SPECIAL ISSUE ARTICLE

Sustainable Development | WILEY

Transdisciplinary research in natural resources management: Towards an integrative and transformative use of co-concepts

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Funding information
Operationalizing Ecosystem Services in Business Sustainability, Grant/Award Number: 315912; Academy of Finland; Marie Sklodowska-Curie, Grant/Award Number: 840207; Maj and Tor Nessling Foundation; Tiina and Antti Herlin Foundation; Finnish Cultural Foundation; European Union's Horizon 2020 Research and Innovation programme, Grant/Award Number: 76538

Abstract

Transdisciplinary research often utilizes collaborative ways of knowledge production to enable deliberate transformations towards sustainability. Multiple concepts with varying definitions are applied, leading to confusion in the aims and uses of these concepts. In this article, we review five concepts relevant to the current debate on the new collaborative ways of knowledge production in transdisciplinary research. We focus on the concepts of co-creation, co-production, co-design, co-learning, and adaptive co-management in the context of natural resources management (NRM). This study couples a literature review and a conceptual analysis, and aims to clarify definitions, use, the interlinkages of these concepts and to shed light on their intertwined nature. We propose an integrative understanding of the concepts to facilitate collaborative modes and to enable the transformative aims of research processes. To this end, we discuss how to harvest the transformative potential of the "co-concepts" by focusing on reflexivity, power analysis and process orientation.

KEYWORDS
adaptive co-management, co-creation, co-design, co-learning, co-production, sustainability transformations

1 | INTRODUCTION

Transdisciplinary research (TD) is increasingly called on to align knowledge and action (Gibbons 1999), and in doing so, to promote sustainability transformations, that is, fundamental changes in the current socio-ecological(−technical) systems towards more sustainable ones (Elmqvist et al., 2019; Miller, 2013; Olsson et al., 2014; Patterson et al., 2019). Pohl (2010) maps TD under three categories of i)

transcending and integrating disciplinary paradigms to address socially relevant issues; ii) expanding these to include non-academic actors; and iii) seeking unity of knowledge beyond disciplinary viewpoints. In this article, we emphasize the processes of generating, exchanging, and integrating knowledge from epistemologically plural sources – scientific and non-scientific – as the key element of TD (Söderbaum, 2009). Consequently, TD typically includes collaboration between academic actors from various disciplines with diverse societal actors, and the problem definition starts from the sustainability deficit expressed by local actors (Jahn et al., 2012, Lang et al., 2012; Brandt et al., 2013).

We use "collaborative" as an umbrella term to encompass the collaborative modes of knowledge production and the engagement of non-academic participants in the research process following different intensities of involvement to achieve both scientific and societal impact (Moser, 2016). These collaborative modes, together with participatory modes (see Bernstein, 2015), are also utilized in transdisciplinary settings, and TD is recognized as an antecedent to co-production (Wyborn et al., 2019). Although not all collaborative research is transdisciplinary, these collaborative modes are often combined with TD to define the relationship to knowledge, as in "transdiciplinary co-production" (Polk, 2015), or describing the timing of collaborative actions; for example, co-creation is used as a phase of TD (Lang et al., 2012). Collaborative modes may even be used interchangeably with TD (O'Connor et al., 2019; Thompson et al., 2017). In general, collaborative modes, like TD, challenge a linear relation between "knowledge producers" and "knowledge users" (Hoffmann et al., 2017) and endorse a more engaged research culture between science and society (Jagannathan et al., 2020; Nowotny et al., 2003). They can support the transformative goals and are better suited to governing change and uncertainty, or in other words, striving for deliberate sustainability transformations (Schneider et al., 2019). They are also extensively promoted by funding bodies and science-policy interfaces such as the EU Horizon2020 projects, regional and national research councils (e.g., the Nordic Council, and the Academy of Finland Strategic Research Council), and international science organizations (IPBES, Future Earth).

Collaborative modes, such as co-creation, co-production, co-design, co-learning, and (adaptive) co-management, are gaining attention as central concepts in sustainability science literature, TD and governance practices. In particular, knowledge co-production has been a prominent concept during the past few years (see, e.g., Norström et al., 2020; Turnhout et al., 2020; Jagannathan et al., 2020; Lemos et al., 2018) and is even considered as "a dominant path to usability of knowledge" (Mach et al., 2020, 30). Overall, literature focusing on the concepts related to collaborative modes is a confluence of several rich scholarly realms to be explored and clarified in this article. As a result, the "co-concepts" mentioned above often have multiple definitions and interpretations, or are even left undefined at times. This confusion in definitions of the concepts has also led to an implementation failure of these approaches (Hasselman, 2017; Cundill & Rodela, 2012).

Different views on the meaning of the concepts, framings and aims of collaborative modes may affect the potential to frame and achieve the anticipated transformative outcomes of transdisciplinary projects (Blythe et al., 2017). This relates to value pluralism and divergent epistemological views on what types of knowledge should count in decision-making and what impact entails (Laursen et al., 2021; Louder et al., 2021). Acknowledging and navigating tensions stemming from different perspectives is crucial in TD because, for example, actors both inside and outside academia may hold rigid expectations of certain types of science-society-policy interactions (Karhunmaa, 2020). These sometimes conflicting views and expectations may influence the resources and skills needed in a project (Bulten et al., 2021) or the research outcomes (Thompson et al., 2017).

Five "co-concepts" central to collaborative modes – co-creation, co-production, co-design, co-learning, and (adaptive) co-management – provide a temporal and conceptual analogy to the main phases that the transdisciplinary literature extensively employs (Jahn et al. 2012; Lang et al., 2012; see also Brandt et al. 2013). However, only a few of scientific articles focus on untangling the overlapping nature of these concepts (such as Voorberg et al., 2015; Mauser et al., 2013). Whilst previous research has identified principles, frameworks and the phases of implementation of TD projects (e.g., Klenk & Meehan, 2015; Hoffmann et al., 2017: Lang et al., 2012), no research has previously assessed and clarified the conceptual plurality in collaborative modes which a researcher faces when practising engagement.

This article addresses the gaps in the understandings of five co-concepts by critically reviewing them, their relationships, and their relation to sustainability transformations. Our aim is twofold: i) to improve conceptual clarity of the concepts in NRM in order to facilitate their application; ii) to offer a new integrated understanding of the concepts and their interlinkages in order to guide the implementation of TD. Understanding the origins of the concepts and their interrelatedness might help to consciously facilitate the transdisciplinary process by mapping out the conceptual and temporal points for aligning different perspectives and anchoring the transformative aims of a project. We propose three praxis recommendations which, together with the integrative understanding of the co-concepts could enable the dissolution of potential epistemological and practice tensions while strengthening the transformative aims of transdisciplinary processes.

While not aiming to be exhaustive, the selected co-concepts have become particularly relevant in the context of the current challenge of co-creating a sustainable future for the Earth's system which science needs to meet. We elaborate our analysis in the context of Natural Resources Management (NRM) literature. NRM is a context in which transformations towards sustainability are crucial, often framed around the ideas of equitable and democratic co-governance (Wolff et al., 2019). In this setting, TD is used as a research mode to link society, sciences and practitioners and as a means to address complex social-ecological issues (Roux et al., 2010; Wolff et al., 2019). TD in NRM often utilizes co-concepts to facilitate environmentally sound and legitimate decision-making, and to include the views of those who are directly dependent on or impact natural resources (e.g., Cvitanovic et al., 2015).

The article is organized as follows. Section 2 presents the selection criteria and analysis method of the literature review. Section 3

maps out the disciplinary origins of the concepts, how they are defined and intended to be used in NRM, and what promises they offer to the research process and outcomes as well as identifying some shared key tensions in the application of the concepts. Section 4 shows the interlinkages of the concepts and provides an integrative understanding of the five concepts for transformative TD. Section 5 critically discusses how to harvest the transformative potential of the co-concepts through a research practice based on reflexivity, power analysis and process orientation.

2 | METHODS

2.1 | Data collection

This study is based on five scoping reviews of the concepts of co-creation, co-production, co-design, co-learning, and adaptive co-management and links them to NRM. NRM literature reports on a wide range of scientific approaches aiming at the sustainable use of natural resources. A scoping review was chosen after a preliminary appraisal of the scholarly literature concerning the concepts when it became evident that while many articles had been published (over 220 papers on co-production of knowledge in NRM alone), most did not offer a conceptual or theoretical understanding of the concepts. Studies mention or employ one or more, but seldom provide a clear explanation of the meaning, positioning, and contribution of the concepts. Five targeted scoping reviews were thus considered effective given the aim of this study. In fact, scoping reviews are considered suitable methods when researchers want to identify knowledge gaps, scope a body of literature, and clarify concepts or investigate research conduct (Munn et al., 2018). Furthermore, we chose key articles that focused primarily on conceptual development or considered more than one co-concept in the process of understanding interlinkages between co-creation, co-production and co-design because they are often used interchangeably. Some of these articles could then be classified under several bodies of literature.

The reviews were conducted using topic search in the Web of Science, during January–February 2020. The individual concepts were used as keywords and coupled with the keywords "natural resources". In total, five searches were performed, each fine-tuned based on the size and diversity of the body of literature identified (see Data S1 for detailed explanations of the review of each concept). The most relevant results were screened for applicable articles. These particularly included review or conceptual papers that were used for further snowball sampling of articles. Hence, the review is mostly based on the intellectual discourse of the concepts.

2.2 | Analysis

The first analysis phase consisted of the authors developing a synthetic overview of the literature for each concept. Each synthesis was structured around three themes: origins and definitions of the concepts in general, their relation to NRM, and the promises of the concept (i.e., what the concept attempts to achieve). Interesting aspects emerging from the review were also thematized for certain concepts. After reviewing the concepts individually, we conducted coding of 40 articles on Atlas.ti, focusing on co-production, co-creation, and co-design to explore and understand the interlinkages between the concepts as presented in the previous literature. We coded for i) relationships between concepts and collaborative knowledge processes, ii) transformative aims they were deemed to have, and iii) relationships with different interfaces (science-society, science-policy, and policy-society) (see Data S1 for coding structure). The coding structure followed the variants that were inductively found during the first phase of the analysis while reviewing the co-production concept. The coding fed particularly into Section 4.1 Interlinkages of the co-concepts.

3 | CLARIFYING THE CONCEPTS

3.1 | Co-creation

3.1.1 | Origin and definitions

The epistemological roots of co-creation are traceable to Latour (1988), who proposed that evidence results from the scientist and the phenomenon being investigated co-constructing each other. Co-creation arises as one of the new forms of knowledge production and use to address change, uncertainty, and transformative goals in the current social-ecological problem settings. As per the other forms, (co-design, co-production), co-creation does not provide solutions but contributes to solution options (Wiek et al., 2015) and process structuring towards "a deeper thinking which in itself is essential for a transition towards a world that is more sustainable" (Wals & Rodela, 2014, 1).

There are several approaches to co-creation, which is widely used in both the scientific literature and in the vocabulary of enterprises and businesses. Galafassi et al. (2018) define knowledge co-creation as "a process where a group of actors (including scientists) engage in developing shared understandings and novel ideas of how to intervene in social-ecological systems". Co-creation is often used synonymously or even interchangeably with knowledge co-production (as in Parsons et al., 2016; Shackleton et al., 2019; Murti & Mathez-Stiefel, 2019). Further, Shackleton et al. (2019, 95) mention co-creation in: "co-design or co-development of projects, co-creation of knowledge, and co-implementation of management". When used as a synonym for co-production, it typically conveys the sense of co-creational instances, such as a co-creation workshop (Moriggi, 2020), or of a more confined (less elaborated) process that does not include stages of co-initiation, co-design, or co-implementation.

3.1.2 | Co-creation in practice and in relation to NRM

As per other collaborative processes, the starting-point for co-creation is a wicked problem constellation (Rittel & Webber, 1973) that calls for mobilizing a diversity of knowledge(s) or even for changing attitudes towards environmental management through deep and protracted stakeholder engagement (Shackleton et al., 2019). Many authors suggest phases for the process of co-creation. For example, Ayre et al. (2018) proposes four temporal, interlinked, and iterative phases: co-initiation, co-design, complementation, and co-evolution, while Mauser et al. (2013) suggest three steps: co-design (including joint framing and definition), co-production, and the dissemination of results. The communalities of these phases evoke the phases of an ideal typical transdisciplinary process (Lang et al., 2012). In more conceptual framings, Galafassi et al. (2018) use the metaphor of weaving, dividing the co-creation process into the phases of unraveling, meshing (innovating), and raveling, while Jean et al. (2018) describe the co-creation process as four stages: socialization, externalization, combination, and internalization.

3.1.3 | Promises of co-creation

The goal of these iterative and non-linear co-creation processes is similar to that of sustainability science endeavors: purposive co-creation typically seeks actionable knowledge, improved understanding, or shared meaning through social learning (e.g., Lopez et al., 2019) and, lastly, changes in the situation or field of inquiry (Mitchell et al., 2015). The literature relating to NRM emphasizes that some common key characteristics of various modes of co-creation exist that may add to its promises: i) process orientation towards intervention and a transformational goal, that is, a situational improvement in relation to the problem originally identified (Polk, 2015); ii) the explicit inclusion of diverse non-academics with various degrees of process involvement, depending on the context characteristics (Medema et al., 2017); iii) generation of innovation and learning between science and society or between government and society (Kok et al., 2019; Schneider et al., 2012; Wals & Rodela, 2014). In addition, co-creation often addresses ethical concerns by, for instance, employing tools suited to communities that are not traditionally invited into political spaces of deliberation (Tremblay & Harris, 2018); or an interest in aspects of empowerment (Ayre et al., 2018).

3.2 | Co-production

3.2.1 | Origin and definitions

The epistemological roots of knowledge co-production — as well as of co-creation — can be related to the philosopher Latour (1988), who considered knowledge and action as reciprocal. Co-production has recently developed into one of the most popular concepts for theorizing usable knowledge and for practising collaborative projects and processes in environmental governance (Miller & Wyborn, 2018; Norström et al., 2020; Turnhout et al., 2020). Miller and Wyborn (2018) trace co-production and its meanings back to three main academic fields: public administration (Ostrom & Ostrom, 1977; Parks et al., 1981), science and technology studies (Jasanoff, 1996; Latour, 1990), and sustainability science (Cash et al., 2003; Kates et al., 2000; Kofinas, 2002). This partly explains why co-production is widely used across various research fields and has multiple definitions. The link between knowledge co-production and public administration or collective management of public goods literature (Ostrom & Ostrom, 1977; Parks et al., 1981; see also Norström et al., 2020) alleviates its strong connection with co-management. The definitions of co-production, as in Norström et al. (2020) or Miller and Wyborn (2018), often contain attributes on i) the unique nature and process-like nature of the co-production act, where knowledge is not the only relevant outcome, and ii) the engagement of diverse actors, including those outside academia.

3.2.2 | Co-production in practice and in relation to NRM

No single or unified definition of knowledge co-production exists, not even when it is examined in the context of only one research field such as NRM. This notion is in line with the conceptual diversity of knowledge co-production described earlier by Norström et al. (2020) in sustainability sciences in general and by Lepenies et al. (2018) in water management, for example. Our review verifies that the definitions of the concept in the current NRM literature mostly fit into the three main traditions of co-production (Miller & Wyborn, 2018), and co-production is roughly understood i) as a joint production of environmental management in certain institutional settings (sensu Ostrom & Ostrom, 1977; Parks et al., 1981) or ii) as a joint production of impactful knowledge and sustainable transitions (sensu Kates et al., 2000; Kofinas, 2002). Thirdly, in contrast to findings concerning the use of the concept, particularly in water management (Lepenies et al., 2018), there are few cases (Muñoz-Erickson et al., 2017; Puente-Rodríguez et al., 2016) that utilize Sheila Jasanoff's co-production idiom/ontology (2004). This view, relating mostly to science and technology studies, concentrates on how political and scientific spheres sustain and co-produce each other as social orders.

Despite these three main traditions of knowledge co-production — public administration, science and technology studies, and sustainability studies — being identifiable in NRM literature, we were able to pinpoint additional nuances in the concept definitions. These nuances relate to their "scopes of ambition", as described by Jagannathan et al. (2020): "pragmatic" co-production may relate to "the production and dissemination of knowledge and services", while "radical" co-production "relates to the transformation of norms and institutional structures within science and society" (Jagannathan et al., 2020, 23). The variants that combine both historical traditions and scopes of (transformative) ambition may be called: i) Outcome-oriented, ii) Practical & Pragmatic, iii) Empowering and

TABLE 1 Variants of co-productions of knowledge

Variants	(1) Outcome-oriented	(2) Practical & pragmatic	(3) Empowering	(4) Transformative
Promises	Better understanding of data and natural resource monitoring.	The rationale is to increase the relevance, scope, and usability of science, hence building adaptive capacity.	Creating partnerships that lead to better environmental management.	Better understanding and democratic management of natural systems by developing synergies across knowledge systems.
Role of non-academics	Informants	Stakeholders	Partners	Co-researchers (often indigenous and local people)
What kind of co-production?	From knowledge transfer to sharing. Actors are valued more as implementers of research outcomes (not because of their knowledge).	Co-production as skill-dependent activity that prevents bias and enhances co-ownership (of knowledge).	Everybody involved as equal partners and co-producers of knowledge. More bound in a certain time and scope than transformative (4.)	Appreciating different knowledge systems and embracing epistemological differences. Linking co-production with political (human rights, indigenous claims, etc.).

iv) Transformative (Table 1). The Outcome-oriented and Pragmatic (1 and 2) variants see co-production as a practice that adds to the effectiveness and usability of scientific information and concentrates on the modus operandi and co-production processes in certain institutional or project-related frameworks. The Empowering and Transformative variants (3 and 4) aim for more normative and transformative governance processes that challenge prevailing knowledge production or even social orders.

The "Modest" transformative scope of knowledge co-production relates to translating (Outcome-oriented) or integrating (Practical & Pragmatic) appropriate expertise from various knowledge systems to scientific knowledge. The rationale is to have better scientific impact (Outcome-oriented) or to build adaptation (Practical & Pragmatic) in projects or organizational frameworks without challenging the universal position of science and the order between power and knowledge (Djenontin & Meadow, 2018; Reyers et al., 2015). Evaluations concerning the validity of knowledge and what knowledge types are needed are still based on science (Marshall et al., 2016), and stakeholders are considered informants rather than co-researchers. In this way, knowledge co-production is an instrument for additionally accurate data (Scholes et al., 2017) or for increasingly usable and impactful research (from a researcher's viewpoint) (Djenontin & Meadow, 2018). While the Practical & Pragmatic variant aims to break the ideal of linear collaboration in research (Reyers et al., 2015), it pragmatically deals with knowledge co-production as a relationship in certain projects that does not have any deeply rooted power-related dimensions.

The "radical" transformative scopes of knowledge co-production embrace equal appreciation of all knowledge systems (Empowering) (O'Connor et al., 2019; Trimble & Lázaro, 2014) or even strengthens various knowledge capacities (Transformative), rather than simply utilizing existing traditional knowledges (Maclean & Cullen, 2009). For the Transformative variant, knowledge co-production facilitates a change in societal and power orders (Brattland & Mustonen, 2018) and is therefore not solely motivated by achieving more research impact. Hence, processes include equal partners or co-researchers (Campbell et al., 2016; Hill et al., 2015; Muñoz-Erickson et al., 2017; Tengö et al., 2014) instead of stakeholders or end-users of knowledge.

3.2.3 | Promises of co-production

The four variants identified in our review overlap in the literature, but we found some clustering around the main three traditions and the scope of ambitions (Table 1). Whether the aim is to gain more accurate data, more usable knowledge, or social transformations, current practitioners and theorists claim that both the theory and practice of knowledge co-production "must go beyond stakeholder engagement by scientists to the more deliberate design of societal transitions" (Wyborn et al., 2019, 319). These accounts see that co-productive research projects are inherently political because of their collaborative modes and transformative potential and above all because of their status as "a normative aspiration" in sustainability sciences (Miller & Wyborn, 2018, 3; see also Turnhout et al., 2020).

3.3 | Co-design

3.3.1 | Origin and definition(s)

Various realms of knowledge contribute to the historical origin of the co-design concept, including socio-technical systems, architecture, service or product innovation, and social change (Zamenopoulos & Alexiou, 2018). The concept dates back to the development of participatory design in the 1970s (Simonsen & Robertson, 2012). In relation to design practice, it appeared to question power relations and notions of expertise (Huybrechts et al., 2017). Co-design occurs as the participatory production of knowledge in the planning and realization of human infrastructures, products, and services, along with the development and implementation of policy processes (Moser, 2016). This collaborative endeavor includes society beyond academia, such as the public sector, private organizations, civil society groups, practitioners, customers, users, local communities, and indigenous people (Moser, 2016). The number and range of actors involved in each project may vary, and agency may also be understood to include non-humans (Ehn, 2008). Through co-design, actors "come together to conceptually develop and create", in response to

concerns or needs, despite "their different agendas, needs, knowledge and skills" (Zamenopoulos & Alexiou, 2018, 12). Co-design thus means recognizing and reconciling "ontological and epistemological differences [...], and understand[ing] issues and concepts" (Parsons et al., 2016, 100).

3.3.2 | Co-design in relation to NRM and in practice

Our review reveals that co-design is relatively rarely used in relation to NRM but that it may be gaining ground alongside the other collaborative approaches. The articles fit well within the categories identified by Moser (2016): the concept is leveraged in the context of knowledge creation, development of human infrastructures, products and services, and policy processes. In regard to knowledge creation, co-design may involve information concerning the status, dynamics, and management options in natural or semi-natural systems. It may include local stakeholders and communities, and indigenous people (Fabricius & Pereira, 2015; Galvin et al., 2016; Parsons et al., 2016; Ponta et al., 2019; Pradhan et al., 2018; Shackleton et al., 2019). The co-design of infrastructures, products, and services may be problem-driven and solution-oriented (Lee, 2019) or directed to social innovation (Gorgel Pinto & Reaes Pinto, 2017). Policy processes range from the simulation of decisions or visions through stakeholder engagement, to uncovering local priorities, and developing planning and management processes (Banerjee et al., 2019; Berninsone et al., 2018; Gill et al., 2019; Wallis et al., 2017). Co-design is usually seen to precede the steps of co-production and co-dissemination (Moser, 2016). It is therefore concerned with setting joint research agendas, research questions, and planning implementation. In general, co-design often refers to engagement at the beginning of a participatory project (e.g., for problem definition, solution development) but may also extend beyond the initial phase, as design-in-use (e.g., for customization or feedback) (Ehn, 2008).

3.3.3 | Promises of co-design

Co-design appears to emerge in response to a need for democracy, innovation, and sustainability (Zamenopoulos & Alexiou, 2018). Hyysalo et al. (2019) suggest it is relevant in the management of socio-technical transitions.

3.4 | Co-learning as a form of social learning in NRM

3.4.1 | Origin and definitions

Learning is considered an essential feature in all the aforementioned co-processes in the sense that collaborative research and activities may contribute to (new) knowledge, skills, and methods, sense-making, and to changes in attitudes, values, and behaviors in certain cases

(see, e.g., Säljö, 1979 for a definition of learning). Various types of learning (social learning, mutual learning, co-learning, transformative learning, and experiential learning) are discussed in the context of transdisciplinary research, and concepts are used in various ways (Wals & Rodela, 2014; Cundill & Rodela, 2012; Muro & Jeffrey, 2008, Reed et al., 2010; Knickel et al. 2019) — sometimes explicitly, sometimes interchangeably, and sometimes only as a label. In the NRM context, social learning may be seen as the most established and frequently used concept, while transformative learning (Mezirow, 2009) and experiential learning (Kolb, 1984) work more as normative theories of how learning occurs. We will therefore, first briefly introduce the main lines of social learning in transdisciplinary and NRM research. Co-learning, on the other hand, is an emerging concept that has also been used to some extent in participatory NRM, environmental sciences and studies, multidisciplinary agricultural research (Web of Science) and in sustainability research in general. Further, because the themes relating to mutual learning and learning as the aim of the other co-concepts are recurrent (see Section on interlinkages 3.2), we will explore its future potential in the NRM context.

3.4.2 | Social learning and co-learning

Social learning was first introduced by psychologist Albert Bandura in the early 1960s, when he suggested that individual learning is influenced by the social norms of the context and occurs through models. Since then, it has become a concept that has been used not only in behavioral sciences, psychology, neurosciences, and educational research, but also in zoology, ecology, and environmental sciences (Web of Science). Given this wide range of research, social learning does not currently indicate a common theoretical perspective, disciplinary heritage, or even language. The definitions in NRM may also remain very generic and vague in that there is confusion as to whether learning occurs at the individual, group, or societal level, through what types of process, and for what outcome (Blackstock et al., 2007; Reed et al., 2010; Gundilla & Rodela, 2012). These diverse ways of using the concepts have caused confusion among researchers and more structured forms of social learning have therefore been sought in NRM (Wals et al., 2009; Reed et al., 2010; Romina, 2014). Here we draw on the definition by Pahl-Wostl et al. (2007), who observed that social learning is 1) at the level of processes between collaborating stakeholders in collaboration processes on short to medium time scales; 2) at the level of change in actor networks (possible outcome/ feedback of processes) on medium to long time scales; and 3) at the level of change in governance structure (formal and informal institutions and cultural values, norms, and paradigms) on long time scales.

According to Glasser (2007), social learning and co-learning may be considered overlapping concepts. The author makes a distinction between active social learning, built on conscious interaction and communication between at least two living beings, and passive learning, which happens as part of social interaction. Active social learning may be further broken down into three rough categories that are a

function of the skills and values of individuals in the collective and the power relationships that define them. These categories, which reflect increasing levels of participation by the group members, are: i) hierarchical – based on predetermined, inflexible relationships between established social groups such as teachers and learners; ii) non-hierarchical – based on two-way learning, where participants are experts in their own right and share their knowledge and experience; and iii) co-learning based on non-hierarchical relationships, collaboration, trust, full participation, and shared exploration. According to this definition, co-learning is the deepest and most democratic mode of social learning. Following Pahl-Wostl et al. (2007) and Glasser (2007), we define preliminary co-learning as learning based on non-hierarchical relationships, collaboration, trust, full participation, and shared exploration on short to medium time scales at the process level between collaborating stakeholders in collaboration processes.

3.4.3 | Co-learning in NRM and in practice

We discern four main uses of co-learning based on the review of the co-learning concept either as used or as possibly applicable in NRM. First, co-learning is used as a catchword for indicating that the process involves learning together, for example, in participatory projects related to ecologically sound agricultural practices in developing countries or co-innovation projects (see, e.g., Jiggins et al., 2019). Second, co-learning is used to express how learning happens; for example, as used by Duxbury et al. (2019, 18): "co-learning through sharing different perspectives and knowledges". Third, co-learning features more explicitly in anthropological research (Dutta, 2019) that emphasizes the inclusivity and equal roles of participants: "[co-learning] is a process of collaborative learning with and in grassroots communities toward co-constructing culturally meaningful knowledge and opening up avenues for social equality". Fourth, co-learning is discussed in relation to reflexivity. For example, Manganelli (2020) observe the interactive nature of reflexivity and learning, and the importance of how social and political dynamics can feed into or challenge reflexive and co-learning agency. Hence, co-learning needs to be considered as embedded in the existing power dynamics.

3.4.4 | Promises of co-learning

Glasser (2007), who introduced co-learning in NRM, suggests that its requirements for team building, complete engagement, "learning-by-doing" (Dewey 1986), and accountability in addition to supporting the penetration of existing knowledge, supports the generation of new knowledge and novel strategies for addressing real-world problems. Therefore, Glasser further suggests that co-learning supports change, and positive change in particular, by building capacity in three fundamental areas: critical evaluation of existing knowledge and problems, knowledge generation, and the

penetration and application of this new knowledge into policy, practice, and everyday life. Thus, in the ideal case of transdisciplinary research, learning should be co-learning, a process in which all participants are equal (Moser, 2016), following the identified third and fourth ways of using co-learning in the literature, along with the proposed tentative definition for co-learning based on Pahl-Wostl et al. (2007) and Glasser (2007).

3.5 | (Adaptive) co-management

3.5.1 | Origins and definitions

Adaptive co-management has its roots in adaptive management and co-management, which developed independently but merged into adaptive co-management. Adaptive management was formulated to deal with uncertainty and complexity (Holling, 1978), and was introduced first in the field of ecology and management (Huitema et al., 2009). Co-management means the sharing of power and responsibility between the government and local resource users, including components such as building institutions, trust, and social capital (Berkes, 2009; Plummer, 2009). Co-management relates to commons literature (Huitema et al., 2009) and has been extensively used in, for example, fisheries research and coastal governance. It is proposed as an alternative for top-down state management to facilitate joint or shared decision-making and conflict resolution in management processes (Fabricius & Currie, 2015; Plummer, 2009). Both knowledge generation and social learning are considered essential for co-management (Berkes, 2009).

Adaptive management and co-management moved towards a common ground because "adaptive management without collaboration lacks legitimacy, and co-management without learning-by-doing does not develop the ability to address emerging problems" (Berkes, 2009 p. 1698). Adaptive co-management is more centered on learning and adapting than co-management (Berkes, 2009) and stems from the recognition that ecological and social uncertainty is a part of governance and is best faced with collaborative processes, including multiple knowledge sources and types that are relevant for problem-solving (Armitage et al., 2011).

Adaptive co-management has gained ground, particularly in social-ecological systems and resilience research, where the focus is largely on understanding functional feedback loops between social and ecological systems and the adaptive capacity of a social-ecological system (Olsson et al., 2004). The literature frequently employs the definition from Folke et al. (2002 p. 20), in which adaptive co-management is "a process by which institutional arrangements and ecological knowledge are tested and revised in a dynamic, ongoing, self-organized process of learning-by-doing'. On the same lines, Fabricius and Currie (2015) refer to "an ongoing process that allows stakeholders to share responsibility within a system where they can explore their objectives, find common ground, learn from their institutions and practices, and adapt and modify them for subsequent cycles", which also relates to iterative learning in management. Hoffmann et al. (2017) instead emphasizes the localized scale and problem-specific scope, along with the role of resource managers of adaptive co-management. Hoffmann et al.'s (2017)

adaptive co-management particularly underscores the distribution of power towards resource users and managers in management.

3.5.2 | Adaptive co-management in practice and in relation to NRM

Based on our review, current use of the concept in NRM is mainly based on the theoretical works of Folke et al. (2002), Berkes (2009), Plummer (2009), Olsson et al. (2004), and Armitage et al. (2011). Recent studies in relation to NRM apply the concept in various cases related to re-creation, tourism, biodiversity, and fisheries, for example. Scholars engage in adaptive co-management in several ways: i) as an analytical tool to evaluate NRM (e.g., den Boer et al., 2019; Villaseñor et al., 2018); ii) as a process to be facilitated through developing frameworks (e.g., Chapman et al., 2016; Islam et al., 2018; Serrao-Neumann et al., 2019) or adding theoretical components (e.g., social representation or economic anthropology) through insights from case studies (e.g., Lai et al., 2016; Pinel, 2013; Trimble & Berkes, 2015); iii) as a framework to facilitate integration of indigenous and scientific knowledge in management (e.g., Cullen-Unsworth et al., 2012), or iv) as an aspirational end goal or a process to be implemented after other processes, such as social learning or participation, function (e.g., Leys & Vanclay, 2011; Cundill & Fabricius, 2010; Rordríguez-Izquierdo et al., 2010).

3.5.3 | Promises of adaptive co-management

Adaptive co-management is presented as a way to govern and manage natural resources under conditions of uncertainty and change by involving heterogeneous actors and cross-scale interactions (Folke et al., 2002; Plummer, 2009). It is seen to benefit dealing with complexity, decentralizing management, increasing the legitimation of decision-making, and helping with conflict resolution and problem-solving (Fabricius & Currie, 2015). It therefore provides a greater role for resource users and local communities in NRM. The common notion in resilience literature is that adaptive co-management may build resilience in social-ecological systems (Olsson et al., 2004). However, adaptive co-management should not be considered as a panacea or answer to all management challenges (Plummer, 2009; Armitage et al., 2009), and power dynamics in particular are not sufficiently understood in relation to adaptive co-management (Armitage et al., 2011; Watson, 2013).

3.6 | Epistemological and practice tensions in the application of the co-concepts

Our review confirms that the application of co-concepts entails not just similarities, but also epistemological and practice tensions, which are shared across the five concepts. The engagement of diverse people, disciplines and knowledges creating epistemological and value

pluralism is seen both as a means to connect better knowledge and action (e.g., Lopez et al., 2019; Shackleton et al., 2019), but also as a source of project-related practice tensions and even inefficiency (e.g., Djenontin & Meadow, 2018). Researchers and other participants (in NRM, often local and indigenous knowledge holders) may hold different epistemic and ontological views which shape the perceptions of the purposes, timing and directions of collaborative research (Watson, 2013; see also Parsons et al., 2016, 100). Researchers may employ different epistemic stances which, for instance, are realized and mobilized in the various perceptions of a) promises for co-production (see Table 1) b) level of integration of different knowledges (e.g., Medema et al., 2017) and c) of choices of methodology (e.g., Djenontin & Meadow, 2018). This leads to conceptual plurality and unconscious use of the different concepts, which can, in the end, impede sharing project aims and hinder achieving planned outcomes (Wals and Rodela, 2014; Plummer et al., 2017).

The epistemological and related conceptual pluralism has practical influence on choices on how to carry out research. Co-concepts can be applied purely as analytical tools, and solution-oriented concepts shaping the researcher's methodological choices within a particular project (e.g., Djenontin & Meadow, 2018; Reyers et al., 2015); or as reflexive and relational ways to guide thinking and to overcome the classic subject-object paradigms (dichotomies such as knowledge producer-knowledge user, knowledge-action, social sphere-scientific sphere) (e.g., Brattland & Mustonen, 2018; Maclean & Cullen, 2009; O'Connor et al., 2019).

Reconciling the output- and process-orientation is a well-known tension in collaborative research (e.g., Lemos et al., 2018; Tremblay & Harris, 2018; Plummer et al., 2017). Process-oriented approaches are more conducive to collaboration compared to knowledge-first approaches, by theorizing science and society as overlapping (Miller, 2013) or even co-constructed (Jasanoff, 2004). The process-outcome tension may be a result of epistemic and conceptual differences as outlined above and affects the timing and methodologies chosen (e.g., Djenontin & Meadow, 2018; Maclean & Cullen, 2009) and, ultimately, the scope of transformative changes which may be achieved.

Our review also confirms that dealing with and accounting for power dynamics pertains to all of the co-concepts (e.g., Ayre et al., 2018; Glasser, 2007; Maclean & Cullen, 2009; Tremblay & Harris, 2018). For example, Watson (2013) argues that co-production and its embeddedness in power relations are not comprehensively understood in the practice of adaptive co-management. This also demonstrates the need to understand the interlinked nature of the co-concepts.

4 | BUILDING COHERENCE AMONG CO-CONCEPTS

4.1 | Interlinkages of the concepts according to the literature

In this section, we lay out the various interpretations of the interlinkages between the concepts and transformative aims, which

relate either to a larger social sphere or to scientific and practical processes (see e.g., Polk, 2015, 113). We mainly focus on literature concerning co-creation, knowledge co-production, and co-design because they are often used interchangeably in NRM (see also Data S1). The literature offers several interpretations of the boundaries of co-concepts. Some scholars consider the concepts as distinct temporal phases in a project, but there is no agreement on the temporal relationships (e.g., Mauser et al., 2013; Reyers et al., 2015). Others see the linkages of concepts as connected to the institutional settings: the options for forms of mediation and brokering varies from bringing actors together to a full third-party mandate "to generate shared understandings" (Harvey et al., 2019, 109). Here, the linkages of individual co-concepts gain power as instrumental tools (e.g., Cvitanovic et al., 2015; Pohl, 2010; Reyers et al., 2015).

Co-creation literature often considers the act of co-creation as a combination of the temporal phases of co-design (at the beginning of the project) and co-production (in the middle of the project) which form a comprehensive process, that is, co-creation (see, for example, Mauser et al., 2013; Ayre et al., 2018). Co-production is more often seen as a more definite act of generating insights on certain phenomena, while co-creation is used to conceptualize the whole research process (Rodriguez Lopez et al., 2019; Campbell et al., 2016; Williams & Robinson, 2020). Co-creation has an all-encompassing meaning in its context of application, spreading from knowledge co-creation, and from the co-creation of research projects, innovative pathways (Wittmayer & Loorbach, 2016), urban transformations (Hölscher & Loorbach, 2019), new understanding and adaptation (Roux et al., 2010), innovation (Schneider et al., 2012), and art as an epistemic mode of co-creation (Herrmann-Pillath, 2020; Ernst et al., 2016), to co-creation for sustainability (Trencher, Bai, et al., 2014; Trencher, Yarime, et al., 2014).

In the co-creation literature, stakeholders are seen as co-designers whereas in knowledge co-production they are sometimes positioned as co-implementers (Voorberg et al., 2015). This notion of co-production being more top-down driven may be true for some co-production variants (see Table 1, variants 1 and 2). However, the co-production literature — particularly concerning co-production with indigenous people — includes several accounts that aim to challenge the hegemonic role of scientific knowledge and science-driven impact and thinking (Brattland & Mustonen, 2018; Hill et al., 2015; Maclean & Cullen, 2009; Tengö et al., 2014). Furthermore, the co-production literature related to the empowering and transformative variants (Table 1) often link co-production and its outputs to co-management and social learning, and underline the meaning of equal participation and equal ownership of the process. Co-creation is rarely mentioned in the co-production literature, and when it is, it is often used interchangeably with knowledge co-production (Lemos & Morehouse, 2005, p. 58–60; Roux et al., 2006).

In the co-production literature, social or mutual learning is understood as a state of enhanced mutual understanding rather than a defined act or guided process, and it is often referred to as the desired outcome of knowledge co-production (O'Connor et al., 2019; Djenontin & Meadow, 2018, 894; Armitage et al., 2011 in Campbell

et al., 2016, 1264) or as a part evaluation as an indicator of process success (Tengö et al., 2014; Trimble & Lázaro, 2014)., Co-creation is also often associated with social learning. Although mutual learning is typically considered one of the main outcomes of inter- and transdisciplinary collaboration (Mitchell et al., 2015), the direction of the link between social learning and co-creation is not fully elucidated. Co-creation as an outcome of social learning or social learning through co-creation are both present in the literature (Murti & Mathez-Stiefel, 2019; Schneider et al., 2012; Ångman et al., 2011).

As to co-design, three perceptions of the concept exist. First, co-design may be considered a complete process in itself, without other co-concepts involved in the process, in which various actors adopt the role of a product or process co-designer (see participatory design literature, e.g., Ehn, 2008). Co-design can thus serve as "a critical time of knowledge generation on its own" (Moser, 2016). A second common notion in NRM-related literature is that co-design is the first phase of co-production, which is implemented before the co-production of actions (Maclean & Cullen, 2009; Moser, 2016; Reyers et al., 2015) and determines the impact of co-production (Wyborn et al., 2019; Parsons et al., 2016; Moser, 2016). On this view, co-design underlines the act of joint planning and understanding the context (Djenontin & Meadow, 2018) and production of research agendas with stakeholders (Lopez et al., 2019; Mauser et al., 2013; Reyers et al., 2015). Third, co-designing of a research project may be considered equal to co-creation and co-production (Voorberg et al., 2015; Williams & Robinson, 2020). Co-creation is then understood as collective co-design (i.e., learning/developing from "collective creativity" (Zamenopoulos & Alexiou, 2018).

4.2 | An integrated view on co-concepts

Based on the review of the concepts and mapping out their interlinkages, we propose a new, integrated understanding of the five co-concepts in a heuristic Figure 1. We argue that an integrated understanding of the concepts — in addition to understanding the concepts individually — may help to overcome some of the typical methodological and epistemological tensions (see Section 3.6) occurring while applying co-concepts in TD. By simultaneously considering i) plurality in the use and definitions and ii) the interlinkages of the concepts, a researcher can more consciously navigate TD through grounding the research in shared understandings and aligning the transformative aims of projects.

With this integrated understanding we do not suggest that it is a necessity to apply all five concepts in a transdisciplinary project. Instead, the integrative understanding may suggest a ground on which researchers could base their own reflexivity, and on which different understandings and tensions could be aligned and bridged.

In Figure 1, we combine both temporal (i.e., timing), epistemic and conceptual relationships (i.e., how the concepts are understood and used individually and in relation to each other), which we found to vary depending on the conceptual perspective they were looked at from. This stresses the multiple possibilities the concepts provide for TD. However, by understanding meanings and relationships of
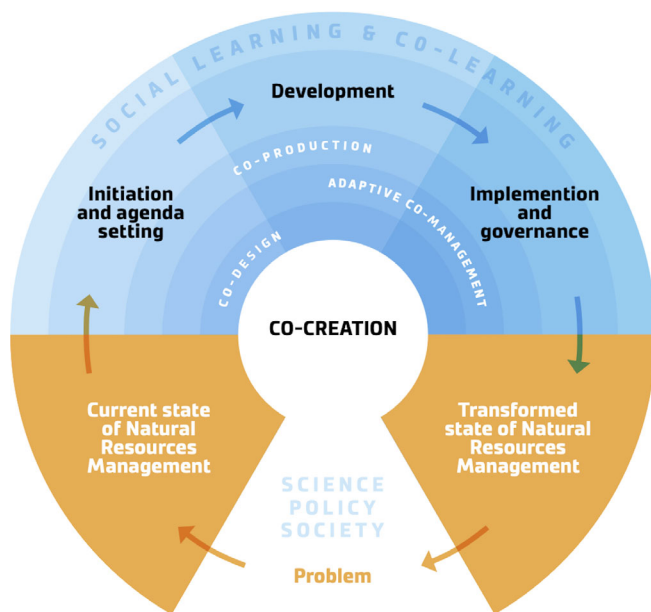
FIGURE 1 An integrated understanding of the "co-concepts'" (co-creation, co-production, co-design, co-learning, (adaptive) co-management) aimed at supporting transdisciplinary collaboration [Colour figure can be viewed at wileyonlinelibrary.com]

different concepts, one is able to analytically identify some phases within a project and explain the interplay with different actors and their knowledge within different contexts.

The temporal dimension is often considered to have only a practical meaning, but it also underlines the transformative potential. For example, timing shapes a researcher's process orientation in the decision about when collaborative modes are applied in a research project. However, the timing of collaborative modes also has an implication in social terms. This relates to the role of actors outside academia, who might act as co-researchers from the beginning of a project or (as the reverse of mere informants) compared to only applying collaborative modes when data is collected and results are being disseminated (see Table 1). The temporal and conceptual interlinkages of the concepts are intertwined together as an interdependent dialogical cycle in practical and societal dimensions rather than forming a continuum (see Figure 1). Hence, integrated understanding expands reflexive thinking outside the individual project unit and invites consideration of one's role as a researcher within the larger society as well.

Based on our analysis, co-creation was used most often to conceptualize the whole process (e.g., Mauser et al., 2013; Ayre et al., 2018; Rodriguez Lopez et al., 2019; Campbell et al., 2016; Williams & Robinson, 2020). Hence, co-creation is positioned as a concept which encompasses the whole TD process both temporally and conceptually. Locating co-design at the beginning of a research project conceptualizes the first phase of coming together, where actors articulate their positions, and determine the concepts, skills and solutions required for the project at hand (e.g., Moser, 2016). This phase, during which different epistemic perspectives are identified

and directed to the action/transformation needed, is an important reflexivity exercise.

Co-production and adaptive co-management are concepts that, based on our analysis, are central in both recognizing and organizing the interface between knowledge and management or governance, which is often the context for applying the co-concepts in NRM. These two concepts develop the ways to bridge multiple understandings and different social capacities into transformative action (see Table 1). Furthermore, social learning and knowledge co-production are parts of "learning through doing" cycles in adaptive co-management and are a necessity for integrating and building capacity between diverse knowledge holders into management (e.g., Cundill & Fabricius, 2010; Plummer & Armitage, 2007; Cvitanovic et al., 2015). In Figure 1, co-learning implies an active intention (Glasser, 2007) compared to the more passive nature of social learning occurring even unintentionally. Co-learning is particularly essential, as it enables both adaptation capacity and reflexivity.

Similarly to Carlsson and Berkes (2005, 67), who consider co-management as a "process rather than a fixed state", all co-concepts can also be seen as collaborative, facilitated processes that require sharing power and constant negotiation between heterogeneous actors. This procedural nature of each concept blurs their temporal, conceptual and epistemic boundaries in relation to each other. We consider that clearly defining and using these five concepts for project orientation in different stages of a project can increase the potential to transform relations, create new knowledge and new approaches to management and governance, along with inaugurating social learning in TD. This should result in a different outcome of the process from the starting-point, and successful collaboration leads to transformations either in the socio-political spheres of NRM or in the research practices themselves depending on the aims of the TD project.

4.3 | How can an integrative view of co-concepts facilitate transdisciplinary research?

The reviews of the five co-concepts and their interlinkages highlight the disorganization in using and defining the concepts, which arguably also affects the application of collaborative modes in TD (Blythe et al., 2017). The proposition of the article is that these different understandings can amplify the epistemological, temporal and practical tensions identified (Section 3.6) in TD, which could be avoided by transparently and consciously aligning definitions and perceptions of collaborative processes and identifying possibly differing aspirations for outcomes. We have offered a review of meanings leading to a structured understanding of the interlinkages of the five co-concepts, which may guide the implementation of various approaches and engagement at the temporal, epistemic and conceptual levels (Figure 1). This provides a common ground to make the different viewpoints in a TD project visible, and thus contributes to more conscious and (self-) reflexive use of the collaborative approaches. As Bulten et al. (2021) point out, researchers need practical guidance and skills to navigate TD. Our integrated view helps to build a researcher's

competence in connecting knowledge and action in TD throughout the project's life span.

We underline that collaborative TD projects may benefit from considering the epistemic nuances that manifest themselves in the various disciplinary traditions of each co-concept and from acknowledging their integrated nature to counteract these effects. Authors are increasingly emphasizing the plurality embedded in collaborative science (Laursen et al., 2021; Thompson et al., 2017). Dealing with the plurality of differing epistemic and value perspectives requires recognizing individual framings in a research practice (Blythe et al., 2017) and ways to build coherence to improve the methods, processes and practices applied. While one can argue that improvements in TD processes are not found at the conceptual level, but in practice (Schikowitz, 2020), we want to recall that epistemological tensions become visible in practice (3.6).

The required consciousness of underlying definitions and viewpoints operates in the sphere between theory and practical considerations, which may help to build a stronger methodology for TD (Rigolot, 2020). This is crucial to ensure that TD remains a transformative research practice, not ending up as an empty buzzword. Co-concepts provide a possible method and conceptual framework to act transdisciplinarily in research projects. The practical tensions of TD, that is, questions on the lack of coherent methodology (see e.g., Thompson et al., 2017) and the need for a new kind of research skills (e.g., Bulten et al., 2021), can also be recognized through the use of co-concepts.

Improvement of methodological notions of TD relates to power imbalances, and discussion about consensus building (Siebenhüner, 2018) and the role of knowledge integration (Mobjörk, 2010). Power issues may lead to conflicts or marginalization of some voices. In addition, power dynamics influence how the processes are shaped and as well the the roles different actors see as acceptable to adopt in TD (Bulten et al., 2021; Mobjörk, 2010; Rosendahl et al. 2015; see also Mach et al., 2020, 31 and Wyborn et al., 2019, 319).We acknowledge that multiple perceptions and definitions of the co-concepts can and will co-exist and we concurrently emphasize the plurality of possibilities embedded in the co-concepts. What is deemed a coherent view in one project might look different in another. Further, the roles of researchers and applied definitions may change over time (Bulten et al., 2021), and here the integrated understanding of co-concepts provides a needed multi-entry point framework. Ultimately, we align our perspective with Pohl (2010) who remarks that "[...] we will not come up with a unifying definition but a structured plurality of definitions" (2010, 71).

5 | ADVANCING THE TRANSFORMATIVE POTENTIAL OF COLLABORATIVE MODES IN TRANSDISCIPLINARY RESEARCH

The article has highlighted the variety of meanings and practices related to the co-concepts and TD in NRM, as well as indicating the inadequacy and plurality of perspectives to their transformative aims. Demonstrating impact is often difficult to measure as the interfaces between science, policy and society are not only underpinned by different understandings of knowledge but also by impact itself (Louder et al., 2021). Therefore, despite our emphasis on the responsibility of researchers in using different co-concepts, we hold that an individual TD project also needs to be looked at in the context of greater structures of academia and society in general so as not to fall into the trap of contributing to existing power relations and maintaining power hegemonies (Blythe et al., 2018; Fazey et al., 2018; Turnhout et al., 2020). Up-scaling of success stories of collaborative TD research through institutionalized mechanisms seems particularly challenging (Brattland & Mustonen, 2018). In other words, a well-functioning science-society interface does not necessarily translate into impact at the science-policy interface. Building such coherence requires reflecting on individual research practice and roles as well as changes in structural aspects, such as funding and measurement mechanisms, that are aligned with the neoliberal structures of the society (Shrivastava et al., 2020) supporting the linear models of interaction between knowledge and action.

Here we see a gap between the demand for TD outcomes and the mechanisms in society to participate in, and applying and utilizing collaborative knowledge production (Irwin et al., 2018). This also illustrates a disjunction between the theory and impact of collaborative approaches (Jagannathan et al., 2020). Matching epistemological considerations with methodology while not missing the "transformative opportunity" (West et al., 2020) in relation to the greater society is hard in practice and requires more attention (Raymond et al., 2021).

Based on the above, we present three recommendations for harvesting the transformative potential of the co-concepts in TD. The recommendations intersect the integrated understanding (Figure 1) and support navigating the epistemological and practical tensions (Section 3.6) in transdisciplinary projects aiming at sustainability transformations.

5.1 | Practice reflexivity at individual and group levels

There is a critical gap between operationalizing and implementing reflexivity to navigate different positions and epistemic perspectives which is often discussed in relation to the co-concepts, particularly to co-learning (e.g., Manganelli, 2020). As Schäpke et al. (2018) puts it, reflexivity supports transdisciplinary collaborations as one type of social learning process, which expands reflexivity as an intersecting aspect through all phases of collaborative knowledge production (Figure 1). Our notion of reflexivity follows van der Molen's two-fold approach to reflexivity (2018, 24): as "the capacity to identify normative and epistemic perspectives and to connect these to collaborative action with respect to the environment..." and as the capacity "to gain insights into complex and dynamic natural systems and to respond to changes in an adaptive manner". Accordingly, we argue that to contribute to the transformative potential of TD, reflexivity needs to go beyond the individual level and be directed towards action. Emphasizing reflexivity enables the deep understanding of

co-concepts, their interlinkages, and intended impact. This may not follow one standardized line of thinking but vary in different processes and contexts. By contrast with Djenontin and Meadow (2018, 886), who mention that "standardization or precise empirical framework" may add to the effectiveness of co-production, we instead underline the need for explicit justifications of the stated positions and aims.

TD expands the roles of researchers beyond an external observer of the world to encompass process facilitation, knowledge brokerage, or self-reflection roles (Wittmayer & Schäpke, 2014). This calls for a certain transparency concerning the normative underlying assumptions of the co-concepts employed and of the desired transformation (Horcea-Milcu et al., 2019). To this end, researchers may employ tools and techniques that assist them in self-positioning on a continuum of ontological, epistemological, and philosophical perspectives (e.g., Moon & Blackman, 2014). An organized reflection around value-based assumptions (Jacobs et al., 2020) and acknowledgment of the various epistemic worldviews even among scientists (Hakkarainen et al., 2020; Sundqvist et al., 2018) helps to determine whether the assumptions and values are in conflict with the normative targets set for the transformation.

5.2 | Consider the power and politics of co-concepts

Explicitly probing relationships between power and knowledge, as well as the management of collective goods helps to harvest and focus the transformative potential of the co-concepts. Examination of the inclusion scope is needed to deliver the promises of the concepts, which is also central for both practical and epistemic development of the concepts. It is important to observe the context (e.g., Norström et al., 2020) and various stakeholder groups, and analyze their relations drawing on concepts such as collective or distributive power. Furthermore, co-concepts provide a new discourse of knowledge production in NRM, which implies embedded power within these concepts themselves (Foucault & Gordon, 1980; Jasanoff, 2004). Thus, explicitly grounding one's views in meanings and promises of different collaborative approaches is crucial to increase the transparency of transdisciplinary processes (Figure 1). We concurrently emphasize that acknowledging the power aspects while practising collaborative research should not replace but complement the sustainable governance of natural resources. This means that other (political) mechanisms outside academia are still needed for transmitting the results to the broader society and enabling both sustainability and equity (see, e.g., Latulippe & Klenk, 2020; Gutiérrez-Zamora & Hernández Estrada, 2020).

5.3 | Value process-orientation

By considering 'co-concepts' as more than mere instrumental means to an end (i.e., resulting in knowledge that benefits only the research in hand rather than distributed and collective understanding), there are

better chances of delivering their transformative promises. A process-orientation shifts the focus from input–outputs to what happens between inputs and outputs, which an integrated view of the co-concepts may help to clarify (Figure 1). Key characteristics of a process-orientation practice are i) proactively allowing and maintaining space for societal learning (Wittmayer & Schäpke, 2014); ii) planning for the evaluation of outcomes, as well as of stakeholder interactions (Fritz et al., 2019); iii) practising formative accompanying research within project teams, appointing a dedicated researcher to observe the collaborative process from within, and produce observable data starting from the researchers themselves (Freeth & Caniglia, 2020). This approach suggests that the focus of understanding collaborative knowledge processes should shift from simply considering knowledge to encompassing the practical and temporal aspects of collaborative approaches along with the social and epistemic terms, which in the end determine the success of generating desired outcomes. This does not mean that the process should be valued over the outcomes, but that an explicit input–output balance may increase the actual transformative potential of the co-concepts.

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