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Research article

Towards transformative change for biodiversity: What can we learn from case studies in Germany?

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ABSTRACT

Current human activities have led to fundamental changes in ecosystems, including the loss of biodiversity, which increasingly leads to irreversible negative impacts on society. Although called for in many policy documents, the debate on how to initiate, promote and specifically support socio-ecological transformations for the conservation and restoration of biodiversity is still in its early stages. So far, efforts to protect biodiversity were only partially successful. Therefore, there is a need for approaches to promote societal change for the benefit of biodiversity. We analysed 22 case studies of biodiversity-enhancing societal processes and projects in Germany to understand barriers and success factors and to identify features that support transformative change towards sustainability and biodiversity mainstreaming. Following Wittmer et al. (2021), the following topics were analysed: a) orientation towards a shared and compelling vision that enables biodiversity conservation or enhancement (transformative vision), b) the role of (different types of) knowledge about how to change the system (transformative knowledge), c) navigating the dynamics inherent in changing development pathways (transformational dynamics), d) enabling emancipated action and opening spaces for creative participation of different social groups (emancipation and agency), and e) targeted interventions that aim to enable governance for transformation. This article discusses lessons learned from examples in Germany to support future transformative processes for biodiversity conservation, restoration and biodiversity mainstreaming. It identifies 16

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features, enabling transformative change for biodiversity, many of which may be applicable in other countries with similar governance contexts. These characteristics suggest that a structured and well-informed approach, based on a broad range of communication, engagement, negotiation, and stakeholder involvement efforts throughout the process, is well-suited for developing and implementing proposals. While in some small cases indirect drivers were addressed, achieving this on a broader scale is the largest remaining challenge.

1. Introduction

Current developments in human activities and lifestyles have led to irreversible ecosystem degradation including biodiversity loss with far-reaching societal consequences (Barnosky et al., 2011; Ceballos et al., 2017; UN Environment, 2019; Dasgupta, 2021). While the international community has established and continuously updated goals for biodiversity conservation and ecosystem restoration, biodiversity continues to drastically decline, demonstrating that current actions are insufficient (WWF, 2022; Halley and Pimm, 2023). Wirth et al., 2024 show that also for Germany, efforts to protect biodiversity were only partially successful.

There is an increasing demand for action-oriented policies initiating transformative change to reduce pressures on biodiversity. The global assessment by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), like others (IPBES, 2019a; Díaz et al., 2019; CBD, 2020; Dasgupta, 2021), concludes that transformative changes are urgently required to slow down and ideally stop rapid biodiversity loss. IPBES calls for a fundamental change in biodiversity conservation policy, action, and overarching governance structures but also in paradigms, goals, and values to enable "*a system-wide reorganisation across technological, economic, and social factors*" (IPBES, 2019a) *p. 14*). It emphasizes that this is the only way to achieve the goals of conserving and sustainably using nature and achieving sustainability (as well as the goals for 2030 and beyond) (IPBES, 2019a) p. 14). We follow this definition and the objectives, stated by IPBES as "*needed for the conservation and sustainable use of biodiversity, long-term human well-being, and sustainable development*" (IPBES, 2021). Transformative change requires existing systems, institutions, policies and practices to be challenged, modified and/or replaced (Jacob et al., 2020).

Transformative change for biodiversity conservation needs governance and policy to not only address direct drivers of biodiversity loss but also tackle the indirect drivers embedded within social-economic paradigms and social-political structures (IPBES, 2019b; Dasgupta, 2021; Visseren-Hamakers et al., 2021). Indirect drivers that negatively influence biodiversity are critical targets for transformative change because they operate diffusely and impact on one or more direct drivers of global ecosystem change (Nelson et al., 2006; Mupepele et al., 2019; Imbert et al., 2021; Považan et al., 2021). The challenge consists in effectively addressing indirect drivers and at the same time sustainably strengthening positive effects, e.g. by increasing the importance of environmental and climate protection or promoting inter- and transdisciplinarity cooperation (Deutsch et al., 2023). Furthermore, effective transformative change requires a combination of top-down and bottom-up approaches that address various indirect and direct drivers simultaneously (Nishi et al., 2021).

Despite sufficient knowledge and a broad array of supporting schemes in place to support biodiversity conservation and restoration (e.g. funding schemes, governing bodies, social support, shared ethical values, motivation), neither the 2010 nor 2020 global biodiversity goals were achieved. At the EU level recently enacted policies, such as the EU Nature Restoration Law (Hering et al., 2023; Stoffers et al., 2024), provide a legally binding framework for restoring degraded ecosystems. Depending on how individual Member States will implement this regulation will determine if and in what way it will support transformative change. Thus, one of the key questions for the future is: How can projects, programmes, and policy initiatives be implemented to contribute to a transformation stopping biodiversity loss and mitigating its impacts? This open question regarding transformative change may be inherent in the concept itself. Some scholars argue that transformative change cannot be predicted, planned, or precisely controlled and that implementing evaluation structures and systems is a difficult task (Chaffin et al., 2016; Patterson et al., 2017; Loorbach et al., 2017; Wunder, S. et al., 2019; Glass and Newig, 2019; Bulkeley et al., 2020; Wittmer et al., 2021; Lee and Waddock, 2021; Visseren-Hamakers et al., 2021). In addition, there are still no clear pathways to achieving biodiversity integration in policy planning and policy implementation (Penca, 2023; Schmeller and Bridgewater, 2023).

However, different preconditions and strategic planning, evaluation and policy elements can be (pre)designed and integrated in guiding change processes towards transformative biodiversity conservation (Schmeller and Bridgewater, 2023). There is an increasing understanding of the requirements and supporting factors to initiate necessary processes of change and align them in the desired direction (IPBES, 2019b, 2024; Jacob et al., 2020). Guiding transformative change mainly requires knowledge on biodiversity-enhancing processes and successful result-oriented actions (Bentz et al., 2022). Evidence on best practices is needed, as are analyses on barriers and success factors in biodiversity conservation projects and processes. Yet, there is still insufficient synthesis work on such projects and processes to better understand the core conditions for transformative change. Without such knowledge, the social-ecological transformation required for successful biodiversity conservation governance cannot be guided effectively.

This paper aims to identify enabling features for transformative change to improve biodiversity. Transformative change for biodiversity in the sense of a fundamental, system-wide and large-scale reorganisation has not occurred in Germany so far. To better understand how transformative change can be supported in the future, we analysed case studies of substantial societal change processes at a smaller scale, in which positive effects in terms of internationally agreed biodiversity targets have occurred (CBD Targets 2, 3, 4, 7; CBD, 2022). They were selected to cover different scales, sectors, initiators, and spatial expansion. Some were specifically designed for biodiversity conservation, others enhanced biodiversity while primarily pursuing other goals. By studying what has worked in the past we hope to provide recommendations on how to further enhance transformative change for biodiversity. The following section explains the research design and methodology, section 3 the results concerning the enabling features. Section 4 discusses how these can be applied in Germany and beyond. Section 5 provides conclusions and recommendations.

2. Research design and methodology

2.1. Case study selection

This study was conducted as part of the German Biodiversity Assessment "Faktencheck Artenvielfalt" (English: checking the facts on biodiversity) (Farwig et al., 2022, Wirth et al., 2024) and in particular the working group "Transformation Potentials" (Hauck et al., 2024). For our analysis, 22 cases of biodiversity-enhancing societal processes in Germany were selected (Table 1). The case studies are examples that have had, or are likely expected to have positive impacts on biodiversity as defined in internationally agreed biodiversity targets (i). In addition to criterion (i), the subsequent criteria were applied to select case studies: (ii) consideration of social and economic goals and/or achievements besides biodiversity conservation, as well as (iii) a reliable

Table 1
Overview and description of the case studies organized by their habitat dimension. A detailed analysis of the case studies can be found in the 'Faktencheck' assessment and its supplementary online material (Hauck et al. 2024, A.10.4, Klein et al. 2024; Müller et al. 2024; Feld et al. 2024; Hodapp et al. 2024; Haase et al. 2024).

Case study (CS)		
Cross-habitat and habitat-independent processes		
[CS 1] Emscher Conversion	Construction of a centralized wastewater treatment system in the Ruhr region and restoration of the Emscher River and its tributaries.	Hauck et al., (2024), A10.4
[CS 2] German Green Belt	The Green Belt is the largest biotope network in Germany, running along the former inner-German border.	Hauck et al., (2024), A10.4
[CS 3] Leipzig Neuseenland	Recultivation/Reclamation of former open-cast mines into an extensive network of lakes and creation of new nature and recreation areas.	Hauck et al., (2024), A10.4
[CS 4] Rhenish lignite mining area	Restoration and reclamation of former lignite mining areas for agricultural and forestry use, as well as for local recreation and tourism.	Hauck et al., (2024), A10.4
[CS 5] Rhön Biosphere Reserve	The Rhön Biosphere Reserve exemplifies the practical realization of integrated landscape conservation spanning federal states.	Hauck et al., (2024), A10.4
[CS 6] Southeast Rügen Biosphere Reserve	The Southeast Rügen Biosphere Reserve exemplifies the tangible execution of integrated landscape conservation.	Hauck et al., (2024), A10.4
[CS 7] Rewilding Oder Delta	The Oder Delta is one of the components of the Rewilding Europe network and aims to conserve and rehabilitate naturally occurring ecosystems.	Hauck et al., (2024), A10.4
[CS 8] Return of the Wolf in Germany	Following the protection of wolves in around 1990, the species gradually began to return to Germany from Eastern Europe after being extinct there for centuries.	Hauck et al., (2024), A10.4
[CS 9] Insect Protection Act	The Insect Protection Act was instituted/adopted and implemented at the national level to address the dwindling insect population in Germany. Its objective is to encourage insect-friendly methods for agriculture and biodiversity conservation.	Hauck et al., (2024), A10.4
[CS 10] Bavarian Biodiversity Petition	The "Biodiversity & Natural Beauty in Bavaria - Save the Bees!"-referendum aims to legally anchor rights of nature in the Bavarian constitution.	Hauck et al., (2024), A10.4
Habitat-specific processes (■ agricultural and open land, ■ forests, ■ inland waters and floodplains, ■ coasts and coastal waters, ■ urban areas)		
[CS 11] ■ Green Roofs	Green roofs contribute to the diversity of ecological niches, habitats for species and ecosystem services (e.g. temperature and water regulation) in urban areas.	Hauck et al., (2024), A10.4
[CS 12] ■ Farm to Fork	The "Farm to Fork" strategy consists of policy goals for sustainable agriculture and is an integral part of the European Green Deal and the execution/implementation of the UN Sustainable Development Goals.	Hauck et al., (2024), A10.4
[CS 13] ■ Community Supported Agriculture	Community-supported agriculture is a social initiative where groups of people/individuals support farmers financially, participate in the harvest, and share the risk of crop failure.	Hauck et al., (2024), A10.4
[CS 14] ■ Regionalwert-AG Freiburg	Regionalwert-AG Freiburg is a citizen-owned corporation committed to promoting a sustainable food and agriculture industry.	Klein et al. (2024)
[CS 15] ■ Flourishing grassland habitats	Insect protection (promotion of flower-visiting insects) through flowering habitats in the open countryside.	Klein et al. (2024)
[CS 16] ■ Stepping stone concept	Strong nature conservation-orientated, sustainable forest use that integrates elements such as biotope trees, deadwood, forest stepping stones, and natural forest reserves into forest management.	Müller et al. (2024)
[CS 17] ■ Bavarian Forest National Park	The Bavarian Forest National Park is Germany's first, oldest, and largest forest national park, with a focus on combining nature conservation, tourism, and an appealing environmental education programs.	Müller et al. (2024)
[CS 18] ■ Wadden Sea National Park	A globally unique and irreplaceable natural area off the German North Sea coast, which strengthens the public perception of the Wadden Sea as an asset worthy of protection through the development of nature-friendly tourism.	Hodapp et al. (2024)
[CS 19] ■ Improvement of water quality of streams since the 1970s	Since the 1970s, advancements in wastewater treatment have continuously improved/enhanced the water quality, leading to an increase in river biodiversity throughout Germany.	Feld et al. (2024)
[CS 20] ■ Improvement of the "ecological quality" of streams since 2000	The adoption/implementation of the EU Water Framework Directive created/established an EU-wide framework for action to improve/enhance the living environment of aquatic organisms.	Feld et al. (2024)
[CS 21] ■ Urban gardens	Urban gardens are forms of public or partially public open space design in residential areas that can have strong ecological and social components in addition to the possibility of self-sufficiency and recreation.	Haase et al. (2024)
[CS 22] ■ Regional Biodiversity Strategy Ruhr Area	The aim of the strategy is to advance both the protection and promotion of biodiversity and green infrastructure in the Ruhr Metropolis by developing regionally coordinated guiding principles, objectives and measures, and to serve as a guiding instrument and roadmap for future initiatives.	Haase et al. (2024)

data and information base. We also aimed to (iv) select different habitats and (v) varying spatial scales.

We selected national, subnational (across administrative borders, including federal state borders), or local (without crossing administrative borders) case studies. In addition, we selected one case that extends beyond the borders of Germany (e.g., rewilding of the Oder Delta between Germany and Poland). We also distinguished according to habitat dimensions: habitat-specific, cross-habitat, and habitat-independent processes. Habitat-specific processes are those affecting a specific (semi-)natural ecosystem and habitat, for example, a forest or an urban area. Cross-habitat processes affect several adjacent habitats, for example, a protected area, or processes dealing with legal, political, or social structures or processes and therefore affect different habitats, for example, citizens' initiatives or changes in legislation. Habitat-independent processes cannot be assigned to specific habitats (see Table 1).

2.2. Case study analysis

We combined two frameworks: Mehring et al., (2024) to analyse change processes and the framework to evaluate transformative potential, by Wittmer et al., (2021). The Mehring et al., 2024 approach was developed by our research team to examine secondary cases of biodiversity-enhancing societal change under a transformative perspective. The Wittmer et al., 2021 framework was selected because it follows a biodiversity-oriented approach, i.e. it examines recommendations from global assessments and reports on the state of nature and the environment, and analyses international cooperation projects in the field of biodiversity for their transformative potential. This allowed us to derive enabling features for biodiversity-friendly change in Germany (Fig. 1, steps 1 to 3).

STEP 1. We started by applying the analytical framework of Mehring et al., (2024) by answering 23 analytical questions *on drivers of change and boundary conditions, the process itself, and the ecological and societal impacts* for each case study. This analysis was based on: literature research (both peer-reviewed scientific publications and grey literature), and expert knowledge (through reports or interviews). The output from the literature research and the data compilation was checked for plausibility and, as an additional validation step, was proofread by a team member who had not been directly involved in the initial literature analysis process (*cross-check 1*). When integrating expert knowledge, the external perspective and possible critical comments were included. This approach also helped to check whether the results of the literature research accurately reflected the context and circumstances of each case study *(reality check)*.

STEP 2. In the next step, we applied the conceptual framework developed by Wittmer et al. (2021) to evaluate transformative potential and to ascertain the enabling characteristics for transformative change. They distinguish five topics or building blocks of transformative change towards sustainability: vision, knowledge, dynamics, emancipation & agency, and transformative governance. For each topic, we formulated questions to analyse how the specific topic is reflected in the cases analysed (Q1-Q12). Table 2 presents a concise overview of the topics, presenting key elements and the questions used to identify these elements in the cases. When analysing the last topic, transformative governance, we also applied the criteria elaborated by Arponen and Salomaa (2023) to examine governance interventions' roles in promoting societal change.

STEP 3. Subsequently, the 23 analytical questions from Mehring et al. (2024) were related to the five topics of Wittmer et al. (2021). Qualitative content analysis (cf. Mayring, 2021) was used to analyse individual case studies and to compare specific aspects **when** answering the questions Q1 - Q12. This approach helped to identify similarities and differences between all cases, and allowed us to better understand what enabled positive impacts for biodiversity and in what ways the cases contribute to the topics identified by Wittmer et al. (2021). From this analysis we derived overarching recommendations and identified 16 enabling features (E1- E16) for biodiversity-friendly transformative change, as developed and presented in the following section and in Fig. 2.

3. Results

3.1. Transformative vision

According to Wittmer et al. (2021) a shared and compelling vision of

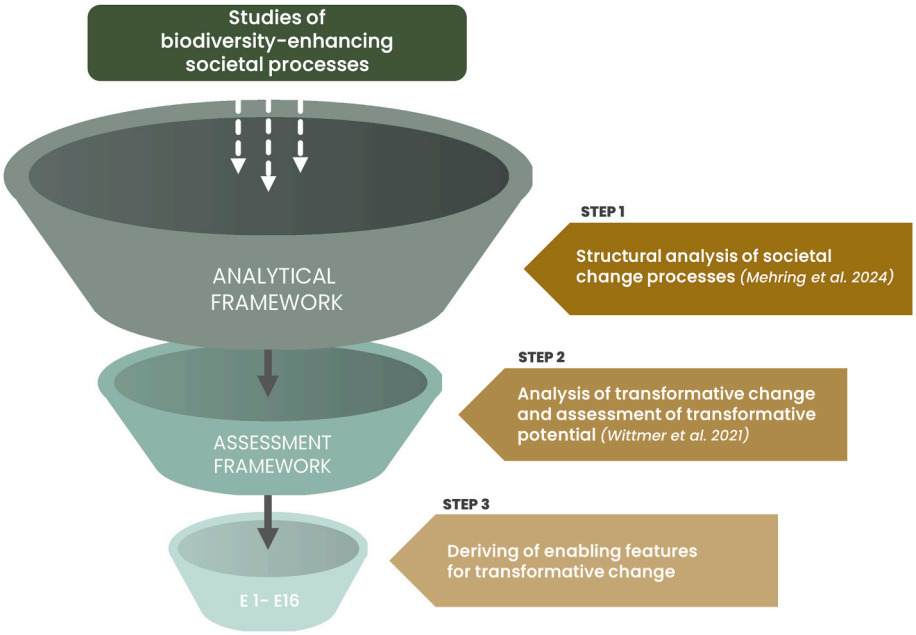

Fig. 1. Methodological approach used to identify enabling features for transformative change (Modified from Hauck et al., 2024). (The exact link between the two frameworks, which illustrates which questions from the analysis of societal change processes are linked to which questions from the framework for transformative change, can be found in the SOM 1).

Table 2
Overview of the topics of transformative change towards sustainability and questions used to analyse them. Source: adapted from Wittmer et al. (2021).

Topic	Questions
(1) **Transformative Vision** A transformative vision provides a shared, compelling view of the future that makes the desired state tangible, or at least imaginable, and thus provides orientation, inspiration, and motivation. These can be further enhanced by narratives outlining how this future might be collectively achieved.	**Q1**: Is there evidence of a shared vision of the future that makes the desired state tangible or at least imaginable? To what extent does this vision include biodiversity? **Q2**: Are there narratives or elements/ ideas for future narratives that convincingly outline how the new system will differ from the current one and ideas on how to get there?
(2) **Transformative Knowledge** The role of knowledge and knowledge processes and how to deal with the associated uncertainties; transformative knowledge is understood as knowledge about the possibilities and limits of - desired - changes in structures and processes that are characteristic of the respective problem situations under investigation.	**Q3**: What were knowledge-specific options and challenges? **Q4**: Was knowledge co-produced (e.g. between practice and research)? **Q5**: What was the linkage between knowledge and values (change in values)?
(3) **Transformative Dynamics** navigation and adequate response to the dynamics inherent in changing development pathways (transformational dynamics); Transformative change "can be nurtured, nudged, and navigated, but such processes cannot be managed or controlled" (Wittmer et al., 2021: 24). To nurture change means to create fertile ground for it; to nudge into change means to provide situation-specific stimuli; and to navigate change refers to seizing opportunities and recognizing obstacles along the way.	**Q6**: To what extent have indirect drivers of the problem been addressed? **Q7**: How is the current unsustainability being addressed? Specifically, has any action been taken to destabilize or completely terminate the unsustainable practices? **Q8**: What sustainable or biodiversity-enhancing alternatives have emerged?
(4) **Emancipation and Agency** Enabling emancipated action and opening up spaces for the creative participation of different social groups; even if there is broad agreement on a vision, the way in which it is implemented will vary. It is important to open up a political space "for individuals and communities to take action on their own behalf" (Scoones et al., 2020).	**Q9**: Has the initiative created opportunities for a public interaction that involves active participation, codetermination, and fairness? **Q10**: Was resistance anticipated and if so, how was resistance addressed? **Q11**: Which societal groups increased their political involvement and which did not?
(5) **Transformative Governance** This topic deals with the governance of transformation processes in the sense of organizing and deciding on actions and solutions.	**Q12**: What interventions, activities, and approaches were involved in each case, and what impact did they have on the change process?

the future, with narratives outlining how to get there are conducive to transformative change. In the cases analysed both shared visions and at least elements of narratives outlining pathways to achieving them have been identified.

Overall, there is clear evidence of shared ideas and guiding principles on which to build. Some case studies followed a formalized process to formulate explicit vision or mission statements (e.g. CS 22 for the regional biodiversity strategy they developed). However, there were also less formalized bottom-up processes. Interestingly biodiversity conservation is not necessarily the primary objective of the initiatives and it is linked and presented in different ways: e.g. as an element of reorientation, such as the reinterpretation of the former inner-German border *Todesstreifen* ("death strip") as a *Lebenslinie* ("lifeline") realized as the green belt, or the restoration of former lignite mining areas. Biodiversity can also be a central aspect motivating economic change, such as in the European Green Deal or community-supported agriculture.

When biodiversity is the primary objective, different aims can be pursued, such as maintaining a good status of biodiversity (CS 2, 5, 6, 16), restoration after decline/local extinction of species or ecosystems (CS 4, 7, 9), securing natural recovery (CS 8), or halting a negative trend (CS 19, 20). In several cases, large-scale spatial planning was applied, especially at the landscape level, and combined with integrative social-ecological thinking to ensure compatibility of other societal demands with biodiversity protection (CS 5, 6, 22).

→ E1: Shared visions and a mutual understanding of objectives have proven helpful, visions can contain different justifications for the protection of biodiversity; in some cases, biodiversity is not an explicit goal.

While none of the cases provide a clear narrative on how we as a society will live and do business differently, e.g. addressing indirect drivers, the case study analysis showed that biodiversity conservation can be an opportunity for (societal) change, a (re)orientation within an ongoing change process, or provide specific added value. From the case studies, several elements were identified that suggest a rethinking of the existing system and outline steps how the new state can be achieved.

- Combining protection and use (landscape level): Several cases combine biodiversity protection with land use in the same area (land sharing approach) by managing and using nature in ways that also protects biodiversity (CS 5, 6, 7, 16). Volunteering and personal initiatives, as well as communication and participation, play a major role in these examples.
- New economic objectives: increasing interest of consumers to grow their own food, or at least to be sure it is produced in a nature-friendly way, as in the CS 13, 14. In terms of biodiversity conservation, these approaches offer the possibility of valuing how products are produced to reflect ecological and social benefits in the price.
- Redefining concepts of the relationship between humans and nature: An integrated implementation of the idea of coexistence also considers people's fears and concerns, and not just, for example, economic compensation for damages caused by a wolf killing sheep (CS 8). A positive interpretation of human-wildlife-coexistence is important in order to allay people's fears (CS 7).
- Shaping of public space: The case study of urban gardens with the initiative "Right to a City for All" shows the (new) role that public space can play as a space for encounters between cultures and as a space for experiencing nature (CS 21).
- Systemic approach: The example of the Farm to Fork strategy (CS 12) and the community-supported agriculture case study (CS 13) show that considering the entire system from production to the consumption leads to more holistic options for action. These reduce the pressures causing biodiversity loss, and approach e.g. farmers as agents of change (CS 15).
- Symbolic significance of biodiversity: as outlined under E1 for the former inner-German border as a "lifeline" (Green Belt) (CS 2).
- Visions can entail different justifications for biodiversity protection (instrumental, relational, and intrinsic). These are not mutually exclusive, several case studies implicitly show relational connections and values (CS 2, 5, 6, 14). In these cases, a high and broad level of stakeholder involvement was realized from the beginning. Some cases explicitly refer to relational value and biodiversity conservation as a primary goal. The argument builds on care and concern for nature to derive a responsibility to counteract the loss of biodiversity case studies Green Roofs, Insect Protection Act and Flowering Habitats in Open Land (CS 9, 11, 15).

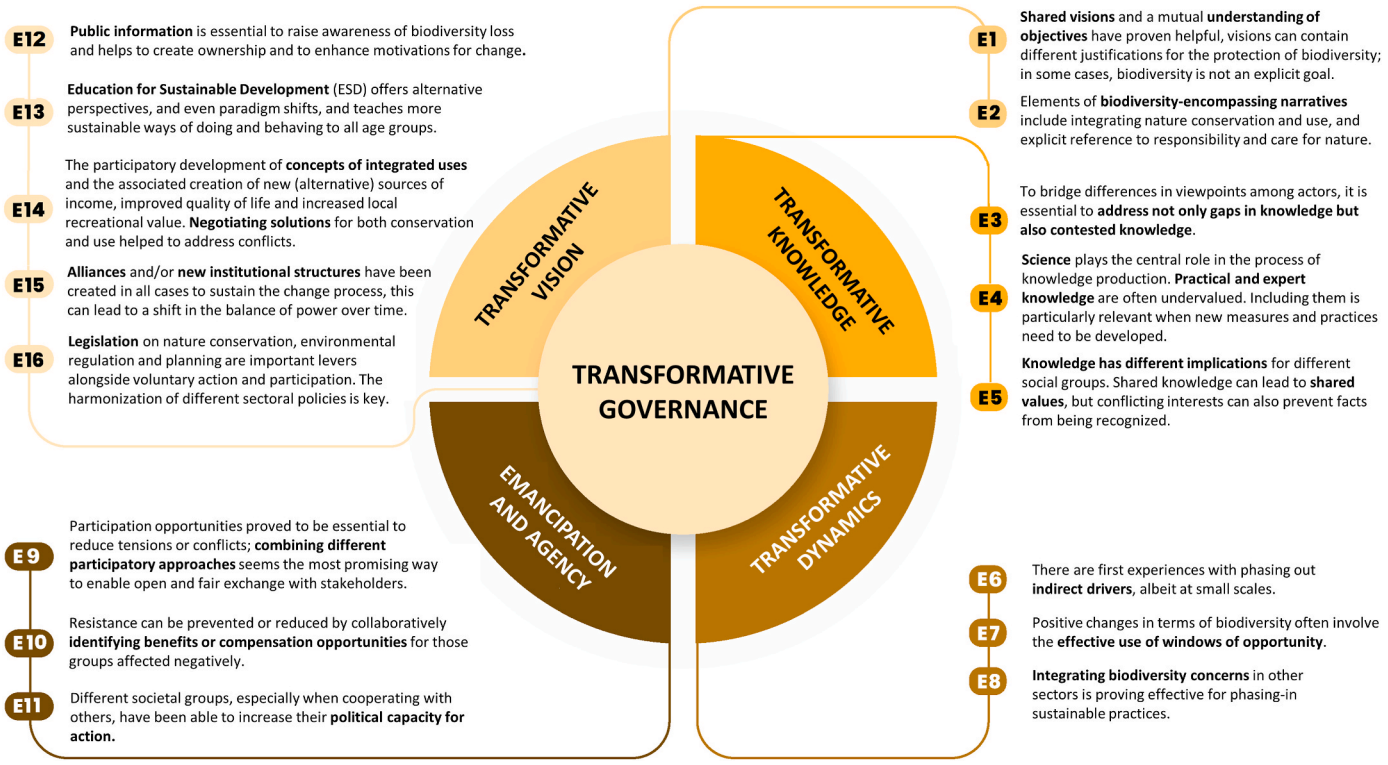

Fig. 2. Summary of findings along the five topics (Vision, Knowledge, Dynamics, Emancipation & Agency and Transformative Governance) (Modified from Hauck et al., 2024).

→ E2: Elements of biodiversity-encompassing narratives include integrating nature conservation and use, and explicit reference to responsibility and care for nature.

3.2. *Transformative knowledge*

Transformative change requires knowledge on the system (system knowledge), a goal of the system transformation (target knowledge) and on how to change a particular system (transformation knowledge) (Jahn et al., 2012).

Knowledge-related challenges can be identified in many case studies, mainly lack of knowledge. Lack of knowledge can occur in scientific understanding, e.g. knowledge of reliable practices or procedures for restoration (CS 3, 4), but also in the local understanding, e.g. in dealing with protection from wildlife (CS 8), or in dealing with invasive species on green roofs (CS 11). The case studies indicate that this lack of knowledge or a lack of successful knowledge transfer prevents necessary action. This is supported by the observation that knowledge about the importance of certain species in the triad of nature, culture and history can break down barriers (CS 2, 5, 6, 16). However, spreading more knowledge about the importance of biodiversity does not necessarily lead to more acceptance and willingness to act, but can also cause resistance and prevent action. This contested knowledge is characterized by the fact that it is not shared and recognized by (all) actors. For example, to what extent factors such as agriculture, climate, and nitrogen inputs contribute to the decline of insect diversity in Germany is not viewed uniformly by all stakeholders (CS 10). In addition, the example of the return of the wolf (CS 8) shows that scientific findings are perceived in the political arena as statements with their own agenda and thus inevitably become part of social conflicts. Some actors argue for a coexistence strategy while others prefer the protection of humans from wild nature/wilderness (CS 7, 8).

→ E3: To bridge differences in viewpoints among actors, it is essential to address not only gaps in knowledge but also contested knowledge.

Scientific knowledge has played a central role in initiating and accompanying change processes. This is particularly true when it comes to identifying causal relationships and recognizing influencing factors that are not generally known to the lay public. Scientific studies are also a central reference point for justifying the need for and nature of change, as well as for implementing conservation measures and monitoring their success. Practical and expert knowledge from stakeholder groups like agriculture, planning, business and engineering is particularly useful when procedures, e.g. for restoration, have to be developed for the first time. (CS 3, 4, 14).

Examples such as the Rhön Biosphere Reserve (CS 5) show that cooperation between policy, science and the public is important, especially when it comes to those affected by and involved in the change process, with their specific forms of knowledge (natural and social sciences, local knowledge, planning knowledge, engineering knowledge). Some cases show that not including relevant stakeholders and their knowledge from the outset limits the scope of achievable outcomes (CS 9).

→ E4: Science plays the central role in the process of knowledge production. Practical and expert knowledge are often undervalued. Including them is particularly relevant when new measures and practices need to be developed.

The example of the return of the European wolf (CS 8) shows how increased knowledge about biodiversity not only represents an opportunity, but can also raise fear and scepticism. Both wolf supporters and opponents have a high level of knowledge. Nevertheless, factual information about the wolf also provides a basis for relativizing or even dispelling prejudices. The case study shows that a purely fact-based, emotionless knowledge transfer is not necessarily successful in

enhancing acceptance. Knowledge in social contexts is not value-free. This is also demonstrated by the example of the sovereignty of interpretation, who is responsible for the decline of insects (CS 9, 15). The case studies show that knowledge alone often does not lead to change, it is the politicisation that gives knowledge importance and value. Knowledge inevitably becomes political if it is to guide societal change. However, strong values towards knowledge can not only create consensus and motivate change. They can also provoke resistance and conflict. In the examples analysed, resistance and conflicts were reduced by sharing information. Knowledge transfer can therefore inform the political reconciliation of interests but it cannot replace it.

→ E5: Knowledge has different implications for different social groups. Shared knowledge can lead to shared values, but conflicting interests can also prevent facts from being recognized.

3.3. Transformational dynamics

According to Loorbach and Oxenaar (2018) transitions or transformations require two parallel processes: developing and expanding the use of a desired (sustainable) practice/technology/approach (phasing in) and the breakdown and discontinuation of unsustainable practices/technologies/approaches (phasing out). There are different approaches and policy options to enhance each of these processes.

The case studies covered a broad range of factors influencing biodiversity as direct and indirect drivers, but especially the latter are usually not explicitly mentioned in the literature analysed. In several cases environmental education and education for sustainable development played an important role (CS 2, 17, 18). Promising examples are those that demonstrate sustainable alternatives and options for community action to support biodiversity conservation. Cases illustrate various methods to make sustainable practices more viable and (at least partly) address the externalisation of costs in agricultural production, including reducing pesticide use, incorporating biodiversity benefits and reducing labour peaks. This gives consumers more environmentally and socially sustainable choices (CS 5, 12, 13, 14). These cases thereby address the indirect drivers of unsustainable production and consumption, however, most of them are on small sometimes experimental scales.

→ E6 There are first experiences with phasing out indirect drivers, albeit at small scales.

In the context of the examined societal change processes that have yielded positive outcomes for biodiversity, the introduction and promotion of sustainable practices and techniques typically occurs where unsustainable practices and techniques are no longer viable options, particularly when they are formally prohibited, thereby necessitating significant changes and creating opportunities for phasing in. The case studies (CS 2, 3, 4) show rather low opportunity costs for biodiversity conservation. Sustainability has a greater chance of success if required sacrifices are small. This was achieved by gaining a protection status for previously only marginally used areas (CS 2, 7) or by restoring ecosystems, such as natural habitats, in locations with extreme environmental conditions (CS 11).

In most of these cases, broader change processes such as passing legislation to reduce pollution (CS 1), German reunification (CS 2) and ending open pit mining as result of the energy transition (CS 3, 4) opened windows of opportunity to achieve biodiversity goals as a positive side effect.

→ E7: Positive changes in terms of biodiversity often involve the effective use of windows of opportunity.

The negative impacts of unsustainable practices on biodiversity are being addressed by harmonizing agriculture, tourism, and landscape planning with nature conservation. The analysis of the case studies identified four overlapping strategies: i) linking nature conservation and agriculture, ii) linking nature conservation and tourism, iii) promoting biodiversity-friendly landscaping, and iv) protecting and supporting natural regeneration processes. There is a broad set of options to integrate nature conservation in agriculture, leading to more environmentally friendly farming: through extensive land use without pesticides, observance of bird-breeding periods (CS 2), increasing the share of organic farming (CS 5), near-natural grazing systems, and carbon certificates (CS 7). Nature conservation and tourism are also working together successfully, e.g., through appreciation of the return of species (CS 1), recreation, running, and hiking routes (CS 3), broad acceptance of process conservation (CS 17), and development of sustainable tourism (CS 6). The promotion of biodiversity-friendly landscaping is contributing to environmentally friendly and climate-adapted cities (CS 11, 21) e.g. via AI-supported lighting (CS 9). Nevertheless, the implementation of more biodiversity-friendly land use practices is not always straightforward and may require compromises.

→ E8: Integrating biodiversity concerns in other sectors is proving effective for phasing-in sustainable practices.

3.4. Emancipation and agency

Even if there is a broad consensus on a vision, there will be different paths to its realization. Transformative change requires the opening up of politically active spaces for the creative participation of different social groups 'in which individuals and communities can act on their own behalf' (Scoones et al., 2020).

The case studies can be divided into 1) top-down processes, where the change process was initiated and driven at the governmental/administrative level, and 2) bottom-up processes, which have been mainly initiated by citizens and through initiatives.

The majority of the case studies have repeatedly facilitated exchange in the course of the change process (CS 1, 3, 13, 14, 18, 19, 20, 22). In many of these cases initially little attention was paid to participatory elements or cases were largely ignored by some actors (governmental entities not knowing about bottom-up processes or citizens not paying attention to top-down processes). After tensions or conflicts occurred, participation was increased; and regardless of initiation, actors in almost all case studies usually combined different approaches of participation.

- *Instruments of information dissemination:* exhibitions, lectures, action days, excursions, newsletters, newspaper reports, leaflets, brochures, press events, national articles, short films, TV, and radio reports (CS 2, 6, 7, 8, 17, 22), social media (CS 9, 15); sometimes, only mentioned as "media".
- *Active exchange:* round tables, meetings/workshops (CS 2, 7, 9, 15, 18, 20, 22), citizen science (CS 5, 10, 18), volunteering (CS 2, 5, 6, 13, 16, 18), members' meetings (CS 6, 13), and festivals and joint activities (CS 13).
- *Formal participation and consultation procedures:* with a public display of the documents (e.g., CS 3).

→ E9: Participation opportunities proved to be essential to reduce tensions or conflicts; combining different participatory approaches seems the most promising way to enable open and fair exchange with stakeholders.

Both top-down (e.g. CS 2, 5, 6, 12, 17) and bottom-up case studies experienced resistance (e.g. CS 9, 10, 11). In particular, farmers and landowners were initially sceptical about new concepts and changes. They feared that nature conservation would restrict their rights or cause economic disadvantages (CS 2, 8, 9, 10, 12). These concerns led to delays in implementation. In addition, some local authorities and their political representatives initially obstructed the processes (CS 5, 6, 8). Resistance at the local level was also triggered by the financial burden

on local authorities (CS 4, 22). Compensation through government support programs helped to cope with resistance.

The capacity and willingness to change practices was enhanced through a) intensive communication and dialogue, b) the payment of compensation or economic incentives (payments for sustainable land use, e.g., CS 2, 8, 12, 15, 20), and c) collaboration in umbrella brands, umbrella associations, and cooperatives made it easier to obtain higher returns and reflect the identification with the initiative (CS 1, 5, 22).

→ E10: Resistance can be prevented or reduced by collaboratively identifying benefits or compensation opportunities for those groups affected negatively.

The principal initiators of top-down processes were often a cooperation between municipalities, federal states, associations or cooperatives (CS 1, 2, 3, 4, 5, 6, 8, 22), which were thus able to expand and improve their capacity to implement change. In bottom-up processes, the initiators tended to be citizens (CS 13, 21), who became politically active. Tourism-oriented actors (tourism associations, hotels, restaurants, etc.) mainly benefited from the processes (CS 1, 2, 3, 5, 6). Societal groups like nature conservation and environmental associations, research and scientific institutions, and groups of active citizens have been able to expand their political influence (CS 1, 7, 16, 21, 22). Support by public media has increased the pressure on politics (CS 2, 9, 10, 15, 16). The degree of influence of farmers and other groups of resistance (as groups with political influence) could not be further specified within our analysis (CS 2, 9, 10, 12).

→ E11: Different societal groups, especially when cooperating with others, have been able to increase their political capacity for action.

3.5. *Transformative governance: intended transformative interventions*

Enabling transformative change towards sustainability requires a whole range of approaches, including many small steps in the same direction. We have used Arponen and Salomaa (2023) to analyse the different transformative governance interventions, as their approach provides a useful categorisation for this purpose.

Public information created awareness of the problem and over time weakened the resistance to, for example, unpopular measures or laws (CS 8) and helped to develop 'ownership' (CS 18). In the context of insect conservation, public awareness raising has led to initiation of new legislation through referendums.

An important part of gaining public support consists in underpinning narratives for change. For example, part of a post-mining landscape becomes the Leipzig "Neuseenland" (CS 3), the Wadden Sea a World Heritage Site (CS 18), the former inner-German border a German Green Belt ("Grünes Band", CS 2). The new terminologies are accompanied by alternative goals and values such as recreational value; something so valuable that it is worth inheriting (natural heritage); or a belt that unites.

→ E12: Public information is essential to raise awareness of biodiversity loss and helps to create ownership and to enhance motivations for change.

While awareness-raising is important for initiating change and overcoming resistance, ESD demonstrates and teaches alternative behaviours and actions. A wide range of information and education activities could be found in the case studies, including a large number of activities for schools and kindergartens, as well as many other activities such as field trips, ranger training, workshops, camps, seminars, training courses, simulation games, and citizen science. These activities helped to change perceptions and empowered participants to represent and communicate these perceptions to others, in some cases even contributing to a paradigm shift (CS 17, 18). Funding for educational work comes mainly from the government, but foundations and donation-based conservation organizations are also involved in capacity building, both financially and especially in terms of staff.

→ E13: Education for Sustainable Development (ESD) offers alternative perspectives, and even paradigm shifts, and teaches more sustainable ways of doing and behaving to all age groups.

The participatory development of integrated use concepts and - often linked to this - the creation of new sources of income were important for success. A common example is the strengthening of sustainable tourism as an alternative source of income to replace environmentally damaging practices (CS 1, 3, 5, 6, 7, 18). The massive improvement in environmental conditions has enabled new uses, such as local recreation, and led to a significant improvement in the quality of life, including an increase in property prices.

The participation methods varied greatly. Formal public stakeholder participation processes can be found as well as round tables, forums, workshops, and conferences.

→ E14: The participatory development of concepts of integrated uses and the associated creation of new (alternative) sources of income, improved quality of life and increased local recreational value. Negotiating solutions for both conservation and use helped to address conflicts.

In most cases, different sectors are working together in associations, networks, or other alliances. Often 'round table' is explicitly mentioned as a form of cooperation (CS 2, 4, 7, 10, 15, 18, 19, 20). In many cases, this cross-sectoral cooperation seems to make change more robust, as potential resistance has already been addressed in the cooperation. Associations are also an important pillar of the change process (CS 3, 11), as they provide alternative information flows and can also lead to a shift in the balance of power over time.

Once change started the importance of building administrative capacity to sustain it is evident in all the case studies reviewed. New institutional structures have been created to sustain the changes (CS 2, 3, 7, 11, 13, 21). These structures include official institutions such as national park administrations, water authorities, nature conservation authorities, etc. (CS 1, 17, 18). Some case studies also refer to newly established consultancy firms, as in the case of green roofs (CS 11), playing a central role in spreading the practice in the field. New structures also enable horizontal policy integration, i.e. the integration of biodiversity objectives into other sectoral policies and fields of action. This cooperation is not always entirely voluntary, as experts have shown in the case of the Wadden Sea (CS 18), where authorities needed instruction from "above" to cooperate.

→ E15: Alliances and/or new institutional structures have been created in all cases to sustain the change process, this can lead to a shift in the balance of power over time.

The Federal Nature Conservation Act is and regional nature conservation laws are mentioned and their importance emphasized in many case studies reports. In the case of the Wadden Sea (CS 18), the EU Habitats Directive is described as the "sharpest sword", it also plays an important role in the protection of wolves. The case studies on water protection and the Wadden Sea (CS 18, 19, 20) illustrate the need for harmonization of different laws, as well as the identification and amendment of environmentally harmful laws. Planning is also frequently mentioned - from the level of the Federal Spatial Planning Act to urban land-use planning and many other specialized plans (CS 1, 3, 4, 17). In principle, planning can also play an important role in adaptation processes, as it is continuously performed. However, time frames are often too long to respond quickly to new circumstances, and synergies and co-benefits are not always systematically sought.

→ E16: Legislation on nature conservation, environmental regulation and planning are important levers alongside voluntary action and participation. The harmonization of different sectoral policies is key.

4. Discussion

In this section we first discuss how the elements conducive to transformative change that we identified in the cases could be further enhanced to increase future transformative potential. The second part reflects on the limitations of our methodology.

4.1. Reflections on the results along the topics of transformative change

The analysis of real-life societal processes successful in protecting biodiversity revealed several insights to further advance conceptual and practical understandings of enabling factors. These are discussed below in relation to the five topics of transformative change: vision, knowledge, dynamics, emancipation & agency and transformative governance. By identifying which features of the cases contributed to these topics in our cases we intend to derive ideas on how transformative change can be supported in the future.

4.1.1. Transformative vision

Only a few cases explicitly developed visions of how a fundamentally improved future might look like, while several case studies implicitly reflected a joint vision or started the process later. In cases where biodiversity was articulated as the main goal of future development, the vision was often further elaborated with several sub-objectives for more sustainable and resilient development of nature and landscape (**E1**). It is important to realize that the reasons for motivating change differ across cases (**E2**). This included, for example, providing guidance and new orientation following political changes (e.g. in the green belt initiative), fostering new ways of doing business (e.g. community supported agriculture), or to improve the quality of life and make the area attractive (e.g. Emscher conversion). The results show that rather than the specific scope of a shared vision it is important that there is agreement on a need for change and willingness to negotiate strategies.

Transformative change can only succeed if all people involved understand it as a joint endeavour (Jahn et al., 2020). The failure to date of national and international efforts to achieve a bending the curve of biodiversity loss makes it clear that we need to turn to new points of reference: the interrelation between societal processes and biodiversity change, and the question of how we want to and can live as society in the future (Mehring et al., 2020).

At the same time, the development of vision(s) requires a critically reflexive position on the current state in order to consider the entire social-ecological system, including its interrelations (Jahn et al., 2020; Wittmer et al., 2021). As far as systemic change is concerned, these visions provide answers to the questions of how the new (transformed) system will differ from the current one. These visions should focus on the root causes of current unsustainability (Massarella et al., 2021) by addressing leverage points for sustainability transformations (Abson et al., 2017). This includes the restructuring of institutions across scales in order to support biodiversity-protecting practices and the strengthening of closer and diverse relations between people and nature (Pascual et al., 2023). Our results call for incorporating different conceptions of biodiversity and value systems into the vision development process, such as intrinsic, instrumental and relational values (Chan et al., 2016; Patterson et al., 2017; Chan et al., 2018; IPBES, 2019b). Nature conservation should no longer be seen as the opposite of nature utilization, care and responsibility towards nature and biodiversity should become more relevant (Jax et al., 2018). To avoid denial of inconvenient truths, narratives should not make claims to superior knowledge (Chilisa, 2017).

4.1.2. Transformative knowledge

Our results are confirming Mehring et al. (2017) who stated that it is not only necessary to address the attested 'lack of action', but also and above all to recognise and overcome a 'lack of knowledge' in order to reverse the trend of biodiversity loss (Mehring et al., 2017). Attempts to overcome this lack of knowledge are always about ignorance, contested or uncertain knowledge, because biodiversity loss, as well as its social causes and consequences, are multifaceted and complex (Mehring et al., 2017). In order to overcome the differences between the stakeholders, it is necessary to deal with contested knowledge and controversies in particular (**E3, E5**). Linking knowledge and values is both necessary and challenging. In the case studies analysed, the dissemination of more knowledge about the importance of biodiversity does not necessarily lead to more acceptance and willingness to act, but can also cause resistance and blockages to action (e.g. the case study of the returning of the wolf).

The attested "lack of knowledge" by Mehring et al. (2017) also implies that synergies between different knowledge systems are needed to inform science and policy (Thaman et al., 2013). Integrating diverse and heterogeneous knowledge from science and practice embodied in different stakeholders and organizations is essential (Cornell et al., 2013; Martín-López and Montes, 2015). In most of the case studies examined, science plays a central role in the co-production of knowledge at the beginning of the change process. However, as the process progresses, the importance shifts to less formalized forms of knowledge, such as practical and expert knowledge (**E4**). Future efforts should therefore actively include practical knowledge and its holders particularly in implementation phases.

4.1.3. Transformational dynamics

When considering the transformation towards sustainability, it is important to recognise possible pathways and to understand the dynamics within them. The different but complementary processes on the path (transition) to sustainability 'phase-in' and 'phase-out' must coincide in order to bring about comprehensive system change (Loorbach and Oxenaar, 2018), as innovation without exnovation results in novelty, but the ecological abolition of the unsustainable processes does not materialize (Paech, N. 2005). Scientific literature that unsustainable practices are strongly influenced by indirect drivers, such as societal values, or unsustainable production and consumption patterns and that these need to transform (IPBES, 2019b; Dasgupta, 2021; Visseren-Hamakers et al., 2021). Our analysis showed that almost all cases addressed direct drivers (**E6**). In contrast, indirect drivers were mainly mentioned in a few small-scale case studies which tried out new often holistic approaches. For further transformation, this means that upscaling such processes, in which biodiversity goals are integrated alongside other sustainability objectives, opens up new possibilities for addressing indirect drivers and thus also for phasing out unsustainable practices.

As we have found that positive changes in terms of transition from unsustainable to sustainable practices were often attributed to the effective use of windows of opportunity (**E7**), it is crucial to recognise and be prepared for making use of them in the future (Wittmer et al., 2021). Windows of opportunity often open up in phases of strong environmental, social, and political change and provide opportunities for novel solution paths initiated by individuals or groups and based on more or less alternative social norms, values, and ethical perspectives (Potthast, 2015; Chaffin et al., 2016).

Our analysis demonstrates that wherever integration of biodiversity concerns into other sectors was achieved this has contributed significantly to the gradual adoption of sustainable practices (**E8**). However, integration requires sustained efforts as evidenced by a study of the Swiss experience that found engagement to be transient rather than sustainable (Reber et al., 2023). This illustrates that while integration is beneficial, it requires continuous commitment and resources to maintain momentum.

4.1.4. Emancipation and agency

Increasing the legitimacy and acceptability of transformative changes (and for certain groups of society, possibly uncomfortable changes) requires knowledge, awareness, active participation, voice, and fairness. Even if these participatory measures are usually resource-intensive (i.e., time, financial, and human resources; De Geus et al., 2022), new ideas often emerge from diverse and bottom-up processes. Therefore, public spaces need to facilitate and expand open-ended negotiations (Scoones et al., 2020). The cases have shown that bundling interests into umbrella associations and the formation of alliances have increased the influence of informal groups on different political levels. Nature conservation associations should be active in such networks in order to ensure the implementation of biodiversity goals (**E11**).

Formally, most top-down processes analysed included participation, nevertheless, there were always groups of resistance in the participation process. The analysis supported the finding that emphasizing the social and economic added value was helpful to reduce resistance (**E9**). For the future it is important to ensure proactive participation approaches and to keep in mind that for an open and fair discourse, it is necessary to identify potential groups of controversy and possible resistance (Bulkeley et al., 2020). Acknowledging and dealing with resistance in a sensitive way helps to find solutions for conflicts. Financial support for farmers and other landowners as compensation for unavoidable disadvantages improved their willingness to accept measures (**E10**). However, such financial support should be only an interim solution to facilitate the transition to sustainability. The use of economic synergies also supported the process, e.g., synergies between nature conservation and tourism since nature conservation measures could also increase the environmental attractiveness for tourism but also synergies between nature conservation and ecosystem services (for all) provided via sustainable agriculture and forestry (Carlsson, 1999; Serra-Llobet et al., 2022).

4.1.5. Transformative governance

Our analysis supports Arponen and Salomaa (2023) in highlighting awareness-raising and education for sustainability as important leverage points for change (**E12, E13**). We also found that long-term alternative livelihoods, e.g. when developed as concepts for integrated uses, have the potential to shift mindsets of people, while compensations and support programs can help to solve conflicts in the short term (**E10, E14)** There is no single measure, solution, technology, or development of small improvements to 'business as usual' that enables transformative change towards biodiversity conservation. Rather, it requires the implementation of a series of interventions, of many even small steps, that work in the same direction, and ultimately enable the transformative change of entire systems (Geels, 2019).

Razzaque et al. (2019) elaborate on the modes of transformative governance, namely that governance needs to be simultaneously inclusive, informed, adaptive, and integrated in order to enhance the transformative potential of interventions and to be able to adjust as transformation unfolds. Other authors have added ensuring accountability to the list of requirements for transformative governance, defining who is held accountable for what by whom, and which elements can serve for monitoring, evaluation and possible sanctions for non-compliance (Mashaw, 2006; Biermann and Gupta, 2011). Unsurprisingly, concepts of integrated uses and intersectoral approaches have a huge potential for inclusion and integration (**E15**). Particularly, the concepts of integrated uses can help to support adaptation and contribute to accountability. Legislation on nature conservation, environmental regulation and planning, play a key role for accountability. Numerous instruments for the conservation and sustainable use of biodiversity already exist in Germany (**E16**). However, enforcement is sometimes incomplete and further instrument refinements and enhancements are required to more effectively address forthcoming challenges - for example, nature conservation management provisions (such as the earliest date for grass moving) need to be adapted to changing phenological patterns and the designation of nature conservation areas needs to better consider climate change-induced species' range shifts.

Yet, our study also identifies cases where the existing, relatively strong legal and policy frameworks sometimes fall short. Strengthening the role of civil society to monitor and claim compliance, as suggested in the EU Biodiversity Strategy for 2030 ((European Commission, 2021), as well as further strengthening rights regarding nature, e.g. by appointing intrinsic rights of nature (Knauβ, 2018), might be promising steps forward.

4.2. Reflections on methodology

The analysis of enabling features was based on 22 case studies of biodiversity-enhancing societal processes and projects in Germany. The focus was limited to Germany to explore enabling features for transformative change for biodiversity within a similar governance context. All case studies have a strictly place-based focus on biodiversity change and do not address issues of biodiversity decline driven by indirect drivers such as pollution or tele-couplings across countries (Haase, 2019; Fitzherbert et al., 2008; Kleemann et al., 2020; Lenzen et al., 2012). Selecting change processes successful for biodiversity in Germany has led to a collection of cases that do not directly involve telecoupling (compare e.g. Friis and Nielsen, 2019). The authors recognise that there are many external drivers of biodiversity loss, particularly in the Global South and low-income countries, and that there are often tele-coupled external demands also arising from Germany (Liu et al., 2007). This also points to a limitation of our approach: while it is open enough that effects of telecoupling could be included, our framework does not explicitly consider or ask for these.

Two further aspects affect our results: (1) our analysis only focussed on positive examples where obstacles were successfully overcome. An analysis of real-world cases, including such that did not achieve positive outcomes for biodiversity, for example, where resistance led to ending the project, would allow researchers to identify barriers to transformative change towards sustainability and to analyse why the barriers could not be overcome in these cases. Such an analysis would also lead to a better understanding of lock-in that frequently occur when far-reaching changes are attempted. (2) We did not include examples of civil society engagement, including movements such as "Fridays for Future" and "Extinction Rebellion", because as ongoing processes and broader movements it is not (or not yet) possible to directly attribute positive biodiversity outcomes to them. Nonetheless their impact on climate and environmental policy in Europe, specifically on the Green New Deal (European Commission, 2019) is commonly assumed and has recently been analysed, e.g. by Pollex and Berker (2024) and IPBES (2024). One of its elements is the nature restoration law, with the goal to restore 20 % of degraded areas by 2030 and all degraded ecosystems by 2050 (European Union, 2024). Plans for the first 20 % are to be finalized in the next 3 years and then to be implemented in all EU Member States. This constitutes an opportunity both to achieve a broad set of positive outcomes for biodiversity and to apply the insights from our study and the framework in a range of different socio-political contexts across Europe. Such an analysis could identify how features interact with each other and provide a more comprehensive overview of barriers and success factors. Transformation will, however, require even more, as it needs to address root causes and not only restore degradation.

5. Conclusion

Our results have shown that biodiversity concerns can be included in different settings and in many different ways; a broad framing alongside other objectives has been helpful. The process of co-creating local or regional visions together with a broad set of stakeholders was more important than the specific objectives or how explicitly biodiversity was included. The processes help to mobilize support and prevent resistance. In the EU, the recently enacted nature restoration law concerns many

sectors of society and restoring nature can work towards different societal objectives. This provides a good starting point for co-creation processes at regional levels, in terms of what matters to people. Ideally, these processes also enable participants to form broad alliances for the implementation phase. To ensure successful implementation that yields the expected results will require different forms of knowledge such as scientific knowledge from different disciplines as well as non-scientific expert knowledge especially when it comes to the development of new strategies and techniques of restoration. Working with different knowledge holders on equal footing throughout the processes, will enhance collaboration and reduce controversy. Governance of change might require the entire policy toolkit from co-developing integrated use concepts, and intersectoral collaboration to public awareness raising and environmental education.

Transformation can only be identified unambiguously ex-post, and transformative change towards sustainability has not yet occurred at societal scale. Therefore, we studied change processes with positive outcomes for biodiversity at smaller scales. We identified enabling features most of which point to the need for a broad range of communication, engagement, negotiation, and stakeholder involvement efforts. Our findings show a diversity of change processes has led to positive outcomes for biodiversity and people. We hope this provides inspiration and motivation for an inclusive implementation of the nature restoration law. This becomes all the more important in times of multiple crises where biodiversity concerns do not easily compete with more immediate worries, and where societal decision-making processes are increasingly challenged by populist seemingly easy proposals that largely deny environmental issues. Our analysis indicates a structured and well-informed approach that allows stakeholders to voice their hopes and concerns and contribute throughout the process is best suited to develop and implement proposals supported by broad alliances of societal groups. While indirect drivers are addressed in some small-scale cases, the largest remaining challenge is how this can be achieved on a broader scale.

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CRediT authorship contribution statement

Vera Schreiner: Writing – original draft, Visualization, Project administration, Methodology, Investigation. **Marion Mehring:** Writing – original draft, Methodology, Investigation, Conceptualization. **Janina Kleemann:** Writing – original draft, Methodology, Investigation, Conceptualization. **Jennifer Hauck:** Writing – original draft, Supervision, Methodology, Investigation, Conceptualization. **Stefan Knauß:** Writing – original draft, Methodology, Investigation. **Christian Poßer:** Writing – original draft, Methodology, Investigation. **Christian Schleyer:** Writing – review & editing, Conceptualization. **Thomas Potthast:** Writing – review & editing, Conceptualization. **Karsten Grunewald:** Writing – review & editing. **Christine Fürst:** Writing – original draft, Funding acquisition. **Jennifer Müller:** Investigation. **Christian Albert:** Writing – review & editing. **Monika Egerer:** Writing – review & editing. **Dagmar Haase:** Writing – review & editing, Funding acquisition. **Sonja C. Jähnig:** Writing – review & editing. **Josef Kaiser:** Writing – review & editing. **Tanja GM. Sanders:** Writing – review & editing. **Pia Sommer:** Writing – review & editing. **Thilo Wellmann:** Writing – review & editing. **Peter Keil:** Writing – review & editing. **Heidi Wittmer:** Writing – original draft, Supervision, Methodology, Investigation, Conceptualization.

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Appendix A. Supplementary data

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Data availability

No data was used for the research described in the article.

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