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RESEARCH ARTICLE

Multiple ways to bend the curve of biodiversity loss: An analytical framework to support transformative change

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Abstract

1. Humans are significantly impacting ecosystems worldwide. Scientists of the IPBES Global Assessment are therefore calling for a transformative change that includes all aspects of society in order to address drivers of biodiversity loss. However, these calls are rather abstract, and thus it remains unclear how this goal can be achieved.
2. With this conceptual contribution, we present an analytical framework for evaluating existing processes of societal change which are enhancing biodiversity, and we illustrate its application using three case studies in Germany. We argue that an empirical analysis provides insights into the causal mechanisms that initiate or promote change processes. In doing so, we can draw recommendations for future transformative change processes with regard to biodiversity conservation. In our analysis, we are dealing with questions concerning the following three areas: the drivers and context of societal change processes, the change processes themselves and finally their impacts.
3. Subsequently, we generate recommendations on how to enhance and support the process of future societal transformation that aims at biodiversity conservation: (a) Retaining co-benefits for biodiversity with goals that are primarily focussing on other objectives; (b) harmonising biodiversity use and conservation by turning conflicts into drivers of transformation; (c) prioritising biodiversity conservation by taking advantage of windows of opportunity.
4. With our conceptual framework, we provide an analytical tool to learn from existing processes of societal change how to support future transformative change. This is an important step that contributes to the generation of relevant knowledge of promoting transformative change for nature and people.

For affiliations refer to page 1956.

KEYWORDS
analytical framework, biodiversity, conservation, Germany, society, transformative change, transformative governance

1 | INTRODUCTION

Global trends show that biodiversity is still declining and the degradation of ecosystems is ongoing (Bardgett et al., 2021; Díaz et al., 2019; Forzieri et al., 2022; Monroe et al., 2019) Therefore, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) calls attention to the fact that current policy efforts are insufficient and more ambitious changes are required (IPBES, 2019). The projected trends until 2050 show that the negative effects on biodiversity will continue if transformative changes do not occur (IPBES, 2019). As a logical consequence, IPBES urges for 'a fundamental, system-wide reorganisation across technological, economic, and social factors, including paradigms, goals, and values', making sustainability the norm, which will then lead to transformative change (IPBES, 2019). A similar plea was made by the Convention on Biological Diversity (CBD) as until now none of the biodiversity goals internationally agreed upon in 2010 have been fully achieved (CBD, 2020; Mehring et al., 2017). The 'Theory of Change' of the CBD (CBD, 2021) specifies the need for transformative measures, which aim to reduce threats to biodiversity and ensure sustainable use of biodiversity in order to meet human needs. The proposed goals and approaches are in line with other international political agreements, such as the 2030 Agenda for Sustainable Development (UN, 2022), and European and national Biodiversity Strategies (EU, 2020).

Even though suggestions of pathways for sustainable 'nature futures' exist (e.g., Pereira et al., 2020), an internationally recognised strategy and operationalisation is still missing. In addition to the lack of standardised methods to monitor and assess biodiversity dynamics across landscapes (Canullo et al., 2020; Marquard et al., 2013; Schröter et al., 2016), standardised methods for comparative analyses of societal change within and between social-ecological systems such as via social-ecological networks are also still limited (Kluger et al., 2020). Although general socio-political support for transformative changes is increasing, the understanding of profound social-ecological changes remains rather abstract, and there is increasing consensus that transformation can be shaped while its controllability remains limited (Jahn et al., 2020). By analysing structural transformations ranging from industrialisation, to systemic approaches that focus on the role of policies and governance, to local initiatives promoting a change agenda (Scoones et al., 2020), transformative processes can be identified and described at different spatial scales. However, ideas on how to accelerate, manage, identify and evaluate their potentials for future transformation, namely the opportunity that could lead to a transformative process, are still being developed. Recently, the debate on transformative change and potentials for transformation has intensified and attempts have been made to draw conclusions from literature with the aim of helping CBD negotiators integrate approaches of transformative change into the Global Biodiversity Framework (CBD, 2022), to make them part of national biodiversity strategies and to implement them at the project level (Bulkeley et al., 2020; Loorbach & Oxenaar, 2018; Wittmer et al., 2021). However, there are only a few empirical studies that address the question of how processes of societal change can actually lead to positive impacts on biodiversity (IPBES, 2021). Therefore, it is necessary to better understand which existing societal processes could indeed lead to fundamental changes with positive effects on biodiversity and to find out whether or how such transformative changes can be supported or initiated.

Against this background, we present an analytical framework for evaluating processes of societal change, which have already led or are very likely to lead to a positive outcome in terms of restoring, conserving or enhancing biodiversity. Even though these societal change processes themselves may not be clear examples of full transformation, they still carry aspects of transformative change. Applying this framework to three case studies from Germany, we learn about potentials for future transformation from existing societal change processes. The novelty of this paper is the presentation and application of an analytical framework that helps to understand how existing societal change processes have been successful in enhancing biodiversity. The idea of this approach is to learn from successful cases that provide concrete concepts for the transformative change of biodiversity. Based on the findings from the case studies, we offer recommendations on how to enhance future societal transformation towards biodiversity conservation.

2 | ANALYTICAL FRAMEWORK

2.1 | Development of the framework

Germany is an interesting and relevant case for understanding potentials for transformative change. Due to Germany's strong economy, the influence of indirect drivers is high. Given global trade relations, Germany also has a strong influence on biodiversity dynamics in other countries (Kleemann et al., 2020). Although biodiversity policies including regulations and national mechanisms for financing and managing biodiversity conservation are operational and have been largely implemented in Germany, a standardised approach to regularly monitor biodiversity and ecosystem services within its national borders, as well as Germany's impact on

biodiversity elsewhere, is still lacking (Albert et al., 2017; Schröter et al., 2016). However, different initiatives and programmes have recently started to address these gaps. For example, the German National Biodiversity Centre that opened in 2021 is planning a standardised and integrated approach to data management and assessment methods with the aim of facilitating the regular monitoring of biodiversity (BfN, n.d.). As part of the MAES[1] (Mapping and Assessment of Ecosystems and their Services) process, national ecosystem service indicators were developed (Grunewald et al., 2022) and the German Biodiversity Assessment 'Faktencheck Artenvielfalt' was initiated in the same year.

In the context of the German Biodiversity Assessment 'Faktencheck Artenvielfalt' (English: checking the facts on biodiversity) (Farwig et al., 2022), an interdisciplinary working group of experts was set up seeking to identify and evaluate potentials for transformation for biodiversity conservation and restoration in Germany (project duration: April 2021–June 2024). The German Biodiversity Assessment was a joint initiative aiming to achieve an assessment of the current national status and to present an evaluation of trends regarding biodiversity in Germany. The project involved 140 scientists and practitioners from universities, non-university research institutions, public administrative institutions, stakeholders and associations and was funded by the German Federal Ministry of Education and Research (BMBF) as part of the Research Initiative on the Conservation of Biological Diversity (FEdA, n.d.). The analytical framework, developed in this project by the working group on 'Transformation Potentials', aims to operationalise transformative change processes by learning from experiences with societal changes that were beneficial for biodiversity.

All members of this working group, including natural, social and political scientists, contributed to the development of the analytical framework. The development of the analytical framework followed a process of obtaining expert knowledge informed by reviewing the relevant literature. To this end, the working group on 'Transformation Potentials' conducted a series of workshops. In a first step, the literature on transformative governance (e.g., Bulkeley et al., 2020; IPBES, 2019; Lee & Waddock, 2021; Visseren-Hamakers et al., 2021; Wittmer et al., 2021; Wunder et al., 2019), transformative research (e.g., Schneider et al., 2019), transdisciplinary research (e.g., Lux et al., 2019), transforming biodiversity conservation (e.g., Grumbine & Xu, 2021; Massarella et al., 2021) and leverage points in the global IPBES assessment (Chan et al., 2020; Fischer & Riechers, 2019; IPBES, 2019) was consulted. Based thereon, design criteria for the analytical framework were developed that were formulated as questions with the aim to outline the processes of societal change. In an iterative process comprising the consultation of literature and the further development of associated questions, those questions became increasingly specified.

[1]The EU Biodiversity Strategy to 2020 calls on Member States to carry out a mapping and assessment of ecosystems and their services (MAES, Maes et al., 2013). As such, an EU-wide ecosystem assessment was launched to provide harmonised information on the condition of ecosystems and biodiversity, and their capacity to provide ecosystem services.

The analytical framework now consists of 41 analytical questions to help identify the factors that contributed to the successful outcome of enhanced biodiversity (Table 1) and five exploratory questions to better describe and understand the respective processes (Table 2). Our criteria for selecting the case studies included the availability of reliable information and data. To analyse the processes in detail, we implemented a white-box approach based on the systems theory (Kasianiuk, 2016; Ljung, 1999; Rudin, 2019). The white-box approach provides an in-depth mapping of all process details and interactions together with their components. This enabled an analysis of not only the initial components (drivers and framework conditions) and conclusions (results) similar to the black-box approach, but it additionally included the process details. Using this as a basis, the case studies were analysed in three different dimensions: drivers and context, processes and impacts (Table 1).

The exploratory questions (Table 2) help to understand how the processes of change started, how they progressed, and what was achieved. By identifying commonalities regarding causes of and obstacles to change processes, we wanted to learn more on the potentials for transformation and on how to deal with typical obstacles. Focusing on impact, a picture emerged of what to expect from the change processes, both in terms of synergistic effects and potential negative consequences. Finally, by using this analytical framework, entry points for enabling and/or inducing transformation were identified.

2.2 | Steps of the analysis

Subsequently, the developed framework was applied to different case studies in Germany. The overall aim of choosing the case study approach was to produce in-depth insights about change processes. For our study, we selected case studies of societal change processes that had shown a positive impact on biodiversity. For a detailed overview of the selection process and criteria, see Section 3. Applying the analytical framework to the case studies, we took the following steps of analysis (Figure 1): To answer the analytical questions, we conducted a literature research (step 1) that included the integration of expert knowledge (step 2). Based on this data and information, the exploratory questions were addressed by compiling a summary for each case study (step 3, see also Section 4). Finally, recommendations were made based on commonalities and differences across case studies (step 4).

2.2.1 | Literature research

The aim of the first step was to obtain information for the analytical questions from relevant literature. Both peer-reviewed scientific publications and grey literature (e.g., project reports, brochures) were taken into account with the aim to provide complementary insights into the case studies. This is especially important as project

TABLE 1 Analytical questions for evaluating processes of societal change with the aim of enhancing biodiversity.

Drivers and context analysis	Process analysis	Impact analysis
D1. What event(s)/factor(s) triggered the process of change? D2. What was the baseline condition regarding the status of biodiversity? D3. What was the goal of the process of change? D4. Which drivers of biodiversity loss are relevant? D4a. indirect drivers D4b. direct drivers D5. What were the main barriers? D5a. ecological barriers D5b. societal barriers D5c. legal barriers D5d. administrative barriers D5e. financial barriers D6. What counter-narratives or controversies existed and what effects did they have? D7. What other circumstances/factors played an important role in the process of change?	P1. How and in which phases did the process of change and the participation proceed? P2. Which actors were involved in the process of change? P2a. Which actors were crucial in initiating and/or driving the process of change (agents of change)? P2b. Which actors actively or passively hindered the process? P2c. Which actors were positively affected by the process of change? (initial situation and/or solution pathways) P2d. Which actors were negatively affected by the process of change? (initial situation and/or solution pathways). P2e. Did the constellation of actors change during the change process? / Which actors were involved in which phase? P3. Which instruments were used for the process of change? P3a. legal and regulatory instruments (e.g., planning instruments) P3b. economic and financial instruments P3c. social and informational instruments P3d. (human) rights-based instruments and customary norms P4. Which measures were implemented for the process of change? P5. Which resources were relevant for the process of change? P5a. personnel/administrative resources P5b. natural resources P5c. financial resources P5d. technical/technological resources/new technologies P6. To what extent have (trans)national network relationships and resulting synergies fostered the process of change? P7. Was there an integrative/cross-sectoral collaboration? P8. Was the process reflexive and did it allow for iterative learning and adaptation to new circumstances? P9. Which role did knowledge play in the process? P9a. How was knowledge (co-)produced? P9b. What kind of knowledge was relevant? (Has the manner of handling the knowledge changed?) P9c. Which role did research play in knowledge (co-) production? P10. Which fundamentally different or new approaches played a role?	I1. Which (ecological) changes for ecosystems and biodiversity have resulted from the process? I1a. What changes have occurred for biodiversity? I1b. What changes have occurred in the provision of ecosystem services? I2. Which societal (socio-economic and socio-cultural) direct and indirect impacts have resulted from the process (including technological and infrastructural impacts as well as institutional changes, everyday practices and norms and values)? I3. To what extent have structures and everyday practices (of biodiversity use) changed? I4. Which negative ecological and societal side effects or rebound effects occurred during the process? I5. Which ecological and societal synergies emerged during the process? I6. Which temporal (future generations) and/or spatial impacts (side effects, tele-coupling) occurred?

results are often only found in reports written for the respective funding bodies. Finally, 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*). If a question from the analytical framework was not relevant for a particular case study, this was indicated in the table (see Supporting Information S1).

2.2.2 | Integration of expert knowledge

In the second step, experts who were familiar with the change process in the respective case study (see Section 3) reviewed the case study in question. The criteria for the selection of experts included considerable practical experience, adeptness in the subject matter of the case study, and direct or indirect experience with the process. At least two external experts added their comments and amendments to the analytical questions. The experts were invited to join the 'Faktencheck' project team as contributing authors of the Biodiversity Assessment and are listed in the acknowledgements of this publication. The expert knowledge was obtained through written or oral interviews and inserted into the analytical framework (see Supporting Information S1). Since it is a decisive factor for integrating expert knowledge during the various steps of the change process, the external perspective and possible critical comments were included. This approach thus offers a second form of validation, namely, to check whether the content of the analytical questions accurately reflects the context and circumstances of the case study in question (*reality-check*). It also allows for the inclusion of different perspectives (triangulation) and enables highlighting categories from the analytical framework that may not be covered by data or published information.

2.2.3 | Development of a summary

Subsequently, in the third step, a summary along the five exploratory questions (Table 2) was created for each case study using the data information gained by applying the analytical questions (Table 1). This step was done by an additional person who was not directly involved in answering the analytical questions in step one. The analytical summary aims to identify enabling conditions as well as barriers within each case study. The summary was then cross-checked by the person who had initially answered the analytical questions (*cross-check 2*). The participants in both cross-checks are co-authors of this manuscript. In a project team workshop, we discussed each case study regarding its potential for transformative change and how this relates to biodiversity following the exploratory questions (Table 2).

2.2.4 | Synthesis across case studies

However, in order to derive recommendations for increasing the transformation potentials, we went beyond the analysis of individual cases. Thus, a comparative analysis of certain aspects was carried out to identify commonalities and differences across all cases to better understand what enabled the positive impacts for biodiversity and to derive recommendations. The synthesis of insights and outcomes across case studies was guided by the analytical framework and the corresponding questions. For each exploratory question (Table 2), we compared the results of all cases to explore the degree of differences as well as the shared commonalities. In this step, the analytical questions were critical to ensure that comparable results were distilled from each case.

3 | CASE STUDIES

3.1 | Selection criteria

For the selection of case studies, it was important to demark the social-ecological system in which the processes of societal change had taken place. Here, different perspectives were taken into account. It is important to keep in mind that system boundaries can be drawn according to the respective context, and this process is always subjective to some degree (Biggs et al., 2021; Cumming & Collier, 2005; Göpel, 2014).

TABLE 2 Exploratory questions derived from the analytical framework, including the respective analytical questions.

Exploratory questions	Analytical questions on the following aspects	Respective analytical questions
What is the link to the drivers of causal biodiversity loss?	Direct and indirect drivers	D1, D4
What kind of positive biodiversity changes have occurred?	Initial and current status of biodiversity	D2, I1
What were important concerns, obstacles, resistances or negative impacts?	Barriers and counter-narratives, negative side effects (temporal and spatial) incl. rebound effects	D5, D6, D7, I4, I6
What were the most important success factors that brought on the change?	Process, actors, instruments, relevant resources, networks, collaboration, role of knowledge, everyday life practices, societal impacts	P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, I2, I3
What was transformed?	Aim of the process, ecological and societal impact incl. synergies	D3, I1, I2, I3, I5

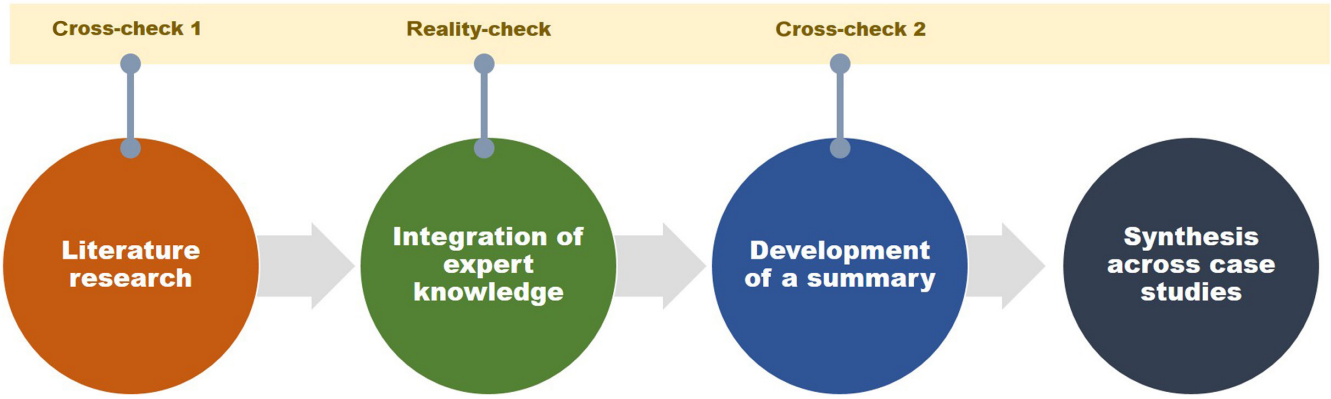

FIGURE 1 Steps of analysis: Applying the analytical framework to the case studies.

For the analysis, different *habitats* were considered, and in this context, the following processes were examined: (1) habitat-specific processes or those affecting a specific (semi)natural ecosystem, for example, a forest or grassland area; (2) processes across habitats or the ones affecting several adjacent habitats; (3) habitat-independent processes, namely those that address legal, political or social structures and processes, and others such as citizens' initiatives or legislative changes which can due to their nature unfold in many different habitats. The case studies were also selected based on the following characteristics with the aim of achieving a high diversity of cases along these dimensions. Case studies with *positive impacts* in terms of internationally agreed biodiversity targets were chosen as so-called best-practice examples. However, the positive effect on biodiversity does not necessarily need to be achieved intentionally or through explicit policies to be able to uncover potential co-benefits and synergies. Case studies with negative impacts on biodiversity were not included. In addition, besides biodiversity conservation, *social and economic goals and/or achievements* were considered in the case studies, as well as political and historical contexts. Social and economic objectives were required to play a role in our case studies, and in some of them social and economic objectives were even at the centre with the conservation of biodiversity as a possible side effect. Significant shifts of socio-economic, ecological and political problems from one region, country or generation to another should not occur. This means that cases with tele-coupling effects were not selected. Additionally, case studies were expected to have a reliable *data and information base* and ideally contact persons in organisations directly involved in the respective process of societal change. To achieve a diversity of spatial and temporal dimensions, the following aspects were considered: the *spatial dimension* of the case studies could be at the national, subnational (federal state) or local level. It was also possible to integrate cross-boundary case studies, for example, with a view to administrative borders or processes at national or federal state level. Furthermore, we included the governance dimension of the process of change. Here, we distinguished between top-down (divergent) and bottom-up (convergent) processes of change. Regarding the *temporal dimension*, the case studies could either represent examples of completed processes of societal change that already show a positive impact in terms of internationally agreed biodiversity targets, or they could be examples of ongoing processes where a positive impact on biodiversity had become apparent but could not yet be backed up with sufficient data.

3.2 | Application to case studies in Germany

To illustrate the application of the analytical framework, we selected three case studies for this publication. We opted for a high diversity across all criteria (Table 3). Although the selected case studies presented in this paper are all located in Germany, the analytical framework can be applied anywhere.

4 | RESULTS: APPLYING THE ANALYTICAL FRAMEWORK TO THE CASE STUDIES

In the following Sections 4.1–4.3, we give a summary of the analysis of the respective case studies (Table 3). A comprehensive and detailed overview according to the analytical framework is presented in the Supporting Information (S1).

4.1 | Stepping stone concept: Habitat-specific case study

The stepping stone concept is illustrated by a habitat-specific case study for forests. Initially, it was mainly used in state forestry and was first implemented in Germany in the region of Steigerwald, Bavaria. The concept was implemented in 2006. After the designation of a national park failed due to pressure from the local population, the concept was seen as an alternative to the national park. Stepping stones are areas between 0.3 and 20 ha as part of managed forests that are set aside from human use. The stepping stone areas connect various large areas that were set aside (natural forest reserves, natural forest areas between 30 and 850 ha). By leaving trees with tree-related microhabitats (Larrieu et al., 2018) (hereafter referred to as biotope trees), as well as standing and lying deadwood within managed forest areas, new structures and habitats are created with the aim of promoting species biodiversity, particularly saproxylic (i.e., deadwood depending) organisms

TABLE 3 Overview of case studies selected for analysis. The dimensions refer to the situation in Germany.

	Stepping stone concept (Section 4.1)	Emscher conversion (Section 4.2)	Referendum on biodiversity (Section 4.3)
General description	Nature conservation-oriented, sustainable forest use that integrates elements, such as biotope trees, deadwood, forest stepping stones and natural forest reserves into forestry use	Construction of a central wastewater treatment system in the Ruhr region and restoration of the river Emscher and its tributaries	Petition for a referendum on 'Biodiversity & natural beauty in Bavaria—save the bees!' to achieve a legal anchoring of nature rights in the Bavarian constitution
Spatial dimension	Local level: Franconia in Bavaria, Southern Germany	Local level: Northern Ruhr area in North Rhine-Westphalia, Western Germany	State level: federal state of Bavaria, Southern Germany
Temporal dimension	Since 2006	1989 to 2021	2018 to 2021
Functions/habitats dimension	Habitat-specific	Across habitats	Habitat-independent
Governance dimension (direction of action)	Top-down and bottom-up	Top-down	Bottom-up

(Mergner & Kraus, 2020; Stokland et al., 2012). The concept is also used for biotope networks to reconnect natural forest reserves because small-scale patches can maintain a high biodiversity (Fahrig, 2020).

4.1.1 | What is the link to the drivers of causal biodiversity loss?

Timber use with its associated sources of income and jobs is an important factor in the Steigerwald region. As a result, there was great resistance against establishing a national park in the region, something that was, however, demanded by other parts of society.

4.1.2 | What kind of positive biodiversity changes have occurred?

The compromise was implementing the stepping stone concept which meant protection by partial closure with an ongoing use of the forest in other areas. The renunciation of utilisation and exploitation leads to the enrichment of deadwood and the retention of biotope trees. The only partially ongoing management made it possible to specifically promote those tree species that would normally be displaced by other tree species. Therefore, by increasing the diversity of forest tree species, a high proportion of deciduous trees (80%) could be reached compared to coniferous tree species (20%). High biodiversity is for instance associated with oaks (Penone et al., 2019) that strongly depend on light and warmth, and therefore would have been outcompeted by the more shade-tolerant beeches.

4.1.3 | What were important concerns, barriers, resistances, and negative impacts?

Resistance came from two sides. On the one hand, there was resistance to reducing the use of forests by family-run sawmills and households collecting firewood from the set-aside areas. On the other hand, acceptance of the stepping stone concept is still lacking among national park supporters and those non-governmental organisations for whom the concept is not going far enough.

4.1.4 | What were the most important success factors that brought on the change?

The most important factor for the protection of biodiversity turned out to be the various ecologically effective elements that are distributed across 17,000 ha throughout the Steigerwald forest and therefore have an impact at the landscape level. On the one hand, ecologically valuable forest areas were taken out of use, establishing a network of habitat structures between the larger protected areas (natural forest reserves). On the other hand, management also enables the preservation of tree species that are extremely important for biodiversity (especially oaks) and that would disappear if the forest were abandoned. Synergies of the concept that arise through recreation, tourism and research have paid off for the set-aside areas. The case study is a popular research object with well-documented positive biodiversity-enhancing developments, and above all, these positive developments have been well communicated. As a result, this concept has been widely accepted by the local population and has influenced the forest management of other actors, some of them international (Krumm et al., 2020).

4.1.5 | What was transformed?

Compared with the forest management of the past that prioritised timber production, the stepping stone concept balances different societal objectives and, in particular, the consideration of biodiversity while still maintaining timber production. By agreeing on an approach that combines forest use with the conservation of the most important habitats within the area, a conflict was resolved that had arisen following a proposal for the establishment of a new national park. Letting go of high protective ambitions (national park) enabled

a more consensual and flexible approach that achieves great results for biodiversity while avoiding the kind of resistance and conflicts that occurred with regard to several national parks. It is therefore an optimisation approach, contrary to the maximisation approach of the past (timber production) or the ideas of the national park advocates ('let nature be nature'). National parks would also have the disadvantage that the historically inherited species would be significantly reduced (e.g., oaks) (Angelstam et al., 2022).

4.2 | Emscher conversion: Case study across habitats

The Emscher region was chosen as a case study across habitats. The area concerned is an (old) industrial sub-region in the northern Ruhr area in North Rhine-Westphalia that is characterised by large-scale industrial enterprises. Over the centuries, the Emscher river system was turning into a wastewater canal. As coal and steel from the Ruhr area were no longer competitive in the global economy, new ideas were developed in the region. From 1989 to 1999, the International Building Exhibition Emscher Park (IBA) initiated a large-scale project to restore the Emscher river system with the underground relocation of the wastewater section and the development of the above-ground restoration of the Emscher river. The Emscher river conversion, stretching over more than 85 km, was formally completed after more than 30 years of planning and construction, with the 'elimination of sewage' in 2021.

4.2.1 | What is the link to the drivers of causal biodiversity loss?

Initially, the technical requirements of the wastewater regulations had to be met. An open wastewater system no longer met the legal standards. Furthermore, due to the elimination of indirect drivers (industry and commerce disappeared in large parts from the region due to structural change), there was a need to create new employment opportunities, and a clear interest developed in increasing the attractiveness of the region. This paved the way for positive changes, not least due to considerable subsidies. Later, following the European Union (EU) Water Framework Directive (WFD), requirements were further increased, and compliance with them has led to a gradual improvement in the overall ecological status in recent decades.

4.2.2 | What kind of positive biodiversity changes have occurred?

There has definitely been a significant increase in species, an improvement in water quality, and morphological form over the course of the conversion process, which was accompanied by in-process surveying and monitoring. This has led to substantial habitat improvement across biotopes, including aquatic, terrestrial and general urban habitats, and has thus enabled wide-ranging recolonisation of various species. Although the enhancement of biodiversity was not the reason for the measures taken, it became increasingly the focus of attention as the conversion progressed. This topic also came to the fore in various stakeholder participation processes and was increasingly used for image-building purposes aiming to attract new companies to the region.

4.2.3 | What were the significant concerns, barriers, resistances, and negative impacts?

There were concerns about the high costs and flood protection. At times, there were lengthy approval processes and during the process, some municipalities were lacking funds. Otherwise, there were few obstacles, and the project did not meet open resistance.

4.2.4 | What were the most important success factors that brought on the change?

The Emscher conversion was initiated in the context of the Emscher Park IBA from 1989 to 1999, which made the transformation of the former coal and steel region on the Ruhr river its main task. The region has managed to continue the process by winning over other initiatives such as Cultural Capital EU 2010, European Green Capital 2017, as well as the International Garden Exhibition (IGA) 2027. Among other things, these initiatives secured part of the financial resources for this regional transformation. Over time, the conversion was also strengthened by meeting requirements for the restoration of the Emscher watercourse made, for example, by the EU WFD. Important success factors were the considerable and intentionally managed synergies with urban planning, housing construction and the areas of cultural promotion and tourism development.

4.2.5 | What was transformed?

Structural change in the economic domain led to a transformation of employment opportunities and income streams. This large landscape restoration made it possible to turn an area formerly dominated by coal mining into an attractive site for housing and new economic sectors. Biodiversity increased as a co-benefit of addressing the waste water contamination of the river system and also due to the overall improvement of landscape conditions.

4.3 | Petition for a referendum on biodiversity: Habitat-independent case study

As a habitat-independent case study, we have chosen the petition for a referendum on biodiversity that took place in 2019 in the German federal state of Bavaria. The petition for the referendum

'Volksbegehren Artenvielfalt und Naturschönheit in Bayern' [Petition for a referendum on biodiversity and natural beauty in Bavaria] ('petition' from here on) ran from January 31st to February 13th in Bavaria and aimed to amend the state's nature conservation law (Article 3, Paragraph 4, Sentence 1, no. 1 BayNatSchG). The aim of the petition was the establishment of specific regulations within the Bavarian nature conservation law with the aim of increasing the protection of biodiversity. The core demands included a Bavaria-wide network of habitats for animals, the preservation of hedges, trees and small bodies of water in agriculture, the creation of flowering verges along all streams and ditches, the expansion of organic farming, the conversion of 10% of all intensively managed meadows into flowering meadows, the conversion of all state-owned land to pesticide-free and the inclusion of nature conservation as a subject in the farmers and foresters training (Lenz et al., 2022). Political parties, as well as environmental and nature conservation associations, launched the petition and received support from a large number of other organisations. A participation of about 10% of the population was required for the referendum to be approved, but in the end, more than 18% signed the petition. Therefore, it is often described as the most successful petition for a referendum in Bavaria (Schäffer, 2020; Westenberger & Schneider, 2022). In July 2019, the Bavarian Parliament approved the requested amendment to the law without any changes (Pautsch, 2020), and so a referendum was no longer necessary. The legislative decision was accompanied by a so-called reconciliation law ('Versöhnungsgesetz'), which defines exemptions and refers to subsidy measures (Hartmann et al., 2021). Subsequently, similar referenda were launched in other federal states, but not all of them were successful.

4.3.1 | What is the link to the drivers of causal biodiversity loss?

The petition primarily addressed the direct driver of land use. In that case, the legal framework for land use was addressed by direct democracy. It should be emphasised that the petition had already contained the draft for the amendment of the law. This draft addressed legal requirements for biotope networks, riparian strips, light pollution, peatland protection, natural forests, organic farming, pesticides, orchards and meadow protection. After the publication of long-term and large-scale citizen science research of biodiversity in Germany, bee species were regarded as representative of insect loss in German biodiversity. The underlying narrative that bees and insects in general are important for pollination (and therefore the provision of numerous fruits and vegetables as human benefits) has fostered the awareness and need for their protection within society. The campaign showed a strong societal identification with bees as the flagship species and, at a higher level, helped to raise people's general awareness for the loss of biodiversity. Although it was not the primary goal of the petition, it is linked to the start of a change in values, not only in society but also in politics.

4.3.2 | What kind of positive biodiversity changes have occurred?

Since the implementation of the petition and the accompanying legal act, different measures have been taken, for example, the Bavarian Orchard Pact for the protection and conservation of orchard meadows was adopted. Other than that, further legal regulations and follow-up measures (catalogue of measures 'Adopt—Improve—Reconcile', optimisation of support programmes for grazing livestock farmers) were implemented and the financial support for insect-friendly areas (green bands and flowering strips) was increased. As part of the conservation of biodiversity, the habitat function and the conservation of genetic diversity have a particularly great potential. However, it remains to be seen how the amendment to the Bavarian nature conservation law will be implemented. The petition also brought about a reorientation of the debate on biodiversity conservation. A change in biodiversity awareness is also apparent within the local population. The extent to which this will ultimately have a positive impact on biodiversity is still under discussion and remains to be seen. At the political level, public demand has caused a shift in assessments, and subsequently strategies have been modified. Finally, the petition was a precursor for the national insect protection law in 2021 and will thereby lead to further positive effects in terms of biodiversity.

4.3.3 | What were significant concerns, obstacles, resistances and negative impacts?

The campaign also experienced significant opposition. It was especially opposed by farmers' associations, who were, among others, supported by hunting associations and some politicians. The opponents particularly criticised the focus on agricultural land use as the main cause of biodiversity loss. Farmers' associations, specifically, felt blamed for a phenomenon that is more complex and has not one, but several driving forces and causal effects. According to them, a broader approach is thus needed that also addresses other sectors and takes, for example, consumer consumption into account as well. However, they pointed out that farmers are already contributing largely to biodiversity conservation and that this commitment should be recognised. They found the amendment to be out of touch with actual practice, especially considering that the resulting restriction of production and the abolition of subsidies would lead to financial hardship and loss of existence under already precarious circumstances. The fact that the key actors in the desired process for fundamental change feel excluded and ignored can certainly be seen as a weakness of this change process.

4.3.4 | What were the most important success factors that brought on the change?

A variety of different factors contributed to the success of the change process. First, the broad mobilisation of alliance partners

from civil society, associations, economy, science and politics led to a strong network, and the establishment of local and decentralised action alliances provided the initiative with a multi-local presence. Second, the media-effective promotion at the beginning of the petition registration period should be mentioned: Numerous celebrities expressed their support, not just at the opening event in front of the Munich City Hall. The campaign received enormous media attention within a short period of time: The petition was widely discussed and communicated by the Bavarian media. Third, promoting the complex issue of declining bee species as a symbol of biodiversity loss and the related slogan 'Save the bees!' contributed to the success. In combination with successful public relations work, the symbol was accepted by broad sections of society, with the message not falling short. Finally, the fourth factor to be mentioned is the fact that the petition addressed an issue that a large part of potential subscribers could easily relate to. They were concerned about the issue at hand, but no change of their own behaviour was required.

4.3.5 | What was transformed?

Petitions for referenda are not common in Germany, and many of them fail to achieve the required percentage of participation. The fact that a petition for a referendum on nature conservation gained a level of subscription that ranks among the highest ever seen in Germany can be taken as an indication for the fact that people care about this topic and can be mobilised around it. It might also be an indication of changing values. It is of course too early to tell whether the implementation of the new regulation will happen and if it is going to have the desired effects on biodiversity. Another thing that remains to be seen is whether people voting for the law will actually change their own behaviour (even if it is not required by law).

5 | DISCUSSION

The analytical framework is the first step to developing a more in-depth analysis and comparison of successful examples of change processes. In this paper, we present three case studies that illustrate the use and potential of the analytical framework when it comes to identifying success factors that contribute to an increase in biodiversity.

5.1 | Empirical insights from the case study analyses

The presented framework aims to improve our understanding of factors, circumstances and actors of potentially transformative processes. The synthesis across the case studies sheds light on the mechanisms of the change process itself, its drivers and the effects on biodiversity. By applying the framework to analyse the case studies, we were able to show that biodiversity conservation can follow different strategies with indirect benefits for biodiversity (Figure 2):

5.1.1 | Retaining co-benefits for biodiversity with other objectives—Indirect benefits for biodiversity

From the synthesis regarding the drivers and contexts across the case studies (see Table 1), the results surprisingly show that biodiversity conservation does not always have to be the explicit goal pursued by the change process. Co-benefits for biodiversity may occur in situations of already existing societal change processes. The case of the Emscher conversion shows that the initiative did not directly address biodiversity goals. Rather, the indirect drivers (related to the political economy of industrial development) changed since the region's companies were no longer able to compete. To revitalise the region, authorities invested in programmes and projects with the aim of restoring the river, creating jobs and improving the image of the region. These changes also strongly benefited biodiversity. The conversion made investments necessary, and the corresponding conditions and legal obligations ensured the restoration of nature and the environment. The positive changes in environmental quality benefited biodiversity and these improvements increased people's awareness of how this enhances the living conditions and attractiveness of the region. Besides that, it was also an economic

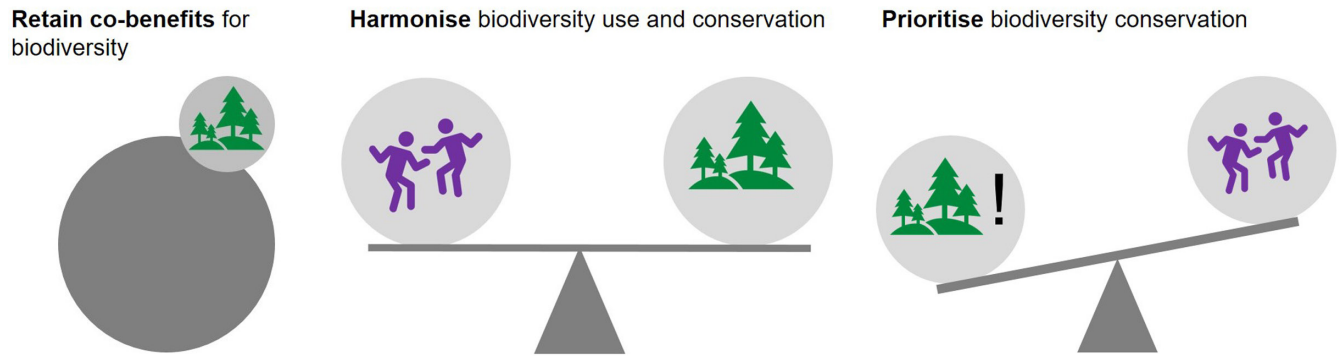

FIGURE 2 Classification of change processes with regard to evident positive effects on biodiversity: Retain a co-benefit for biodiversity, harmonise biodiversity use and conservation, prioritise biodiversity conservation.

advantage on the local level. However, it was not a deliberate or conscious change aimed at the indirect driving forces. It was rather a response to a regional transformation following the displacement of indirect drivers to other parts of the world. The measures addressed the effects of a direct driver (pollution) through restoration. The example shows that there is significant potential for positive biodiversity outcomes in different kinds of societal change processes. Thus, making sure such co-benefits can be realised is one important strategy to enable positive outcomes for biodiversity in transformation processes.

5.1.2 | Harmonising biodiversity use and conservation—Turning conflicts into drivers of transformation

The analysis across the case studies revealed that mediating conflicts arising from diverging stakeholder interests led to positive outcomes for both biodiversity and economic activities in the region. It turned out that deliberation processes play a key role in harmonising the diverging interests of biodiversity use versus conservation. The arising conflicts can for example be addressed by developing joint visions and by aiming for solutions that satisfy all interests involved at least to some extent. Thus, outcomes can be beneficial for the realisation of the two conflicting interests, as the stepping stone case study exemplifies. A conflict regarding the establishment of a new national park was resolved by agreeing on an approach that combined forest use with conservation within the area. In the petition for a referendum, key actors in the process who targeted for fundamental change felt excluded and ignored. This can certainly be seen as a weakness of this process, and it remains to be seen how successful this initiative will be in implementing the changes achieved in legislation.

Mediating conflicts with the aim of finding strategies to achieve biodiversity conservation as well as use within the same area increases mutual understanding between individual groups with their different interests and goals. This can also help to build broader societal consensus on the benefits of conservation. It is generally agreed that shared future narratives are helpful in generating support for the conservation and sustainable use of biodiversity. Specific examples of successful collaboration are good starting points for building these shared narratives.

5.1.3 | Prioritising biodiversity conservation—Taking advantage of windows of opportunity

Transformation processes often occur after initial disturbances or societal upheavals and create 'windows of opportunity' for new values, behaviours and institutions to emerge (Otto et al., 2020; Radeloff et al., 2013). Conservationists need to seize these moments to ensure biodiversity conservation is most effective (Radeloff et al., 2013). Our case study examples highlight that these moments do not necessarily need to be disturbances. A range of societal change processes can contribute significantly to enhancing biodiversity. Here, it is interesting to note that both bottom-up and top-down approaches can contribute. And taking the example of the Emscher conversion, improving biodiversity was not even an explicit goal in the transformation of the former coal and steel region. It was rather a positive side effect of improving the environmental conditions. Similarly, the case study on the stepping stone concept shows that the failed implementation of the national park opened the way for a more consensual and flexible approach, which achieved high outcomes for biodiversity while avoiding resistance and conflicts. Finally, from the example of the petition for a referendum, we can see that initiatives in which biodiversity protection itself becomes a central societal goal are another option for enhancing biodiversity. They can be demanded through civil society participation and stipulated by law as politically binding targets.

In general, the case studies illustrate that opportunities or entry points for transformative change for biodiversity can be thought of and defined more broadly. Prioritising biodiversity-friendly behaviour by establishing new regulations can be interpreted as an attempt by society to formalise changes with regard to the value of biodiversity. However, as this was a majority that overruled the primarily affected minority, this approach is less collaborative than the other two change processes, and it is too early to assess the results on the ground. The notion that co-benefits are indeed useful is the very reason why the concept of ecosystem services exists as a framework. This logic dates back to Daily's book 'Nature's services' (1997), and has been of central importance for all subsequent work on ecosystem services (e.g., Díaz et al., 2018; MEA, 2005).

In sum, the results help to improve our understanding of transformative change in favour of biodiversity. Our analysis reveals that there can be different goals and narratives for biodiversity conservation, namely to retain co-benefits, harmonisation and prioritisation. Our results demonstrate how benefits for biodiversity can be achieved in multiple ways. The case studies exemplify that there are also potentials for transformation to be found in ongoing societal change processes in other sectors, but likewise in conflicts and in the mobilisation of civil society aiming to initiate a demand for concrete goals. These results are in line with Pereira et al. (2020) stating that there are multiple ways to bend the curve of biodiversity loss.

5.2 | Reflection on the framework in light of the conceptual discussions on transformative change

The analytical framework presented herein aims to discern how processes of societal change can positively affect biodiversity. The intention is to learn from these processes how transformative change for biodiversity can be supported (Kindler, 1979). Our framework builds on conceptual discussions of transformative change and makes an essential contribution to its further development by providing a tool for empirical analysis.

Applying the approach from transdisciplinary research on investigating how to promote potentials for effectiveness (Lux

et al., 2019) helped to sub-divide the processes of change by differentiating between drivers and contexts, the change process itself and subsequent impacts. According to Kluger et al. (2020), so far there has been a lack of standardised methods for comparative analysis of societal change processes within and between social-ecological systems. With our analytical framework, we provide a tool for evaluating processes of change even if there are no baseline data available. However, the integration of experts and their respective knowledge into the analysis was crucial to review the data and interpretations.

Applying our analytical framework to the different case studies enabled us to better understand how biodiversity was affected and to identify factors initiating and/or supporting biodiversity conservation. Thus, we could learn from the past and subsequently deduce recommendations for future transformation processes. It remains to be seen to what extent the results from the case studies can be transferred, especially to other countries. At this national level, the analytical framework could be used in a comparative way (comparing similar processes in different geographic regions) to demonstrate how individual factors within the framework differ across various geographic and cultural contexts. Moreover, regular repetition of the analysis (for example at intervals of approx. 5 years) within the same case studies using this framework might not only reveal changes and developments, but also show whether additional indicators are needed to understand transformative processes.

Finally, even if our analysis focused on positive case studies, the analytical framework can also be used to provide insights into the reasons why some efforts fail to improve biodiversity conservation and help to better understand missed entry points or lock-ins that were overlooked. In addition, future research could deepen the understanding of transformative change for biodiversity conservation, for example, the balance between conflict and consensus in driving transformative change. For instance, it would be intriguing to explore how agreement or disagreement among actors influences the transformative processes. Additionally, the role of power dynamics is essential to understand transformative change. Future research could delve into how power is distributed and exercised among various stakeholders, including governmental bodies, non-governmental organisations, private sectors and local communities among others. The presented framework can be used to better understand these urging topics.

6 | CONCLUSIONS

The current calls for transformative change are rather abstract, and it remains unclear which transformation processes positively affect biodiversity either directly or indirectly or why they are not successful in this respect. The analytical framework presented in this paper goes beyond the statistical quantitative analysis of biodiversity (e.g., biodiversity metrics or biogeographical information) by providing a qualitative tool and a data basis to explore the various levels and types of interaction relevant for advancing societal change in a particular context. The results of our analysis of successful examples of biodiversity conservation in accordance with societal needs can inform and inspire future initiatives to foster transformative change. Beyond the case studies analysed here, we hope that our framework will contribute to providing insights into pathways that balance societal needs with biodiversity conservation and will help to create relevant knowledge supporting transformative change for nature and people. Our overall conclusion is that biodiversity conservation should take multiple approaches to transformation, consider diverse pathways to bend the curve of biodiversity loss, try to make use of as many windows of opportunity as possible and build new collaboration strategies.

AUTHOR CONTRIBUTIONS

All authors contributed to the study conception and design. The analytical framework was developed by Christine Fürst, Karsten Grunewald, Jennifer Hauck, Janina Kleemann, Stefan Knauß, Michael Kolkmann, Marion Mehring, Christian Poßer, Vera Schreiner and Heidi Wittmer. Case studies for analysis and development of the framework were contributed by Christian Albert, Anna S. Brietzke, Jennifer Hauck, Janina Kleemann, Stefan Knauß, Michael Kolkmann, Ludwig Lettenmaier, Marion Mehring, Christian Poßer, Tanja G. M. Sanders, Vera Schreiner, Tanja M. Straka and Heidi Wittmer. The first draft of the manuscript was written by Marion Mehring, Anna S. Brietzke, Janina Kleemann, Stefan Knauß, Christian Poßer and Vera Schreiner and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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DATA AVAILABILITY STATEMENT

The manuscript does not include any primary data. See Supporting Information S1 for the filled in analytical framework as part of the literature search.

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SUPPORTING INFORMATION

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

Appendix S1. Filled in analytical framework as part of the literature search for the three case studies.

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