (2017, 2018). For a more detailed analysis of the different human–nature dimensions relating to the case studies, see (Balázsi et al. 2019) for a focus on the Romanian case studies, (Riechers et al. 2019) for the German case studies, and (Riechers et al. 2020a, b) for a comparison of both countries

HNC	Exemplary conceptual background	Summary of the empirical studies
Material	Focusses often on food, fuel, or other goods (Wackernagel et al. 1999; Haberl et al. 2004; Dorninger et al. 2017)	Stemming from the use of fuel (biogas, wood), food (collected, self-grown), building material, the collection of artisan goods, owning land, agriculture and forestry, and the use of regional products
Experiential	Especially activities in nature Soga and Gaston (Miller 2005; Keniger et al. 2013; Soga and Gaston 2016)	Identified as frequent nature visits, especially close to home; includes recreation, social activities in nature, stimulation of the senses, motoric development
Cognitive	Spans elements such as spirituality, aesthetics and place attachment (Kals et al. 1999; Stedman 2003; Brown and Raymond 2007)	Described as learning by doing, observing in nature through an active awareness of the daily encounters with nature, self-identification with the landscape, knowledge about the environment and farming practices, knowledge and visibility of specific historical events and cultural sites
Emotional	Captures awareness and knowledge about natural systems (e.g. Bradley et al. 1999; Schultz 2001; Schultz 2002)	Includes love for nature, spiritual and religious connections to it, aesthetics, feeling inspired and creative by being in nature, strong sense of place, curiosity to look for new and special encounters or experiences in nature, also negative emotions, such as fear and sadness regarding the state of the landscape
Philosophical	Relates to conceptions of humanity's place in nature (e.g. van den Born 2008; Raymond et al. 2013)	Differing notions of sustainability, on consumerism and the constant need for growth, environmental protection, preservation of traditions, the highlighted responsibilities of agriculture and forestry, the definition of nature (and for whom it is)

Table 2 Overview of the case studies with focus on human–nature connectedness that informed the perspective piece. See also supplementary S1 and S2. *Sources* Relevant literature for Romania: (Solyom et al. 2011; Hanspach et al. 2014; Hartel et al. 2016; Horcea-Milcu et al. 2017; Balázsi et al. 2019; Klaniecki et al. 2019); for Germany: (Guerrero et al. 2012; Brandt and Glemnitz 2014; Hallmann et al. 2017; LSN 2019a; LSN 2019b)

Region	Name, county	Case study description	Methods used
Lower Saxony (Germany)	Bispingen, Lower Saxony	Partly inside the Lüneburger heath nature park. Environmental protection laws have slowed down landscape change because of restrictions to agricultural intensification and large-scale infrastructure projects. 30% of the total land area (in 2017) of Bispingen is used for agricultural practices	Qualitative interviews (n=17); qualitative content analysis
	Dötlingen, Lower Saxony	More rapid landscape change over the last decades. 65% of total surface in Dötlingen is used agriculturally (in 2017), predominantly as cropland. Associated drivers have included EU agricultural subsidies and national subsidies for renewable energy production	Qualitative interviews (n=17); qualitative content analysis
Transylvania (Romania)	Erdővidék, Covasna	A smallholder-dominated cultural landscape with large patches of forests, grasslands and abundant wildlife. Driven by socioeconomic and institutional change, increases in both land abandonment and intensification are considered possible in the near future	Qualitative interviews (n=20); qualitative content analysis
	Aranyosszék, Cluj & Alba	Flat, crop-dominated and subject to strong urban influences due to its proximity to the cities of Cluj-Napoca and Turda. Land use intensity has increased, and smallholder vegetable cultivation has been increasingly replaced by industrial croplands	Qualitative interviews (n=19); qualitative content analysis
	Pogány-havas, Harghita & Bacău	Small land holdings, with most inhabitants practising semi-subsistence farming, extensive livestock grazing, and hay meadows maintenance. The region is home to some of the most biodiverse and productive pastures and meadows in Europe and numerous threatened species	Face-to-face questionnaire (n=379); statistical analysis

more comprehensive overview of this topic, we therefore refer to Restall and Conrad (2015) and Ives et al. (2017).

Methods and empirical background

In this perspective paper, we draw on five empirical case studies that have looked specifically at HNC and on our own knowledge and experience (Fazey et al. 2006) living and working in cultural landscapes. Our empirical case studies were located in Transylvania, Romania (Erdővidék, Aranyosszék, and Pogány-havas) and Lower Saxony, Germany (Bispingen and Dötlingen) (see Table 2, Figure S1). The study areas showed differing rapidity and extend of landscape changes, yet all experienced landscape simplification. Table 2 and S1/S2 show a detailed description of all five cultural landscapes and methods used.

In four study areas (Erdővidék, Aranyosszék, Bispingen, Dötlingen), we used problem-centred interviews (Flick 2006), to understand different dimensions of human–nature connectedness, the relation between these dimensions and how they are influenced by landscape change. Our interview guideline included sections on interviewees' material, experiential, cognitive, emotional, and philosophical connectedness. Regarding landscape change, we asked specifically for perceived changes in the last 20 years, how these influenced interviewees' lives and how interviewees perceived the trajectory of changes for the coming 20 years. We interviewed a diversity of informed laypersons and experts who we expected to be connected to a given landscape, resulting in 73 interviews (Table 1). Data were analysed using summarizing qualitative content analysis (Mayring 2008). Based on concepts used in human–nature connectedness research (Ives et al. 2017, 2018), we created a deductive coding tree which was iteratively adjusted inductively, driven by the narratives and topics raised by the interviewees.

In the Pogány-havas microregion, we used a face-to face survey (n=379). The questionnaire consisted of four sections: demographics, energy acceptability, environmental values, place attachment, energy conservation attitudes and behavioural intention. Three dimensions of place attachment—place dependence, place identity and nature bonding—were assessed. We performed several analyses to understand the relationships between the dimensions of place attachment, energy conservation attitudes and behavioural intention. We further used a cluster analysis as our primary data analysis technique in an attempt to identify homogenous groups within our population that would be characterized by similar norms, practices and material culture.

Based on these empirical studies, the authors used the leverage point perspective to synthesize the separate results to this comprehensive overview. Using the original data and results, we first identified common leverage points to foster HNC in cultural landscapes and then classified these on a scale from shallow to deep.

RESULTS AND DISCUSSION

Leverage points to foster HNC in cultural landscapes

In the following, we highlight four concrete leverage points that can result in observable changes within a system along with their practical recommendations on how to address them. We draw from our empirical research and show examples from Romania and Germany. The leverage points are as follows: (1) maintain and enhance the structural diversity of landscapes, (2) maintain and enhance economically and ecologically sustainable small-scale agriculture, (3) strengthen sense of place and (4) strengthen sense of agency in actors.

Maintain and enhance the structural diversity of landscapes

Due to system-wide feedback loops (e.g. intensive land use, soil degradation), landscape complexity and ecological resilience are decreasing all over the globe (Foley et al. 2005). For example, in one of our study areas (commune Dötlingen, District Oldenburg, Germany), the percentage of area used for intensive maize production nearly doubled in 20 years (Landesamt für Statistik Niedersachsen 2018a, b) causing a homogenization of cultivated crops (e.g. Linhart and Dhungel 2013). Apart from the ecological contributions of structurally complex landscapes, our studies showed positive connections to relational values, such as cultural and individual identity (Riechers et al. 2020a), and to traditions regarding small-scale farming (Fischer et al. 2012; Molnár et al. 2015). This could mean that there is a reinforcing feedback loop between structurally complex landscapes and structurally rich social relations—that could act as a deep lever to foster sustainability (Riechers et al. 2019).

In all our five cultural landscapes, a perceived structurally complex landscape was related to several dimensions of HNC. Our study participants saw structural landscape diversity as beautiful and connecting inhabitants emotionally to landscapes. The structural landscape diversity was seen as an expression of a character of a landscape, which increased inhabitants' sense of place. Respondents stated that places of high structural landscape diversity foster awareness and knowledge for nature and hence visited and loved them more. Yet, in all study areas, landscapes were subject to simplification through intensification of land use as well as the abandonment of

agricultural land. Generally, structural landscape diversity is rooted in materials (e.g. amount of land used for certain purposes) yet influences a wide range of HNC and hence becomes a deep leverage point. For example, on a material level, structurally complex landscapes are key to protect terrestrial ecosystems and its biodiversity, especially for wild (Green et al. 2005) and farmland biodiversity, presenting a buffer for negative effects of intensive agriculture (Tscharntke et al. 2005). This means that a material connectedness may be heightened by a diverse landscape that enables a diversity of local products, while also increasing possibilities to work and relax in nature (experiential connectedness). Complex landscapes maintain diverse layers of formal and informal knowledge on nature and practices how to manage it, and can increase memories and bonds to structural elements (e.g. trees, roads, view, beauty) of the landscapes.

Maintain and enhance economically and ecologically sustainable small-scale agriculture

Our experiences highlight that small-scale agriculture contributed greatly to all dimensions of connectedness through, for example, regional products, sense of place, aesthetics and time spent in nature. It links to the cultural heritage of a landscape, giving it its aesthetic mosaic structure, and features of traditional management and local identity. Landscape change stemming from intensification or abandonment of agriculture can alienate inhabitants from 'their' landscapes emotionally, materially and experientially. Especially, small-scale farms were expressed to strengthen knowledge and interaction with nature, while large industrialized ones foster controversies about landscape ownership, economic gain and development. Yet, due to a global system intent, the land use became driven by economic efficiency, leading, in turn, to intensification and accumulation of resources in the hands of few people or companies. Farmers and foresters face common challenges all over the world (De Haan et al. 2001; Stringer et al. 2008), which is due to the prevailing global economic growth paradigm (Pedroli et al. 2007; Zimmerer 2007). A significant percentage of small-scale farms produce market commodities in Europe (Labarthe and Laurent 2013) and are of specific importance for income diversification in rural areas (European Commission 2003). Small-scale farms can alter parameters, such as those regarding biodiversity and ecological resilience (e.g. birds Nagy et al. 2009; or butterflies Konvicka et al. 2016) and can generally increase landscape complexity by enhancing crop diversities (FAO 2011).

Studies show that family farming, that is farming in shared small groups, as is traditionally practised in many areas of Transylvania has substantial production advantages to intensive farming (Mathijs and Swinnen 2001; Sabates-Wheeler 2002). These small landholdings have been managed by traditional farming practices for generations, leading to high biodiversity (Biró et al. 2011). Further, Pedroli et al. (2007) stress the economic and social benefits of small-scale farming landscapes, especially for providing identity and inspiration (see also overview of positive effects of small-scale farming in Guiomar et al. 2018). This is captured in our own empirical results (Balázsi et al. 2019) and in the literature, as inhabitants who stated to be often in nature, linked this to material goods from nature (such as food, agriculture in general, or care for own land, see also Hawkes and Acott 2013) and to cognitive connectedness through learning by doing and experience (see, e.g. Collado et al. 2013; Tekken et al. 2017). However, future changes such as farm consolidation and rural depopulation are likely to impact human–nature connections, especially in rural regions of Romania. While land use is a domain grounded within shallow leverage points as in materials (e.g. land use, production) and processes (e.g. crop rotation, fertilizer use), it is bounded by the system intent and design which limit or allow sustainable land use (e.g. agricultural policies, institutional design that implement policies).

Strengthen sense of place

Based on the definition of Williams and Stewart (1998, p. 19), sense of place is "the collection of meanings, beliefs, symbols, values and feelings that individuals and groups associate with a particular locality". Meaning can be created through ecological (such as structural landscape diversity), social (community belonging, childhood) or social–ecological attributes (interactions with nature) by individuals or through collective meanings and shared experiences (Stedman 2002; Yung et al. 2003). Sense of place is said to combine place meanings and place attachment (Trentelman 2009; Brehm et al. 2013). In particular, place attachment is positively related to environmental action (Kals et al. 1999; Vaske and Kobrin 2001). In our case studies, a strong sense of place (emotional connection) was related to philosophical (e.g. preservation of traditions), material (e.g. regional products), cognitive (knowledge on regional history and culture) and experiential (social activities) connections to nature, bridging shallow and deep leverage points (see Fig. 1, but also e.g. Riechers et al. 2020b). Strengthening sense of place can hence increase especially emotional, experiential and cognitive connections and may empower the inhabitants and the region to gain and distribute more agency.

Our studies showed that sense of place was related not only to local identity, ethnicity, cultural identity, and languages and dialect, but also to sites of cultural heritage or

natural specificity (Balázsi et al. 2019; Riechers et al. 2020b). It linked to landscape and the history of the community, to a traditional way of life including village structure or the traditional construction of buildings. Respondents perceived this strong rooted feeling of home as a possible catalyst to preserve natural areas, traditional regional products or species, and bounded the community together. In Romania, we found that residents have strong attitudes and norms towards conserving resources and that environmental behaviour is strongly rooted in being a responsible steward of natural resources and in practising frugality in the face of low incomes. We also saw in our results a potential fragility of this stewardship because of globalization-generated changes, especially when human–nature disconnections increased (Balázsi et al. 2019). Furthermore, our study participants linked the desire to maintain traditional customs to their sense of place. People in the Romanian communities highlighted the need for interventions that should focus first on developing a reliable and affordable energy supply, as this was one of their main concerns, along with supporting traditional stewardship values, conservation attitudes and practices (Klaniecki et al. 2019). Our data suggested that the loss of sense of place may have led to an alienation of inhabitants' sense of home and belonging, including the social community to which they used to belong. Sense of place and agency seem more an expression of a systems design which can foster or hinder such expression (Riechers et al. 2019).

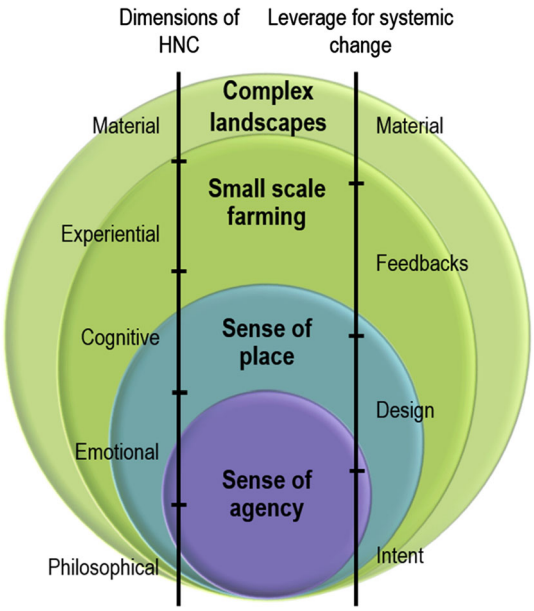

Fig. 1 A graphical depiction of the four crosscutting themes being nested from an ecological and physical landscape attributes level (structural complexity of landscapes) to a socio-cultural level (sense of agency), showing the interdependence and relationship between the crosscutting themes. *HNC* Human–nature connectedness

Strengthen a sense of agency in actors

The sense of agency inhabitants perceived to alter landscapes, land, and development trajectories influenced how they saw their role in nature. In parts of Germany, ownership and access to land got limited through a stronger intensification of agriculture and the accumulation of land in the hands of a few farmers. These land use changes did not necessarily correspond to inhabitants' values of a good life, but they felt incapable of changing this trajectory of intensification. This loss of agency led to a retreat from the landscapes. Interviewees often followed up by expressing feelings of apathy or frustration, cumulating into inaction or less active involvement. This includes retreating into home gardens when, for example, surrounded by highly intensive land use, or causes emotional alienation due to strong discomfort regarding the landscape (Riechers et al. 2019). Strong feelings of agency empowered inhabitants to tackle problems with their own hands, to create knowledge exchanges or NGOs and actively, in their private and public life, tried to influence a landscapes' trajectory to their choosing. Especially, in our study areas in Germany, we found a mismatch between inhabitants felt responsibility for landscapes and their perceived agency to alter them. This argumentation is reminiscent to social–ecological traps (Boonstra and de Boer 2014), in which behavioural responses reinforce unsustainable outcomes, here unsustainable landscape change (Steneck et al. 2011), because the system is designed in a way that restrict behavioural options. Or to use (Giddens 1984) terminology, it is comparable to structuration, a process of interactions between human action and conditions that (re) produce action. While inhabitants own desires may point towards a sustainable landscape (having their own different wish of a system goal), their own action and behaviour are guided by a system design that caters to an economic growth paradigm, inhibiting inhabitants influence on "their" landscapes and forcing farmers into ever-growing industrialized production.

Our German study sites showed that the idea of unlimited economic growth is criticized by the majority of our interviewees. Similarly, in Romania, rural inhabitants are concerned about unsustainable land use practices that occur with agricultural development, but still keep the informal knowledge of traditional farming that could be a source of inspiration for many sustainable practices. In Romania, community projects often failed because of lack of community or stakeholder support, or lack of shared information of people who have limited role in local decision-making. Additionally, limited resource availabilities and perceived sense of threat related to a further loss of place or property can make collaboration difficult. In rural communities in Transylvania, knowledge is an important driver

for helping people to make informed opinions in order to become vocal and feel empowered in taking decisions for their communities. By strengthening actors' and actor groups' agency through, for example, informal or formal education and strengthening social cohesion (Mikulcak et al. 2015), one could create capabilities for intervention. It can also be a lever to foster self- and re-organization of a system, opening the possibility to renegotiate system goals.

Interactions between leverage points

Based on our shared experience living and working in cultural landscapes, as well as our empirical studies, we see strong interactions between shallow and deep leverage points. Coming back to the classification of leverage points into parameters, feedback, design and intent (Abson et al. 2017), we see our four leverage points crosscutting a range of places from deep to shallow leverage points. Structural landscape diversity and small-scale agriculture are rooted in materials (e.g. land use, production) and processes (e.g. crop rotation, fertilizer use), yet both are bounded by the system intent and design which limit or allow sustainable land use. Both leverage points influence a wide range of human–nature connections and it is likely that structurally complex landscapes and structurally rich social relations may reinforce each other—acting as a deep lever to foster sustainability. Sense of place and agency seem more a combination of systems design and intent, which can strengthen or hinder such expression. Those two leverage points can also act as levers that help enable self- and re-organization of a system, opening the possibility to renegotiate its values and goals, embodied within a system of interest out of which they arise (see Fig. 1). We suggest that the interaction between shallow and deep leverage points is crucial to be understood for research and any future policy recommendations (Manlosa et al. 2018).

Interventions within these leverage points that could foster HNC are, however, scale dependent—showing differences between the individual, community or global level. In our case studies, especially the differentiation between a societal level of philosophical and material connectedness and their interplay with the individual level was relevant. A philosophical connectedness on a societal level captures much more the underlying paradigms, as exemplified by paradigms of economic wealth, social welfare and regulations and rules for environmental protection (Riechers et al. 2020b). For example, in Romania and Germany, the current paradigm is one of economic growth which is fostering telecoupling and teleconnections (Yu et al. 2013; Dorninger et al. 2017) of material flows in the regions. The societal material connectedness is hence characterized by an ever-increasing dislocation of production, use and consumption. Individuals do not have influence and agency over such globalized supply and demand chains. The possibility of this societal material connectedness to act as a leverage point is therefore limited. A shift towards a more sustainable landscape trajectory that emerges from an ecocentric worldview could be achieved by redesigning system goals on the ethics of environmental justice. This could be a powerful and deep leverage point (Schultz 2002) with multiple effects on shallow system characteristics such as parameters (e.g. environmental policies and regulations, prices of healthy products, expenditures for polluters). Further, a focus on personal sustainability of individuals could enhance a new paradigm and goal of the system (Ives et al. 2020) which might have ripple effects for the sense of agency, and sense of place people inherit (Plesa 2019; Sörqvist and Langeborg 2019).

Another linkage is the design of the system (deep leverage)—how information flows are structured, the rules of the system and the agency and power to change or self-organize the structure. In Romania, our studies point to institutional changes (through shifting political paradigms) that alienated people from the land and also created conflicts between political sectors and actors, due to unclear and conflicting legislation (van Dijk 2007; Levers et al. 2016; Balázsi 2018). One typical institutional failure is the situation of the small-scale farming (Hartel et al. 2014). Small-scale farmers, or peasants as they are preferred to be called, are marginalized and often pressured to sell or rent their lands by the agricultural industry. Further, the national food policy limits how and which products can be marketed, creating institutional barriers for small-scale farmers for additional income (Mikulcak et al. 2015). This system design fosters the growth of farmers away from small-scale agriculture and towards a more intensive, monoculture farming system (Loos et al. 2015). Similar institutional processes can be found all over the world (Mihók et al. 2015; Auer et al. 2017; Balázsi 2018). Redesigning institutions, how they function and how legislations are implemented shape the cultural landscape through its agriculture, forestry or environmental conservation and directly affect the feedback mechanism and parameters of the system.

CONCLUSION

Cultural landscapes are changing and impact the way inhabitants connect to their landscapes and nature—but this connection can also impact the way landscapes will continue to change in the future. The environmental crisis of our days requires action, and our research presents possible directions to intervene in a possible spiral of disconnectedness from nature. We found four leverage points to strengthen human–nature

connectedness (HNC) through our empirical studies done in five landscapes in Transylvania, Romania and Lower Saxony Germany: (1) maintaining and enhancing the structural diversity of landscapes, (2) economically and ecologically sustainable small-scale agriculture, (3) strengthen sense of place and (4) strengthen sense of agency of actors. Especially important for a sustainability transformation is the emphasis on interlinkages between these shallow and deep leverage points. All four leverage points can reinforce each other, as it is possible that that structurally complex landscapes and structurally rich social relations are linked. Redesigning the function and structure of formal and informal institutions (deep leverage point) directly affect the feedback mechanism and parameters of the system (shallow leverage point). Strengthen sense of place and agency may enable self- and re-organization of the social–ecological system by opening the possibility to renegotiate its values and goals which may ultimately enhance structural diversity of landscapes and small-scale agriculture. Our wider research showed similar examples from across the globe (Riechers et al. 2020a), making room for the hypothesis that degrading landscapes might also degrade social relations. The interaction between shallow and deep leverage points is an under researched area, and we see necessity to understand such interlinkages to foster transformative change. Further research also needs to focus on the scale dependency and agency to intervene in social–ecological systems to foster transformative change. Individual agency, for example, might be limited when tasks with refocussing a growth-centric economic paradigm which influenced land use and consumer behaviour in both countries. Yet, while our studies point to concrete leverage points, we by no means argue for a generalization of interventions and we are certain that multiple other leverage points exist that can foster HNC. Instead, with our results, we intend to highlight the importance of looking for deep leverage points that may span across multiple dimensions of HNC, highlight the interaction between shallow and deep ones and are not confined by disciplinary or geographical boundaries.

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PERSPECTIVE: HUMAN-NATURE CONNECTEDNESS AS LEVERAGE POINT

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Key advantages of the leverage points perspective to shape human-nature relations

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ABSTRACT

This perspective paper synthesises the special issue 'Human-nature connectedness as a leverage point for sustainability transformation'. Based on the articles in this special issue, we aim to foster the operationalisation of the leverage points perspective to shape human-nature relations to enable sustainability transformations. Specifically, we draw on four key advantages of the leverage points perspective: (i) the explicit recognition of deep leverage points; (ii) the ability to examine the interactions between shallow and deep system changes; (iii) the combination of causal and teleological modes of research; and (iv) the ability to function as a methodological boundary object. The contributions to this special issue revealed three deep leverage points addressing paradigm shifts in research and beyond: relational thinking and values, stewardship philosophy and shifting the economic growth paradigm to focus on human well-being. We highlight interlinkages between leverage points to further strengthen the transformative potential of interventions that aim at triggering shifts in our understanding about human-nature relations. Further, we show a way to bridge causal and teleological approaches by envisioning desired futures. Lastly, we emphasise the potential of arts-based methodologies, including participatory, transdisciplinary research to foster sustainability transformation and how this can be combined within the leverage points perspective.

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Introduction

Many years of effort towards averting the unsustainable trajectory of our world´s development prove that technological and short-term policy strategies are insufficient to achieve the internationally agreed sustainable development goals (Rockström et al. 2009; UN 2015; Steffen et al. 2018). As an example, conservation policies are often unable to halt the severe loss of biodiversity, which stresses the need for more effective interventions at the wider institutional and societal level to reach conservation goals (Rands et al. 2010). In other words, achieving sustainability requires transformations of social-ecological systems (Meadows 2008). Understanding where and how to intervene in social-ecological systems is thus a core question of sustainability research, yet only a few overarching principles have so far demonstrated effectiveness (Meadows 1999; Dorninger et al. 2020).

To enable transformations of social-ecological systems to more sustainable states, it is important to know where to intervene in a system for leveraging change. Meadows (1999) proposed a hierarchy of places, which Abson et al. (2017) categorized into four system characteristics (Table 1). These leverage points range from shallow (e.g. changes in parameters or feedbacks) to deep and transformative ones (e.g. changes in system intent, goals and paradigms). We argue that many interventions target highly tangible but essentially shallow leverage points (i.e. using interventions that are easy but have limited potential for transformational change). Given the pressing sustainability challenges the world is facing, we see an urgent need to focus on less obvious but potentially

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Table 1. Twelve leverage points *sensu* Meadows (1999) and their corresponding system characteristics as summarized by Abson et al. (2017). Deep leverage points = design and intent; Shallow leverage points = parameters and feedbacks.

Leverage points	System characteristics	Examples
12. Constants, parameters, numbers 11. The size of buffers and other stabilizing stocks, relative to their flows 10. Structure of material stocks and flows	Parameters: measurable system features	Subsidies, taxes, population age structures; transport networks
9. Length of delays, relative to the rate of system changes 8. Strength of negative feedback loops, relative to the effect they are trying to correct against 7. Gain around driving positive feedback loops	Feedbacks: interaction within the system	Teleconnections, birth rates, models to predict responses
6. Structure of information flow 5. Rules of the system 4. Power to add, change, evolve, or self-organize system structure	Design: systemic structures	Access to information, formal & informal institutional constrains
3. Goal of the system 2. Mind-set or paradigm that the system – its goals, structure, rules, delays, parameters – arises from 1. Power to transcend paradigms	Intent: long-term trajectory of system behaviour	Value & belief system, economic system, understanding of how the world works

more effective interventions (Fischer and Riechers 2019). One such powerful area of intervention are human-nature relations (Abson et al. 2017; Riechers et al. 2021).

The connection between humans and their surrounding nature has been highlighted in their significance over the past decade (Folke et al. 2011; Russell et al. 2013; Zylstra et al. 2014), as strengthening this connection may simultaneously increase human well-being and the ecological sustainability (Nisbet et al. 2009; Capaldi et al. 2014; Shanahan et al. 2016). Humans constantly interact with their surrounding nature. Through these human-nature interactions grows a relation, which can be seen as one realm of leverage. In this realm, targeting the most effective leverage points has a high potential to transform our world into a more sustainable state (Abson et al. 2017; Riechers et al. 2020a). The authors of the special issue 'Human-nature connectedness as a leverage point for sustainability transformation' presented their findings on what some of these leverage points could be. The theoretical and conceptual background of research within the realm of human-nature relations comprises decades of disciplinary and interdisciplinary work. Within this synthesis, we refer to these interactions as 'human-nature relations' to enable various concepts that are used in the articles in this special issue to be integrated under this broad umbrella term (Riechers et al. 2021, this issue).

We draw this synthesis on four key advantages of the leverage points perspective (Fischer and Riechers 2019): (i) the explicit recognition of deep leverage points which are influential yet difficult to act upon (Dorninger et al. 2020); (ii) enabling the examination of interactions between shallow and deep system changes (Manlosa et al. 2018); (iii) the combination of causal (change arises from variables influencing one another) and teleological (change arises from human intent) modes of research; and (iv) the ability to function as a methodological boundary object for inter- and transdisciplinary research.

Using the leverage points perspective as analytical lens, we synthesize aspects of the articles in this special issue by putting them into the broader context of transformative research. Our synthesis helps to operationalise and concretize the four key advantages to enable a comprehensive overview on how human-nature relations may serve as a realm of leverage that enables entry points to sustainability transformations. This perspective paper is structured as follows: we will (1) describe exemplary deep leverage points based on paradigm shifts, (2) provide examples for interlinkages between leverage points, (3) discuss the incorporation of causal and intent-based (teleological) approaches through envisioning a desired future and (4) consider arts-based methods to be integrated in sustainability science through the methodological boundary object of the leverage points perspective.

Deep leverage points to shape human-nature relations

Deep leverage points may foster transformative change through strengthening connections between humans and their surrounding nature (Riechers et al. 2021). Meadows (1999) named paradigm shifts as one of the deepest levers of change (Table 1). From the contributions in this special issue, we noted three deep leverage points that aim at the following paradigm shifts: (a) acknowledging (and strengthening) relational thinking and values, (b) a stewardship philosophy and (c) shifting from a growth-based economy to one focussed on human well-being.

A relational turn in research and values

Values in sustainability transformation have been discussed extensively over the last decades (Horcea-Milcu et al. 2019). Meadows (1999) highlights 'values' as deep leverage points and in the discussion about shaping human-nature relations, researching values becomes paramount (e.g. Chan et al. 2012; Pascual et al. 2017).

In fact, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) included relational values in its classification (Díaz et al. 2015), being understood as the values encompassing all possible relationships between humans and nature, including relationships between people mediated by nature (Chan et al. 2016; Riechers et al. 2020b). Relational values hold a fundamental meaning of human-nature interactions that goes beyond instrumental values, representing meaningful relationships and responsibilities established between humans and nature such as care and stewardship (Himes and Muraca 2018; García-Llorente et al. 2018).

To systemically transform the way researchers approach human-nature relations, West et al. (2020 this issue) argue for a 'relational turn'. Drawing on relational understandings about the nature of reality, the 'relational turn' aims to revise and revisit the reductionists assumptions present in sustainability science to better capture the complexity of human-nature relations (Stenseke 2018; West et al. 2018, 2019; Hertz et al. 2020; Darnhofer 2020). In such a shift, the dichotomous categories of 'humans' and 'nature' would be revised in favour of concepts that better capture the inextricability of humans and nature within holistic assemblages, to avoid identifying system components as *either* 'human/social' *or* 'natural/ecological' (Ostrom 2009; Schoon and Van Der Leeuw 2015). Such a 'relational turn' may ultimately lead to a shift or an opening up in complexity thinking from substantialist to relational assumptions that may help to overcome false dichotomies between humans and nature. West et al. (2020 this issue) argue that overcoming this conceptual dichotomy may allow for the creation of different types of knowledge and positively influence the science-policy interface through generating novel governance, management and policy approaches.

To operationalise a 'relational turn' in research and values, Chakroun and Droz (2020 this issue) propose bridging the concepts of landscape and milieu. The framework of the milieu developed by Droz (2020) captures how the milieu is both 'the matrix that nurtures human communities, shaping their cultures and their ways of living *and* the imprint that is shaped by the historical relations of humans with each other and with their environment' (Chakroun and Droz 2020 this issue). Thus, humans experience their environment as webs of meanings, values and affordances. The authors apply this framework to three biodiversity-rich cultural landscapes in Japan and highlight how particular cultural meanings and values lead to different usages of space and of the environment and how, in return, certain landscapes can influence people's experiences and therewith lead to pro-environmental behaviour (Hinds and Sparks 2008; Gifford and Nilsson 2014). Approaching sustainability through landscapes enables researchers to go beyond the artificial and abstract separation between 'internal' (e.g. ethical decision-making) and external processes (e.g. environmental degradations) and complements recent studies that have tended to exclude or limit consideration of the internal state of individuals (e.g. Palomo et al. 2014; Hanspach et al. 2016). Chakroun and Droz (2020, this issue) argue that people's inner worlds are essential for sustainability, especially because the direct sensory interactions with nature help to acknowledge and foster a deeper connection to nature (Abram 1997; Balázsi et al. 2019; Riechers et al. 2020b).

Facilitating a 'relational turn' in practise nevertheless may pose challenges (Raymond et al. 2021). The inclusion of people's relation with nature into policy and social structures is often lacking as policies do not cater for recognition of such relations (Mattijssen et al. 2020 this issue). Instead, nature conservation policy focusses more on instrumental or intrinsic values (i.e. biodiversity and economy-based). The authors argue that this simplification of human-nature relations risks to oversee other relations with nature, with negative effects for conservation policy and management (Klain et al. 2017). Lack of consideration of relational values, the authors suggest, could be a reason for why nature policies often fail to address biodiversity loss effectively and often trigger resistance and/or alienation among actors. Humans 'are deeply affected by emotions and stories with meaning. We want to believe our lives are worthwhile and meaningful' (Richardson et al. 2020 this issue). Mattijssen et al. (2020 this issue) further argue that a recognition and incorporation of relational values can serve as deep leverage points for policy interventions that aim to support citizen's contribution to nature conservation and strengthen biodiversity policy. Hence, through values, such as relational ones, social structures and policies can and should re-emerge as Humanity's story.

To counter this lack of recognition, Richardson et al. (2020 this issue) and Mattijssen et al. (2020 this issue) present evidence from practical examples in which relational values and a relational turn can be fostered. Richardson et al. (2020 this issue) suggest a regenerative potential of human-nature relations at multiple levels (from individual to societies), in all of the four system characteristics by Abson et al. (2017). They provide concrete recommendations for specific informed interventions to improve the human–nature relations in education, health, housing, arts, health and transport and governance. In order to promote the incorporation of relational values in nature policy and practice and more effectively engage with citizens in this context, Mattijssen et al. (2020 this issue) describe six possible 'routes' for policy makers:

(1) The incorporation of pluralized meanings of nature;
(2) The uptake of relational language in policy discourse;
(3) A prioritization of landscape-based policy;
(4) Empowering local citizens in nature conservation;
(5) Re-orienting nature education to stimulate people's personal experience of nature; and
(6) Using digital technology to stimulate new relationships with nature.

While this list of routes is not exhaustive, all points offer significant potential to influence human-nature relations in a way that fosters transformative changes towards sustainability (Mattijssen et al. 2020 this issue).

A stewardship philosophy

Stewardship can be seen as a specific relational value and offers a way to achieve a 'relational turn' (West et al. 2018). For example, a stewardship philosophy towards maintaining natural elements in agricultural landscapes would benefit the conservation of agrobiodiversity (Raatikainen et al. 2020 this issue). To strengthen the connections humans have with their surrounding nature, it is necessary to focus on experiential and emotional aspects, as well as strengthening compassionate relationships (Lumber et al. 2017). A stewardship philosophy may also transform our thinking to include the agency and rights of non-human entities, which can change the underlying conceptualizations of human-nature relations on both the personal and societal scale towards a mindset that encourages sustainable action (Raatikainen et al. 2020 this issue). The relevance of ´green care´ activities is recognised as an innovative approach that combines caring for people and caring for land. The stewardship philosophy combines three elements that have not been previously connected: (1) multifunctional landscapes and recognition of the plurality of values; (2) social services and health care; and (3) the possibility of strengthening the farming sector and local communities (García-Llorente et al. 2018).

The notion of 'landscape stewardship' is very much in line with argumentations for a relational turn and invites deliberately considering and opening up discursive spaces for engaging with diverse values of landscape. This may help to alleviate heated conflicts in land management, which often arise at the brink between agriculture and nature conservation. Within the context of land management, Bieling et al. (2020 this issue) define landscape stewardship as a management approach as well as an essentially ethical concept. Landscape stewardship are 'efforts to create, nurture and enable responsibility in landowners and resource users to manage and protect land and its natural and cultural heritage (Brown and Mitchell 2000, p. 70)'. Landscape stewardship highlights responsibility, collaboration, participation, plurality and communication (Cockburn et al. 2019). The concept and practice of stewardship combines various landscape values with management practises, comprising (1) prudential aspects like interest in long-term productivity and sustainable use of the land (instrumental values); (2) moral, justice-related aspects like duties to future generations and the global poor (intrinsic values, human rights); and (3) aspects of the Good Life like feelings of attachment, aesthetic ideals or identity (relational values) (Bieling et al. 2020 this issue). In this regard, it is crucial to highlight especially indigenous peoples who manage and influence over one fourth of the earth's surface (Garnett et al. 2018). Indigenous peoples and communities are 'carriers and caregivers of biodiversity and they also hold a unique and invaluable indigenous and local knowledge for sustainable stewardship of nature' (Burgos-Ayala et al. 2020a this issue).

A new economic paradigm

Rana et al. (2020 this issue) emphasize a shift away from the economic growth paradigm (Meadows 1999, 2008). In general, a growing economy can be defined as an increase in the production and consumption of market traded goods and services. This increase in production accounts for a growing use of resources leading to, among others, resource depletion (Brown et al. 2014; Kallis et al. 2018) and climate change (Stern 2004; IPCC 2018; IPBES 2019). Instead of trying to mitigate the negative consequences of an economic growth paradigm, the focus should be on how to transform it into a more sustainable one. Such a transformation is utterly necessary in order to achieve a sustainable economy (IPBES 2019). This need for a paradigm shift was also experienced by the young participants of Rana et al. (2020 this issue) visioning exercise for positive and sustainable futures based on the Seeds of the Good Anthropocene project (Bennett et al. 2016). Core components for a desirable future were alternative economies and new metrics to measure development (i.e. recognizing well-being and happiness). This links back to a rising discussion about alternatives to growth in society, policy and academia (Costanza et al. 2014; Polasky et al. 2015; Raworth 2017). Movements such as degrowth and other alternative economic models could enrich these discussions and are critical for interventions to halt biodiversity losses (Hinton and Maclurcan 2017; D'Alessandro et al. 2020; Otero et al. 2020). Alternatives to the current growth paradigm may be able to challenge the status quo, especially if they are able to provide meaningful and context-specific examples (Berg and Hukkinen 2011). Steering away

from economic growth is complicated because the current dominant paradigm is deeply integrated into the social, institutional, political and economic fabric of global societies (Fournier 2008; Raworth 2017). However, changing and challenging this paradigm can be a deep leverage point to foster a sustainability transformation of the way humans interact with nature (Rana et al. 2020 this issue).

Interlinkages between leverage points to shape human-nature relations

A leverage points perspective postulates that transformative change is unlikely if only shallow leverage points are acted upon; but it also recognizes that acting on deep leverage points is difficult in practice, even if the benefits could be substantial (Ehrlich and Kennedy 2005; Abson et al. 2017). Based on this, it is important to understand better how shallow and deep systemic changes interact in different situations (Manlosa et al. 2018; Riechers et al. 2021). Such interactions among leverage points or changes at different levels of systemic depth suggest that 'chains of leverage' (i.e. how shallow, mid-level and deep systemic changes interact with one another) can be studied (Fischer and Riechers 2019). In this section, we exemplify how interlinkages between leverage points can influence human-nature relations by referring to three articles in this special issue: Pérez-Ramírez et al. (2021 this issue) and Rosengren et al. (2021 this issue) show interlinkages between shallow and deep leverage points, while Burgos-Ayala et al. (2020a this issue) highlight that different interlinkages between leverage points may lead to different outcomes.

Drawing on the system characteristics by Abson et al. (2017) (Table 1), Pérez-Ramírez et al. (2021 this issue) looked at such possible interactions. They defined modifiable and measurable parameters as the number of participants of the farming initiative, of ecological crops, including traditional varieties, productivity, or the number of pollinators. Feedbacks were assessed in relation to the efficiency of the initiative, including the amount of time spent by the participants for the project, the workshops and the evaluation surveys of the project. The design characteristics related to the information flow and self-organization through the collective development of an educational plan and a new social association run by transdisciplinary actors, while the system intent was addressed by the ideological foundations used in agroecology. Through participatory farming activities, Pérez-Ramírez et al. (2021 this issue) noted how some interventions were easy to implement but reached only shallow leverage (e.g. time spent to develop an agro-ecological project), but were important for reaching the set targets. Such shallow leverage points also fostered interventions that were more difficult to implement, which showed a deeper leverage for transformative change (e.g. working on the agroecological paradigm). A similar synergistic effect was noted by Rosengren et al. (2021 this issue). Their indicated leverage points of 'gender equality', 'social learning', 'information and knowledge' and 'access to finance' should not be regarded in isolation but rather as an ensemble of topics conjointly having the potential to create positive change (Rosengren et al. 2021 this issue). The authors identified the leverage point of 'gender equality' as holding great potential to create systemic change by impacting the rules of the system. The leverage points of 'social learning' and 'information and knowledge' are tightly linked and rooted in the power to add, change, evolve or self-organize a system and structures of information flows – both deep leverage points (Meadows 1999). The leverage point 'access to finance', will not have the power to improve adaptive capacity substantially on its own – despite often being a focal point in political and economic interventions (Rosengren et al. 2021 this issue).

Interlinkages between leverage points can also be crucial for successful project outcomes. Burgos-Ayala et al. (2020a this issue) highlight two project groups, which combined and concretised deep and shallow leverage points differently and hence, found contrasting outcomes. The authors looked at frequently targeted leverage points within environmental management projects involving indigenous peoples as their main actor. Leverage points were information sharing, participatory praxis and involvement of indigenous peoples but intervention in these leverage points differed (Burgos-Ayala et al. 2020a). Highlighting the intricate and complex nature of the interlinkages between shallow and deep leverage points to foster human-nature relation is crucial for a comprehensive systemic understanding. Operationalising and analysing these interlinkages is a difficult task but the three examples given here suggest ways to achieve this goal in different situations and empirical settings.

Causal and teleological combinations to shape human-nature relations

Sustainability research uses predictive models (e.g. on climate change or resource depletions to forecast the future). Rana et al. (2020 this issue) provide an extension to such investigations by bridging causal (nothing can happen without a cause) and teleological (events and developments are meant to achieve a purpose and happen because of that) approaches can shape human-nature relations today by identifying desired visions for tomorrow. Rana et al. (2020 this issue) used a visioning method adapted from the Seeds of the Good Anthropocene project (Pereira et al. 2018) and Nature Futures Framework (Pereira

et al. 2020) to highlight more sustainable futures and ways to get there. Such visioning exercises can contribute to generating desired social change (Totin et al. 2017). Highlighting the desirability of such a vision can provide an inspiring narrative and engender action (Wiek and Iwaniec 2014). Hence, based on the causal explanation already existing for their specific social-ecological system in question, the authors used a participatory process of visioning to promote collective action for transitions toward desirable futures (Oteros-Rozas et al. 2015; Lundquist et al. 2017; Hamann et al. 2020). With this participatory process; they aimed to generate literacy about the future among their workshop participants to enable changes in values and behaviour (Wiek and Iwaniec 2014; Bennett et al. 2016; Pereira et al. 2018). Through analysing and comparing different possible futures, the authors identified a number of leverage points to shape human-nature relations (Rana et al. 2020 this issue). Key deep leverage points were: an alternative economic paradigm (see above), new governmental structures and institutions to improve justice and inclusive planning and management. These deep leverage points related directly to ongoing debates in the sustainability literature on which pathways and interventions are required to achieve a better future for humanity and the planet, and show how articulating positive visions of the future can help reaching them.

Methodological boundary objects to shape human-nature relations

The leverage points perspective can serve as a methodological boundary object for inter- and transdisciplinary research, as it can combine a wide range of causal to teleological approaches (Fischer and Riechers 2019). Especially in the realm of human-nature relations in which multiple demands, values and emotions are integrated, new methodologies are helpful for developing more encompassing analyses. One such collection of methodologies mentioned by authors of this special issue are arts-based approaches, which can serve as possible methodological additions to strengthen the connections humans have with their surrounding nature (Muhr 2020; Raatikainen et al. 2020; Richardson et al. 2020). Such diverse and flexible approaches towards implementing senses of belonging to overcome the dichotomy between nature and humans have proven useful in various projects, particularly when working with non-academics.

Combining art and transdisciplinarity has the potential to uncover deep connection to landscapes, benefitting from the fact that art can be a direct channel to human emotions (Xenakis et al. 2012; Riechers et al. 2019). Muhr (2020 this issue) describes arts-based research of being capable of tapping into often neglected emotions and embodied experiences regarding to nature. Most art forms incorporate non-verbal components. This could potentially transcend the cognitive dimensions of human-nature interactions and highlight an unspoken knowledge – making arts-based approaches particularly interesting for researching emotional connections to nature (Muhr 2020 this issue). Working with and through art can be a way of helping communities understand and address their problems through participatory research that incorporates a diversity of knowledge forms (Bodorkós and Pataki 2009). Additionally, art requires active involvement from participants, to go out and observe, create and change natural places. The appreciation of different forms of knowing, acting and using dialogical ways to explore these unfolds the complexity, uncertainties and disputed values of various different actors involved (Fazey et al. 2018). Raatikainen et al. (2020 this issue), for example, focused on the opportunities of arts-based environmental education in advancing environmental management and Richardson et al. (2020 this issue) promote arts-based activities to operationalise pathways to nature connectedness. Arts-based practices allowed participants to recognize their corporality and develop an experiential, expressive and informed connection with nature, independent of the participants' age, native language, or educational background. Another asset of arts-based work is its inherent creativity; stretching the boundaries of the epistemology, ontology and methodology of science.

Arts-based approaches can further inspire discussions that emphasize deep leverage points, as they differ from quantitative and qualitative research in their purposes (Leavy 2009; Barone and Eisner 2012). Muhr (2020 this issue) identified a process of producing and using (scientific) knowledge as leverage point in his work (see also Abson et al. 2017). Transformative art can be a powerful tool to guide and innovate sustainability transition, combined with research that points out the critical needs for transformative action and when building on multiple kinds of knowledges (Raatikainen et al. 2020 this issue). From a leverage points perspective, arts-based interventions can advance the methods and methodologies of research and therewith change the rules of a system – and initiate promising chains of leverage for a different access to sustainability science (Heinrichs 2018, 2019), as stated by Muhr (2020 this issue). By including other and potentially non-scientific types of knowledge, leverage points addressing human-nature relations may spark novel and powerful pathways towards sustainability transformation.

Summary

This synthesis of the special issue 'Human-nature connectedness as a leverage point for sustainability

transformation' reveals insights about human-nature relations based on the key advantages of the leverage points perspective. As we show by our emphasis on specific aspects of each contribution, there seems to be a general need for a paradigm shift from utilitarian to relational interactions, which is represented by a shift away from the prior conceptualisation of human-nature connectedness to a more overarching term (human-nature relations). Another related deep leverage point was the strengthening of a stewardship philosophy to shape human-nature relations to more sustainable states. Lastly, the deep leverage point of shifting away from the economic growth paradigm to a more just and encompassing one was highlighted. However, transformations towards sustainability do not only require focusing on deep leverage points, but also needs to account for how different leverage points are interlinked with each other. Such interlinkages can further strengthen the transformative potential of interventions to shape human-nature relations into a more sustainable state. Further, we exemplified the need to bridge causal and teleological approaches – to not only focus on the status quo of the system (and how we got here) but also on the desired state of the system (and how to get there). This special issue highlights how the leverage points perspective can act as a methodological boundary object that harbours many ways to operationalise human-nature relations and questions academic knowledge. This was exemplified by the work with arts-based methods and participatory, transdisciplinary research aimed to shape human-nature relations from the bottom up. Overall, this special issue has helped to concretize leverage points that can positively shape human-nature relations, identify what these relations may look like and how the leverage points perspective can be used.

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