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Global analysis of social learning's archetypes in natural resource management: understanding pathways of co-creation of knowledge

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Although social learning (SL) conceptualization and implementation are flourishing in sustainability sciences, and its non-rigid conceptual fluidity is regarded as an advantage, research must advance the understanding of SL phenomenon patterns based on empirical data, thus contributing to the identification of its forms and triggering mechanisms, particularly those that can address urgent Anthropocene socio-ecological problems. This study aims to discover fundamental patterns along which SL in natural resources management differs by identifying SL archetypes and establishing correlations between the SL process and overall geopolitical conditions. Using a systematic literature review comprising 137 case studies in the five continents, content analysis, and correlations were performed. Results show two main archetypes of social learning (endogenous and exogenous). Their occurrence was linked, to where social learning occurs and how venues/preconditions for social learning are placed. In the Global South, endogenous SL should be better potentialized as a catalyzer of deliberative processes for sustainable natural resources management.

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Introduction

Attempts to improve sustainable natural resource management (NRM) increasingly highlight the importance of generating conducive contexts for the co-creation of social-ecological strategies based on learning approaches, rather than relying on technocratic models built on hierarchy and linear conceptions of knowledge transfer (Kristjanson et al., 2014; Rodela, 2011; Pahl-Wostl, 2009; Ison and Russell, 2000; Armitage et al., 2008). Although technological advancements and technical understandings of social-ecological system dynamics are undoubtedly important and widely adopted in the environmental and agricultural sciences to steer sustainable transitions (e.g., climate-smart agriculture and sustainable intensification, among others), technocratic models tend not to transcend technical knowledge (Blok, 2018). Instead, they obscure the collective understanding of interdependencies, complexity, uncertainty, and competing truths in sustainable development (SD) agendas (Rist et al., 2007). Where technocratic management overshadows human responsibilities for the multiple crises of the Anthropocene, humanistic approaches focusing on collective processes and risk, bring them to light (Blok, 2018). Therefore, sustainable NRM requires further research and development that enables and institutionalizes new practice dynamics, interactions, roles, responsibilities, and pathways to co-create novel systems of knowledge and knowing.

Here, knowledge of sustainable NRM is understood as a form of cognitive understandings that guide natural resource management strategies, and as a relational achievement (Ison et al., 2013). Replacing accounts of individual discoverers and/or technology, knowledge for sustainable NRM is a result of humans-biophysical world interactions and co-creation processes (Gergen, 2011), which should be fostered to accelerate transformative development and democratic decision-making. This perspective has gained momentum since 2000, with a particular interest in learning-based and co-creation approaches in sustainability sciences (Kristjanson et al., 2014; Bonatti, 2018). However, knowledge co-creation settings can also face challenges, especially in co-creation settings among Global North and Global South actors. In this context, the current difference between “co-creation” and “classic” crowdsourcing initiatives is far from clear, resulting in some skepticism about the co-creation process since it can be used as a form of coloniality (Quijano, 2007) and scientific extractivism (Mpoe and Swartz, 2019). Co-creation denotes a deeper relationship and commitment by the involved parties, who must work to jointly ideate, design, and produce knowledge and strategies that benefit all based on alternative pedagogies in the form of practical reflexivity and dialogical research (praxis) (Freire, 2020; Baron, 2004). These alternative pedagogies are associated with social learning (SL) processes (Lotz-Sisitka et al., 2015).

Created during the 1960s in the educational sciences (Bandura and Walters, 1977), SL has quickly evolved conceptually and been adopted by several different disciplines and sub-disciplines. During the 1980s, SL was intensively used in Organizational Sociology, and in the 2000s, Sustainability Sciences embraced the concept as a fundamental pathway for the co-creation of strategies for sustainable natural resource management (Cundill and Rodela, 2012), hence establishing a second school of social learning (Bonatti, 2018). SL continues to be conceptualized, understood, and used in many different ways (Wals, 2007; Muro and Jeffrey, 2008; Reed et al., 2010; Collins and Ison, 2009; Bonatti et al., 2022).

Here, SL is defined as a process based on collaborative groups and networks that: (a) integrate different sources of knowledge; (b) undertake iterative and transformative actions as a result of critical learnings that transcend the individual and become

situated within wider social units (Reed et al., 2010); and (c) generate an epistemological point of view that defines knowledge not as an object that can be transferred between people but as the result of an emergent, relational dynamic of social interactions (Ison et al., 2013). Social learning (the second school) is a process crucial for natural resource management and is found in different kinds of institutions and communities, although with diverse forms and functions. This implies that questions concerning the different functions of SL, how it contributes to sustainable transformations, and questions concerning conditions and structures that foster its emergence cannot be answered in a general way (Ison et al., 2013). Furthermore, the rapid growth and diversification of SL approaches have generated, in some cases, divergence about the meanings, outcomes, and limitations of SL for NRM. Since purposeful empirical social learning research is still comparatively new (Cundill et al., 2014; Kristjanson et al., 2014), emerging at a time of significant inter and transdisciplinary interest in societal change toward a more sustainable future (Cundill et al., 2014), research should forge a stronger and deeper understanding of SL processes, along with potential models for societal transformation and sustainable NRM. While some remarkable advances in social learning classifications (Rodela, 2011; Cundill and Rodela, 2012; Slater and Robinson, 2020) and metaphors (Ison et al., 2013) have been established, the actual design and organization of empirical cases that aim to trigger social learning remain largely underexplored. Therefore, although the conceptualization of social learning is rapidly evolving in sustainability science, and its non-rigid conceptual fluidity is regarded as an advantage (Ison et al., 2013), it is critical that research advances the understanding of social learning phenomenon patterns based on empirical evidence (Kristjanson et al., 2014). Further developments in this regard could contribute to the identification of different social learning forms, particularly those most effective in addressing urgent social-ecological problems in the Anthropocene.

To close this gap, this research advances theory in this area by identifying overall geopolitical contexts that differentiate social learning and identifying their archetypes. Archetypes are models based on patterns of behaviors or phenomena (Oberlack et al., 2019; Eisenack et al., 2019). Thus, archetypes of social learning refer to the fundamental paths/patterns through which people involved in NRM learn from each other in a social context. By investigating archetypes of social learning, this study can advance the understanding of social learning approaches and definitions of ‘what is’ social learning (Rodela, 2011; Cundill and Rodela, 2012; Ison et al., 2013; Reed et al., 2010), focusing particularly on the following research questions: What are the archetypal pathways of social learning in NRM? How do they occur in different social and geopolitical contexts? The primary aim is not only to understand the observed social learning phenomena through extensive empirical data but also to establish correlations between social learning, geopolitical location, and general socioeconomic conditions. This is crucial for advancing the study of social learning and is particularly significant in showcasing potential alternative models of social learning that may emerge from various contexts.

This study, therefore, adopts a working hypothesis based on previous SL studies to guide the analysis. Chavez-Miguel et al. (2022), Bonatti et al. (2022), and Souza et al. (2020) show initial evidence regarding the potential emergence of different kinds of social learning based on initiatives led by communities living in adverse socioeconomic conditions in the Global South. Their research focuses, respectively, on *Escuelas Campesinas* (in Colombia), the Bucket Revolution, and the community of *Lomba do Pinheiro* (both in Brazil). These case studies offered initial

evidence about a kind of social learning that is triggered through collective action at community levels that emerged autonomously possibly indicating different patterns of relational dynamics among social actors occurring in the Global South.

Although the Global South is not a static concept, it is understood that the concepts of Global North and Global South (or the North–South divide in a global context) are used to describe a grouping of countries sharing similar socioeconomic and political characteristics (Dados and Connell, 2012). The Global South is a term generally used to identify countries in the regions of Latin America, Africa, parts of Asia, and Oceania. Most, though not all, of the countries in the Global South, are characterized by low-income, dense populations, poor infrastructure, colonial past, minorities' exclusion, and marginalization processes (Mahler, 2017, 2018). Although this distinction has limitations given the changing global dynamics (Gray and Gills, 2016) and the potential to overlook specific contexts related to class, gender, and race that contribute to global inequalities (Dados and Connell, 2012), it represents the latest development and critical approach to the previous definition called developing or developing countries.

The previous studies, findings (Chavez-Miguel et al., 2022; Bonatti et al., 2022; Souza et al., 2020) are the central source of information for the development and investigation of the hypothesis of this study, and this type of social learning can be called Endogenous SL. A definition of this type of SL is only found in the work of Carlile (2013), where it is defined as a process rooted in the political, economic and social frameworks of the locality or region. This process would embody a form of social learning that convened stakeholders that represented not just a socially differentiated community of actors but a set of actors that acknowledged the traditions and local authorities of the region as well as an understanding of the local organizations (Carlile, 2013). Therefore, for the purpose of the analysis carried out here, Endogenous SL is initially understood as the process through which interacting individuals within a society or group learn from one another, rather than from external sources or formal instruction (Cunningham and Cunningham, 2008). This type of learning is “endogenous” because it originates from within the system or community itself (Wals and van der Leij, 2007). It involves the exchange of knowledge, behaviors, and skills through observation, practices, and communication among peers (Reed et al., 2010) sharing a territory (Berkes, 2009). This concept can be related to Endogenous Development which focuses on leveraging local resources, knowledge, and capacities to foster sustainable development from within a community or region (Vázquez-Barquero, 2002). It prioritizes the participation and empowerment of local populations, ensuring that development initiatives are culturally appropriate and rooted in local traditions and/or practices (Escobar, 1995; Ray, 1999).

A second type of SL called Exogenous, for which a formal definition does not exist (or cannot be found) in the literature, has also been identified, which could be included among the current social learning concepts. In this type of social learning, individuals or groups learn from experiences, information, and influences that originate outside their immediate social context or community (Reed et al., 2010) based on interactions with external social actors such as representatives of organizations. As a result, this study elaborates on actual and potential differences between endogenous and exogenous SL patterns to be confirmed on the basis of further empirical evidence.

The differentiation of two initial archetypes is crucial to provide a parameter for identifying the potential emergence of different types of social learning, based on initiatives led by communities living in the different geopolitical contexts. Although this study recognizes the limitations of using

North–South relations (Gray and Gills, 2016; Dados and Connell, 2012), the adoption of this geopolitical differentiation was essential because different patterns of relational dynamics may occur in different socio-economic contexts, which could have implications for the emergence of different kinds of social learning to be identified at the global level.

Methods

To understand the observed social learning phenomena through extensive empirical data and to establish correlations between social learning and power structures and socio-economic conditions, four interconnected steps were applied: (1) development of the analytical framework (2) case study selection; (3) case study classification; and (4) clustering and definition of archetypes. Steps 2 and 3 are based on a systematic literature review, defined as systematic methods to identify, select, and critically appraise relevant research, collecting and analyzing data from the studies that are included in the review (Petticrew and Roberts, 2008).

Step 1—Development of the analytical framework. To answer the research questions, this study applied an archetype analysis, which can identify/represent recurring interaction patterns (Moallemi et al., 2022). Archetype analysis avoids the traps of overgeneralization and ideography by identifying recurring but non-universal patterns that hold for well-defined subsets of cases (Eisenack et al., 2019). This kind of analysis in sustainability research offers the opportunity to assess recurrent causes and effects of human–nature interactions as an integrated set of processes rather than isolated factors while considering the specific spatiotemporal contexts in which they evolve. Therefore, this study seeks to discover social learning generalizations about key interlinkages and patterns relevant to sustainable natural resource research by using archetype analysis as a core methodological approach (Kates et al., 2001). These patterns are useful for understanding functional similarities and differences from a broader perspective, thus informing decisions that must be made across diverse knowledge co-creation contexts (Miller et al., 2014; Sietz et al., 2019), linking empirical evidence with broader learning processes. Importantly, recognizing similarities can enhance learning and inform the scaling-up of sustainability improvements.

The analytical framework synthesizes some insights from a collection of seminal studies (Cundill and Rodela, 2012; Scholz et al., 2014; Slater and Robinson, 2020), which delineate essential characteristics and attributes of social learning in terms of materials (Slater and Robinson, 2020), processes (Cundill and Rodela, 2012), involved actors, methodologies, resources, and resulting outcomes such as new knowledge, reflective thinking, and newly forged relationships (Table 2). These fundamental elements were methodically integrated and organized through the lens of archetype analysis (Fig. 1), leading to the development of a comprehensive conceptual model that articulates the social learning phenomena within natural resource management (NRM). This model is structured around three principal dimensions—outputs, inputs, and geopolitical context—each aligning with the archetype analysis's structural components: design, outcome, and diagnostic criteria.

The geopolitical context dimension delves into the interplay between political and geographic territories, drawing on the conceptualizations by Quijano (2007) and Dados and Connell (2012). The input dimension encapsulates the essential tools, participants, processes, and materials that facilitate social learning events (Cundill and Rodela, 2012; Slater and Robinson, 2020). Conversely, the output dimension captures the tangible and intangible products emanating from the social learning

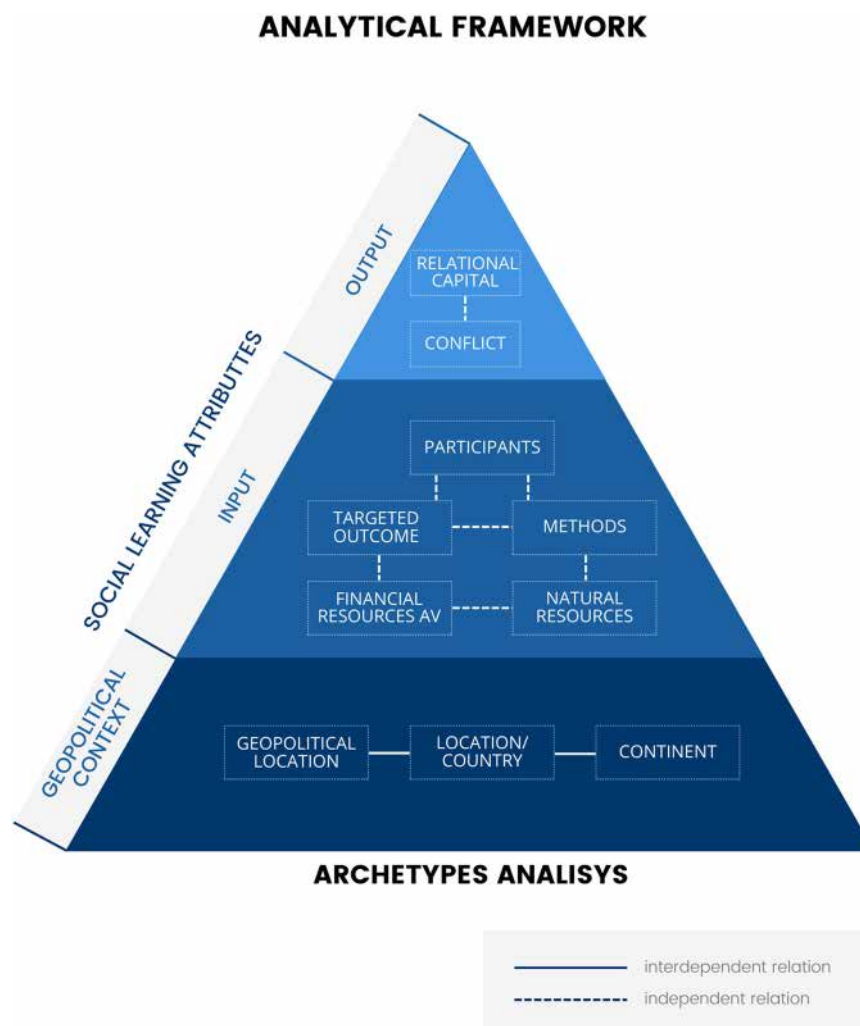


Fig. 1 Analytical framework.

interactions (Scholz et al., 2014). Notably, this study opted to exclude the transformation of mental models from our analysis, as outlined by Scholz et al. (2014), due to their inherently higher subjective nature.

The 10 social learning key characteristics were defined as the 10 specific categories of analysis. In order to analyze comparable factors across heterogeneous cases, this study prioritized the inclusion of more objective categories (such as 'geopolitical location', 'location', 'country', 'natural resource addressed' and 'resource availability'). However, subjective categories ('relational capital', 'methods', 'targeted objective' and 'level of social learning') are also included because of the importance of trying to understand the inputs and outputs of a social phenomenon (in this case, the social learning process). Therefore, this study has a certain degree of subjectivity in its analysis. These categories were classified as interdependent or independent to further analyses. The explanation of the interconnections and dependencies among categories was crucial for clarifying the possibility of category exclusions if necessary and enhancing the comprehension of our analytical framework. Analyzing interdependent relations requires an approach that considers the direct interactions, causal relations, and connections variables. In contrast, independent relations can be examined separately, focusing on individual effects.

Classifying and analyzing a consistent quantity of social learning cases based on these categories of analysis enables us

to investigate the SL phenomenon in depth and its context, to identify the boundaries between the phenomenon under investigation and the context in which it occurs, as well as to generalize SL recurrent mechanisms, co-relations, and patterns (Cundill et al., 2014).

Step 2—Selection of study cases. To understand the current forms of social learning in NRM, this study systematically reviewed a selection of international peer-reviewed literature that directly assesses the status, processes, tools, barriers, outcomes, and opportunities for social learning NRM. Specific keywords were used in our initial search, such as "social learning" and "natural resource management," in combination with variations of "case of study," "study case," "case," or "case study," which helped identify the initial 4220 documents (with 4072 of these documents from Web of Science and 158 from Science direct). These keywords were developed based on a rigorous process that drew from previous literature in the field and the collective familiarity of the authors with the topic (period of data collection September 20 to December 20, 2022). Non-empirical (theoretical and conceptual) literature and empirical cases of social learning that occurs without human group in-person collaboration were excluded. In other words, our review focused on empirical studies that included collaboration for on-ground actions, as well as publications including "learning" in the content.

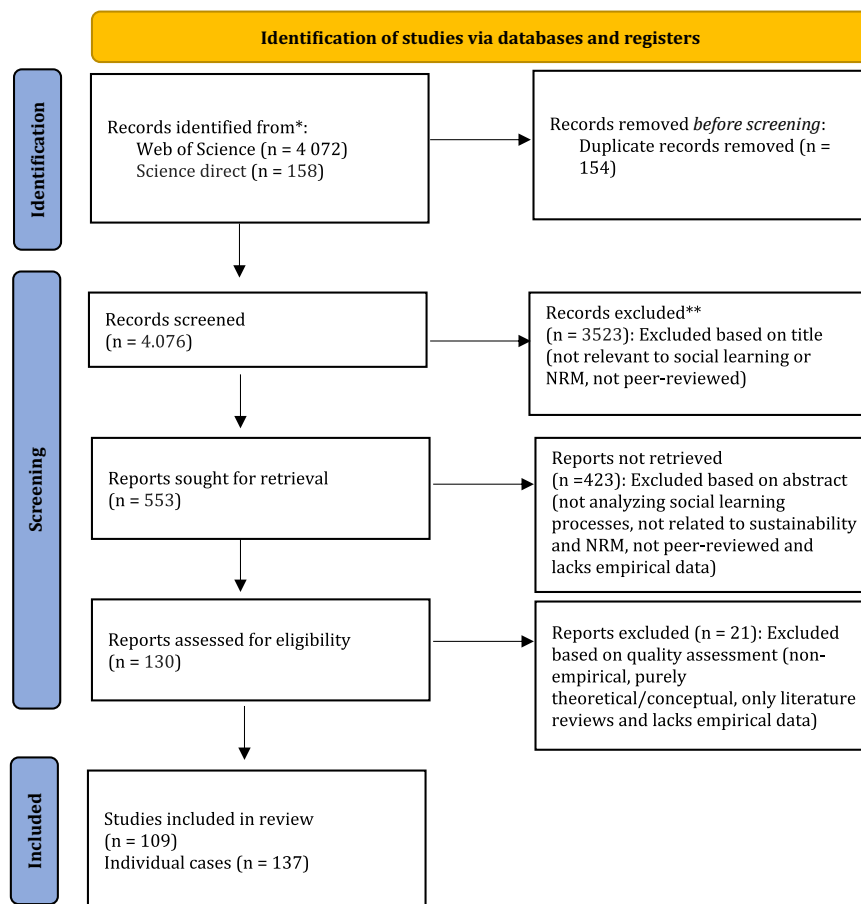


Fig. 2 PRISMA flowchart of primary study selection.

To ensure a high standard of reporting quality of the revision process and its replicability, our study follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, which includes a standard methodology that uses a guideline checklist and a flow diagram (Page et al., 2021). The flow diagram, which provides a schematic overview of the review steps, is depicted in Fig. 2.

After removing duplicate records (154), an initial screening of titles took place, excluding a total of 3523 records that were marked as ineligible. Subsequently, the remaining 553 documents were manually screened and further filtered based on the abstracts to include only peer-reviewed publications that: (1) explicitly analyze social learning or learning processes, directly mention social learning processes, or specifically use methods mentioning social learning; (2) relate it to sustainability and natural resources management (i.e., land use, water management, biodiversity, etc.); and (3) are peer-reviewed and published in international scientific journals (Table 1 includes specific criteria to including or excluding the articles). Accordingly, it was selected 130 articles that went through a full-text assessment. The scope of this review is limited to the natural resource management literature. This does not negate the importance of the other bodies of literature on the topic, particularly in the areas of pedagogy, governance, and policy. Rather, the limited scope of this review highlights the challenge of summarizing a large and rapidly growing discourse on social learning in natural resource management.

In order to ensure the reliability and validity of this systematic literature review, a rigorous quality assessment was conducted. This involved a multi-step process to evaluate the included studies and ensure the consistency and comparability of the data.

During the coding phase (Step 3), it became evident that one category of analysis, namely “Conflict,” consistently lacked sufficient and consistent information across the selected studies. Consequently, this category was deemed unsuitable for inclusion in the review. The decision to exclude the “Conflict” category was made in order to maintain the overall quality and reliability of the review by focusing on categories with more robust and consistent data. As illustrated in the analytical framework, conflict is an independent variable. Consequently, the exclusion of this category would not affect the overall analysis.

In addition to the exclusion of categories, meticulous attention was paid to the methodologies employed in the selected studies. It was observed that some articles employed methods related to computer games as a social learning process that were not directly comparable to the primary research focus of this systematic review. In order to maintain methodological consistency, comparability, and relevance to the research question, 21 articles were excluded from the review. Consequently, only a final sample of 109 articles met the inclusion criteria (see Supplementary Material: List of articles). To maintain the individual case study as the unit of analysis, articles discussing more than one case were analyzed on a per-case basis. This resulted in a total number of 137 individual cases of social learning for natural resource management.

Step 3—Classification of the cases according to categories of analysis. A content analysis was conducted on the selected papers through the following ten analytical categories of the analytical framework: 1. geopolitical location; 2. The type of participants; 3. Scope of learning; 4. Outcomes; 5. Relational capital generated; 6.

Table 1 Criteria for selecting the articles.		
Dimension	Inclusion criteria	Exclusion criteria
Document type	Peer-reviewed article	Not a peer-reviewed publication
NRM scope	The article discusses SL in the context of sustainability science and NRM (e.g., land use, water management, biodiversity, etc.)	The article focuses on other academic fields, such as health and management sciences, SL for digitalization, digital learning
SL scope	Paper related to social learning for NRM mentioning as a social learning process or conduct a method related to social learning/learning Explicit analysis of social learning or learning processes • Empirical studies that detail group learning activities • Descriptions or evaluations of collaborative learning, community engagement, or participatory methods within the study • Use of social learning tools, or assessment of learning outcomes in NRM settings	Paper does not focus on natural resource management but instead focuses on education programs or corporative management, and digital learning as a pure tool.
Methodology	Includes results from a case study Use of empirical data (quantitative or qualitative results from on-ground, collaborative NRM projects)	Non-empirical (theoretical & conceptual) literature. Does conduct only a literature review.
Publication period	Non All available included	Non
Language	Papers indexed in English	Non-English indexed papers

Conflicts generated; 7. SL mediation/methodology applied; 8. Financial resource availability during the SL process; 9. SL level (endogenous or exogenous process); and 10. Natural resources are addressed with the SL process (Table 2).

The classification of the articles according to the categories of analysis was conducted by an interdisciplinary team (*n*: 10) comprising geographers, politicians, agronomists, an economist, a sociologist, and a pedagogue, which had rounds of inter-rater checks for concordance. Regarding quality assurance of coding, to enable cross-article comparisons, we conducted a quality assessment of each coder to identify those who had missed entries or skipped significant questions/indicators. Individual training was conducted to understand and calibrate the categories of analysis and its variables. As such, all included studies underwent a thorough and independent review by the research team. The analysis and evidence synthesis were conducted using established coding procedures, adhering to recognized methodological guidelines (Haddaway et al., 2015). Each selected study was reviewed independently and cross-checked by at least two team members against these indicators. Discrepancies were resolved not merely by discussion, but by referring back to our operational definitions and consulting a third reviewer if necessary. This approach ensured a high standard of consistency and rigor in the assessment process.

Step 4—Clustering and defining archetypes: data treatment, patterns identification, and archetypes generation. Correlations between categories of analysis were processed to identify underlying structural conditions that differentiate and cluster the cases, resulting in potentially different archetypes. A comprehensive archetype analysis characterizes each archetype by three elements: (i) a configuration of attributes; (ii) a theory or hypothesis that explains the relation between the attributes; and (iii) a set of cases where it holds (Sietz et al., 2019).

Following this rationality, data treatment follows three steps: (1) finding the significant, positive, and negative correlations using Pearson’s bivariate correlations in the extracted information of the 109 papers/137 cases; (2) decomposing each significant correlation to discover attributes; and (3) constructing and linking the multiple variables analyzed then explaining and analyzing the working hypotheses. For that, we loaded the collected social learning data into a Python file and calculated the

Pearson correlations with the aid of the Python library *pandas*. The network graphs were then created using the *Python library networks* by scaling each node with the strength of its corresponding correlation with the SL archetype (endogenous or exogenous) and colored depending on whether the correlation is positive or negative. Due to the social subject being analyzed, the correlation classification (weak to strong) follows the principles of correlation coefficients proposed by Akoglu (2018). The values ranged from strong negative correlations (dark red areas) to strong positive correlations (dark green areas).

A cartographic representation comparing the occurrence of Endogenous SL and Exogenous SL at the country scale was generated by ratio calculation with the help of the Python libraries *Pandas* and *Plotly*. A data analyst and a mathematician led this data analysis with the support of the team previously described.

Study limitations. It is essential to acknowledge the inherent limitations of our systematic review in the context of the field of Social learning in NRM. One prominent limitation arises from the significant heterogeneity in research methodologies (cases) observed across the body of literature we reviewed. In the absence of a universally agreed-upon protocol and the prevalent use of mixed methods by researchers, achieving a high degree of comparability among the studies included in this review was a formidable challenge. To mitigate this limitation, we made concerted efforts to carefully discuss it in interdisciplinary team and contextualize our results within the framework of this heterogeneity. Finally, it important to highlight that archetype analysis is was also chosen considering heterogeneity. As a methodology, archetype analysis is primarily driven by the objective of explaining outcomes in heterogeneous cases that lack universal patterns (Eisenack et al., 2019). Ultimately, the review omits certain publications like books, proceedings, dissertations, and non-English regional journals due to its primary emphasis on bibliographic databases. By prioritizing bibliographic databases, various other material types have been left out of the review. Further limitations are related to the overall use of the geopolitical category. It is important to note that the Global North-South divide is a simplification of complex realities. There are significant variations within each category, and some countries may not fit neatly into either group (Milanovic, 2016). Additionally, the rise of emerging economies, such as China and India, has challenged

Table 2 Description of dimensions and indicators of the categories of analysis.

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1. Dimension: Geopolitical context (Dados and Connell, 2012; Mahler, 2017, 2018; Capdepuy, 2023; Quijano, 2007)			
Representative analytical category (Classified as Objective or Subjective)		Short description/guiding questions/	
Geopolitical location (objective)	Where is the case? a. Global South b. Global North	Where is the case? Global North and Global South describe a grouping of countries sharing similar socioeconomic and political characteristics (Dados and Connell, 2012). The Global South is a term generally used to identify countries in the regions of Latin America, Africa, Asia, and parts of Oceania. Most, though not all, of the countries in the Global South are characterized by low-income, dense populations, poor infrastructure, colonial past, minorities' exclusion, and marginalization processes (Mahler, 2017, 2018; Capdepuy, 2023; Quijano, 2007). Indicators: Economic development: ○ Global North: Characterized by high-income, industrialized economies with advanced technological infrastructure. ○ Global South: Characterized by lower-income, less industrialized economies, often relying more on agriculture and resource extraction. Historical context ○ Global North: Largely composed of former colonial powers and countries that benefited from colonialism and imperialism. ○ Global South: Largely composed of former colonies and countries that experienced exploitation and underdevelopment due to colonialism and imperialism. Political power ○ Global North: Countries that often have greater political influence in international organizations and global decision-making processes. ○ Global South: Countries that often have less political influence and are underrepresented in global governance structures. Social indicators: ○ Global North: Generally have higher levels of formal education, health, and income. ○ Global South: Challenges related to poverty, inequality, and limited access to education and income Continent geographical position refers to the specific continent where the case is situated.	
Continent (objective)	Geographical position: a. Europe b. Asia c. Africa d. Americas e. Oceania		
Location/Country (objective)	Specific Country/Countries (more than one should be included if multiple case studies)		
2. Dimension: input (aspects from Scholz et al., 2014; Slater and Robinson, 2020)			
Representative analytical category (Classified as objective or subjective)		Short description/guiding questions/	
Participants (Objective)	Who participated? The focus of the collaboration is community members or formal institution representatives. All Stakeholders taking part in the process are participants (Scholz et al., 2014) Participants = type of stakeholders participating in the social learning process: a. Community individuals b. General stakeholders/institutions representatives c. Both (a and b)	Who participated? The focus of the collaboration is community members or formal institution representatives. Participants = type of stakeholders participating in the social learning process: a. Community individuals. Community individuals are individuals who are part of a particular community, whether that community is defined by clear geographical location, shared interests, cultural ties, etc. They play an integral role in the functioning and development of the community. Key indicators for community individuals: ● Shared physical location/Residency: a group that shares the same geographical location; members are often residents of a specific area, such as a neighborhood, town, or city. They may or not participate in local activities and organizations. ● Shared Identity, Cultural or Ethnic Ties in certain determined geographical regions: groups that shared cultural backgrounds, languages, traditions, or ethnicities. Members may share common heritage and customs (James et al., 2012). ● Shared Social Support Networks: Some communities serve as social or support networks (for example, some Favelas/Slums). Members provide emotional, practical, or social support to one another. b. General stakeholders/institutions representatives. General stakeholders/institutions representatives are individuals or officials who act on behalf of established, structured organizations or entities that have specific roles and responsibilities within a society. These individuals represent and uphold the interests, policies, and functions of their respective institutions. Formal institutions can include government bodies, educational institutions, corporations, non-profit organizations, and other entities that have recognized authority and responsibilities. - c All participants/multiples (the process involved a and b)	

Table 2 (continued)			
2. Dimension: input (aspects from Scholz et al., 2014; Slater and Robinson, 2020)			
Representative analytical category (Classified as objective or subjective)	Short description/guiding questions/	Indicators/definitions/aspects to be considered in when coding	
Targeted outcome/objectives (Subjective)	What was the objective in the SL process? Target outcome? a. NRM locally b. NRM not locally (state, national or international level) c. Political agreements d. Community development e. All/Multiples “no single objective strongly prioritized”	What was the objective in the SL process? Target outcome? What was the objective/scope? What was the initial driver for people’s participation? About which issues people had an influence? a. Natural resources management (NRM) locally: Increased knowledge about natural resources of the local territory, enhanced skills and/or changed behavior in natural resources management at the local/community, household level. b. NRM not locally (state, national or international level): Increased knowledge about natural resources, enhanced skills and/or changed behavior in natural resources management at the state, national or international level. c. Political agreements: Political agreements on natural resources management are formal agreements, treaties, or arrangements between actors, governments, international organizations, or other political entities that establish a plan and/or actions for the management of natural resources. Other questions to consider: are new authorities or institutions? They come together to find an agreement? d. Community development: a process that involves and/or empowers community members to take collective action and achieve improvements in various aspects of their lives in a community (here related to NRM) like: • Social capital/political capital among the community members (Scholz et al., 2014) • Increased knowledge and enhanced skills about community conditions. • Enhanced interaction between individuals, groups, and organizations of the community. • Opportunities and action in the community for self-organization. • Active involvement of local residents and stakeholders in the decision-making processes that affect their lives. e. All levels/Multiples = “no single objective strongly prioritized” Was there a SL methodology planned/organized from the beginning of the process? a. Learning by doing b. Pre-established method c. Mixed	
Methods (Subjective)	Was there a SL methodology planned/organized from the beginning of the process? a. Learning by doing b. Pre-established method c. Mixed	a. Learning by doing b. Pre-established method c. Mixed (depending on the moment of the process) Aspects to consider/indicators: Who initiated the process? Professional, external agent, and/or community people? Who took leadership in the facilitation of the process? Professional, external agent, community people? Was the methodology created/defined at the beginning of the process? Was the methodology changed/adapted along the process? Is there a clear leadership conducting the methodology? Is this so right from the beginning, or evolving (in which way)? (Craps, 2003) Were initial external resources to meet the requirements or demands of a specific task or objective? Was the social learning process part of a project funded by external agencies? Do the participants of the project or community have to cope with finding financial resources to implement the SL process? What was the natural resource (s) (renewable and non-renewable materials and substances found in the natural environment) target in the process to be better managed?	
Financial resources availability (Objective)	Were there clear financial resources (FR) available to implement the social learning process/or funded project? a. Financial resources (FR) available/funded project b. FR scarcity/non-funded projects/Community own resources c. Both depending on the period that the project took place		
Natural Resource addressed (Objective)	What kind of natural resources were targeted for better management?		
3. Dimension: output (aspects from Scholz et al., 2014; Cundill and Rodela, 2012)			
Representative analytical category (Classified as objective or subjective)	Short description/guiding questions/	Indicators/definitions/aspects to be considered in when coding	
Relational capital (Subjective)	Relational capital a. Strength overall participation b. Increase critical thinking c. Increase environmental knowledge d. a and b e. a and c f. b and c g. a, b and c	Relational capital refers to a relational outcome generated in a human exchange relationship that cannot be generated by either firm in isolation. It is identified as a resource that is created through social network processes (Watne and Heide, 2004) when people learn how to work together; collective action around common environmental concerns (Cundill and Rodela, 2012) Indicators: a. Strength overall participation; Number of participants, an increasing number of participants, consistent participation;	

Table 2 (continued)		
3. Dimension: output (aspects from Scholz et al., 2014; Cundil and Rodela, 2012)		
Representative analytical category (Classified as objective or subjective)	Short description/guiding questions/	Indicators/definitions/aspects to be considered in when coding
Conflicts (excluded from the analysis) SL level (subjective)	Was there conflict or not/were they mentioned or not? Endogenous or exogenous. a. Endogenous b. Exogenous: c. Both/multiple processes	occurrence or development of a community of practice (CoP) Wenger, 1998). Refers to outputs associated with actors' relationships and activities (Scholz et al., 2014) b. Increase critical thinking/reflexive practice (Cundil and Rodela, 2012; Craps and Maurel, 2003): Were political power relations/structures among institutions (Young, 1995) and/or questioned? Were the living conditions and development structures questioned? Were roles and responsibilities in NRM questioned? Were there processes of participants doing their own problem solutions, self-reflection on identifying issues, considering alternatives to different realities, and making decisions? c. Increase environmental knowledge (Craps and Maurel, 2003): New knowledge (and knowledge actions, and products): new skills, actions and/or behaviors, products and new relationships. Knowledge is regarded here as shaped by social practices, i.e. socially constructed. Thus, it is emergent, pluralistic, negotiated and collaboratively created through processes that do not separate practice and knowledge. New Actions allude to shared methods of overcoming common challenges arising from the common creation endeavor (Bloor, 1976; Latour and Woolgar, 1979; Collins, 1985). Further options below are the possible combinations of the above aspects. d. a and b e. a and c f. b and c g. a, b and c Excluded from the analysis
		How was the process started? For whom was there a problem, and by whom was it raised? Who started the process gives insight by whom an issue was framed (social construction of the resource)? Was it based on community rationalities? (Carille, 2013). There is no problem, solution, or causal relation unless there is a social actor stating it and/or accepting it (Craps and Maurel, 2003). Were the local needs the main trigger of the process? What kind of actors were involved? Were they mainly from a shared community or representative of external or institutional interests? a. Endogenous. Endogenous cases show a spontaneous learning process initiated, facilitated, and or led by community-based engagement and rationales. Endogenous SL is initially defined to the process through which individuals within a society or group learn from one another based on interactions and the social environment, rather than from external sources or formal instruction (Cunningham and Cunningham, 2008). This type of learning is "endogenous" when originated from within the system or community itself (Wals and van der Leij, 2007). It involves the exchange of knowledge, behaviors, and skills through observation, practices and communication among peers sharing the same territory (Berkes, 2009; Reed et al., 2010). b. Exogenous. Exogenous cases exhibit learning processes if it is not related to the community members but instead centered on external stakeholders mediated by formal institutions/organizations (non-community-based process). Individuals or groups learn from experiences, information, and influences that originate outside their immediate social context or community (Reed et al., 2010) based on interactions of external actors such as representatives of organizations. The process is based on the transfer or interchange of external knowledge and/or technologies. External definition: Stakeholders who are mainly not members of the community and are mediated by formal institutions. a. Both/hybrid/multiple processes. Did the process change? (for example, started by the community and changed to external actors, or vice versa)

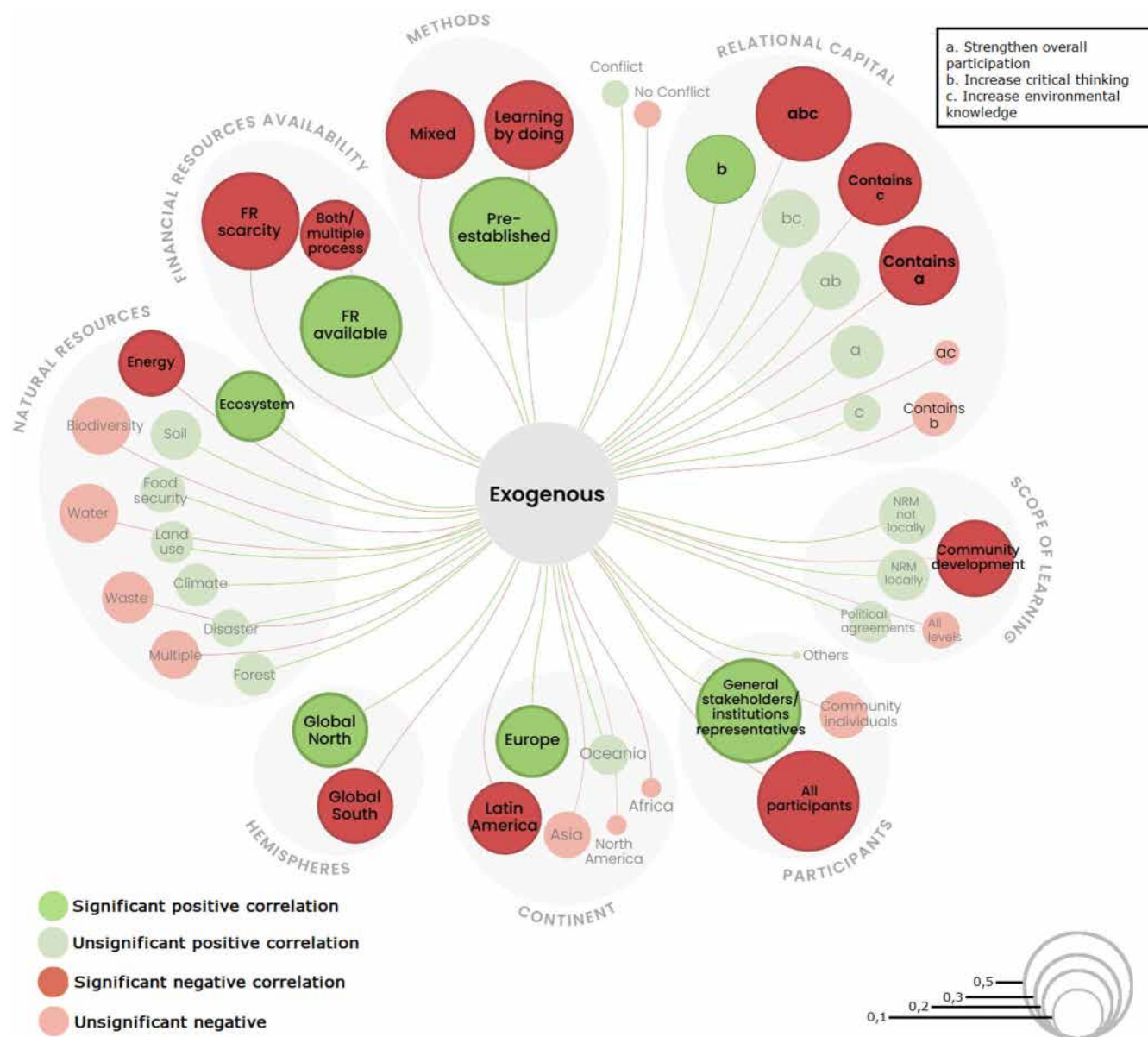


Fig. 3 Exogenous significant, positive, and negative correlations between SL levels related to the other categories of analysis.

the traditional North-South dichotomy (Gray and Gills, 2016). Finally, it is acknowledged that other categories of analysis, such as governance systems, can be investigated in future research.

Results

The results show significant correlations, both positive and negative, among the variables of the categories of analysis (SL level related to the others). The results are presented based on the two archetypes (endogenous and exogenous SL) (Figs. 3 and 4). Although there are nuances, the results show a trend aligned with the initial working hypothesis.

As a general result, the positive correlations, with strong to moderate effect strength among the variables, indicate that the patterns of each archetype of social learning can be characterized as (i) Endogenous social learning associated with learning by doing methods, financial resources scarcity, Global South, knowledge focused on community development, community individuals engagement and (ii) Exogenous social learning, associated to financial resources availability, fixed methods,

Global North, general stakeholders engagement, focused on environmental knowledge and political agreements. Of the 137 study cases, discussed across 109 articles, 33 are classified as Endogenous SL, 90 as Exogenous SL, and 14 could not be categorized as belonging solely to one or another archetype.

The 14 cases have non-clear patterns (not patterned). Therefore it was not possible to define it as a pure Archetype itself. However, it was chosen to present it as a result to indicate that other kinds of archetypes might exist. The fact that 14 cases are not clearly categorized indicates that the proposed framework is not able to take account of the whole diversity of the social learning phenomena, implying the exclusion of specific cases. Examples of such cases include sources that were initially reporting Exogenous SL processes and then transitioning or having characteristics of Endogenous SL. As stated by Eisenack et al. (2019) if one observation does not fit to an archetype, this does not falsify the archetype simply because archetypes are not required to be universal. It only falsifies the applicability of that archetype in that case.

The results showing the strongest correlations for Exogenous SL and Endogenous SL are related to the three categories of

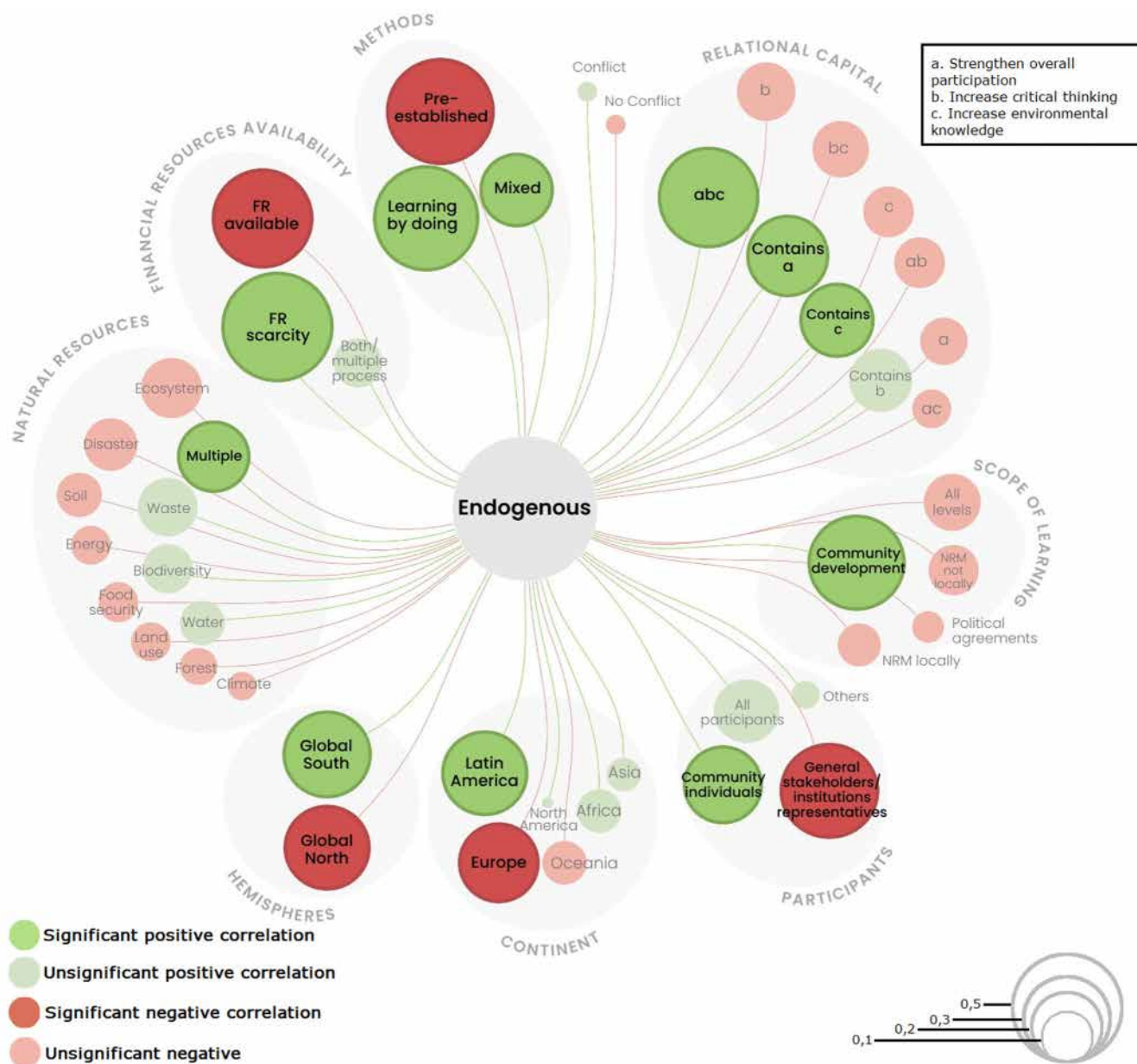


Fig. 4 Endogenous significant, positive, and negative correlations between SL levels related to the other categories of analysis.

analysis of input: “financial resources,” “method applied,” and “types of participants” (Figs. 3 and 4). The other categories of analysis can also be associated with Endogenous or Exogenous archetypes. Regarding the “Continent” category, while Europe is the continent where most cases of Exogenous appear, Latin America has the most frequency Endogenous cases. The category “location” does not show significant results related to specific countries. These results suggest that they are the conditions (structure and inputs) under which the different kinds of SL archetypes emerged, generating different outputs. Although these two archetypes are distinguishable, they are not entirely opponent or antagonist archetypes. The existence of these archetypes does not exclude the existence of other archetypes.

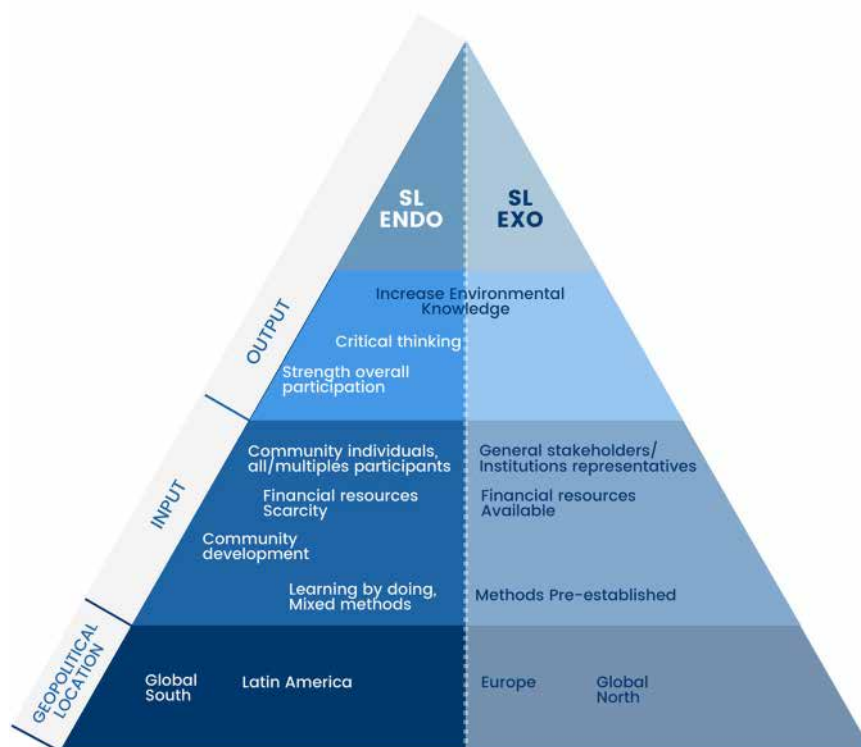
For this category of ‘natural resources’, endogenous SL is more closely correlated with ‘multiple resources’, while exogenous SL is more closely correlated with ‘ecosystems’. This may suggest that in some, but not most, cases, the social learning process has addressed multiple resources or systems. In the dataset, the proportion of occurrences of several natural resources is close for

endogenous and exogenous (e.g. water, 42% of endogenous cases and 30% of exogenous cases), making the correlation for these items non-significant and signaling that this relationship could be due to chance rather than being a characteristic component of any archetypes.

Exogenous archetypes: correlations and characterization. See Fig. 3.

Endogenous archetypes: correlations and characterization. See Fig. 4.

Analysis of the multiple variables and the relation between the attributes. In Fig. 5, the patterns of each archetype of social learning characterized as structure, input, and outcome are represented in a hierarchical form. Here, we construct and link the multiple variables, explaining and analyzing the working

FIG 3: SOCIAL LEARNING ARCHETYPES ESSENTIAL FEATURES BASED ON CORRELATIONS FOUND**Fig. 5** Social learning archetypes essential features based on correlations found.

hypotheses about Endogenous and Exogenous SL according to the co-relations found.

As the left side of Fig. 5 summarizes, in the SL endogenous archetype features where social learning outcomes are focused on increasing critical thinking and environmental knowledge, and strengthening participation. The inputs/conditions for generating these outputs are related to the use of learning-by-doing methods under conditions of scarcity of financial resources, with the aim of community development and participation mainly of individuals in the community. These conditions may have their origins in the geopolitical context of the societies in which these archetypes occur.

On the right side of Fig. 5, in the SL Exogenous archetype, the social learning outputs are more centered on increased critical thinking and some combinations. The inputs/conditions (center of Fig. 1) for producing these outcomes are related to the use of pre-established methods in the condition of availability of financial resources with the participation of general stakeholders.

The correlations between exogenous SL and the Global North, as opposed to endogenous SL and the Global South, are not the strongest, but they clearly indicate a trend. Although most of the attributes of the structures, inputs, and outputs of each SL in NRM differ, the combined outcomes of relational capital (arrangements between a–c) have some common aspects (especially increased environmental knowledge). In the map (Fig. 6), the occurrence of Endogenous SL and Exogenous SL at the country scale is shown.

Discussion

The results showed evidence of at least two main archetypes (Endogenous SL and Exogenous SL); confirming the working

hypothesis that different patterns of SL are occurring. The inputs for and outputs of SL in NRM (as documented in the literature analyzed) differ strongly between processes with Exogenous SL and Endogenous SL. It can be associated with where social learning takes place (Global North/Europe or Global South/Latin America). Therefore, would the characteristics of Global North or South determine how the venues and preconditions for social learning are placed (more power-imbalanced settings and fewer resources)?

As presented in our hypothesis, a few studies (Chavez-Miguel et al., 2022; Bonatti et al., 2022; Souza et al., 2020) suggest that a different kind of social learning occurs in the territories of the Global South. When looking at communities in the Global South, the focus of social learning is more closely related to community development done by community individuals, where most “learning by doing” methodologies and low-resource SL processes are used. SL Endogenous might be a process close to what Pahl-Wostl (2009) conceptualized as social learning that proceeds in a stepwise fashion moving from single to double to triple loop learning where informal networks are considered to play a crucial role in learning processes.

As shown in the map (Fig. 6), the results of SL Endogenous show a correlation with the Global South, particularly Latin America. This region has been related to the emergence of numerous grassroots movements rooted in co-creation processes and community rationalities. Prominent examples include La Vía Campesina across Latin America (Desmarais, 2008), the landless workers’ movement in Brazil (Wolford, 2010), and the Proceso de Comunidades Negras in the Colombian Pacific (Escobar, 2008). Moreover, theoretical frameworks, including Freire (2020) and Fals Borda and Mora-Osejo (2004), shed light on several community-based initiatives and endogenous development in neglected areas.

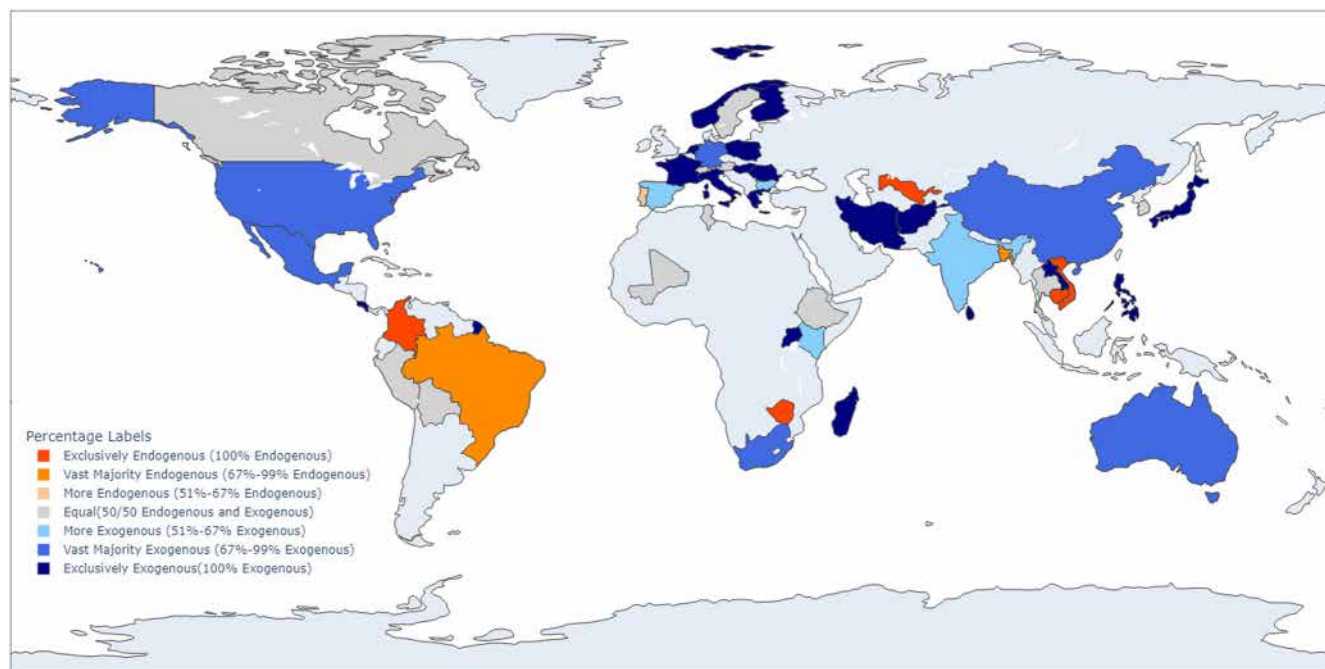


Fig. 6 A cartographic representation delineating the occurrence of Endogenous SL and Exogenous SL at the country scale.

In contrast to the community-based, endogenous archetypes of social learning seen in many Latin American contexts, Exogenous social learning processes are more prevalent in the Global North, particularly in Europe. Unlike community-based initiatives that often emphasize the importance of local knowledge, local identities, and their connection to specific territories, exogenous processes may not place a similar emphasis on these aspects. Exogenous social learning then incorporates a high level of advocacy and diverse civil society groups not directly representing the communities in multi-stakeholder networks (Pahl-Wostl et al., 2013). However, the focus of these processes is often on political agreements, policy development, and scientific recommendations that guide a societal transition towards sustainability (Schäpke et al., 2017). This may overlook the intricacies of local identities and their ties to the land and natural resources.

In the Global South, characterized processes such as structural exclusion and neglect (Mahler, 2018; Capdepuy, 2023) may exert an influence in terms of a self-designed process of innovative social learning emerging under a scarcity of financial resources, through the engagement of community members focusing on self-determined priorities for local development in the face of multiple crises. Therefore, it may indicate that some Global South communities might have developed endogenous social learning processes based on their self-rationalities and structures (Souza et al., 2020) in response to multiple crises and the possibility of handling an intersected process of exclusion (Bonatti et al., 2022). These results are in line with the assertion of Cundill et al. (2014) that social learning processes emerge in diverse contexts. For them, in the Global South, several factors that “go beyond choices related purely to methodological rigor influence the agenda of social learning research” (p.11). Exogenous SL might be established in settings where social actors have suffered less exclusion and marginalization by existing governance systems, possibly with more symmetric power relations. In general, the literature provides a variety of perspectives on various models and tools for social learning related to NRM and governance. In the Global North, for example, SL is often considered crucial for making the management and governance of natural resources more sustainable (Reed et al., 2010; Cundill

and Rodela, 2012) without being directly related to community development. It is also tightly coupled with the history of interactions among those institutional representatives involved in NRM and their relational dynamics within a multi-stakeholder network. As results show, in Exogenous SL, stakeholders/institutional representatives tend to follow the agenda of developing learning focused on natural resource management.

In the case of Endogenous SL, which more commonly emerges in communities with historical legacies of oppression, distrust, and power asymmetries between actors, these factors should play a significant role in determining the kinds of research processes that are considered ethically and socially appropriate (Cundill et al., 2014). This may be creating the need for a ‘community engaged’ orientation to research through which scientific inquiry is not seen as ‘separate’ from the world in which it is constituted, but rather as a valid contributor to expanding learning. According to Freire (2020), a development process should start with an understanding of the participants’ perspectives about their reality. Thus, participants develop a type of diagnosis with a particular focus on how they understand their reality at that moment. At the beginning of the process, the mental models of the participants over their reality are also investigated. They become active, presenting narratives, images, improvisations, characters, and objects that reflect their true understanding of their realities. Through dialog, participants are encouraged to investigate and establish new perceptions about ways to see the proposed problems (Freire, 2020; Bonatti et al., 2021).

Policies and programs based on SL Exogenous approaches may undervalue or overlook the occurrence and potential of SL Endogenous approaches. It is crucial to understand the logic of SL Endogenous to promote sustainable NRM that clearly supports all involved actors while avoiding the replication of coloniality (Quijano, 2007; Escobar, 2012). Therefore, SL processes in the Global South can be better facilitated with what Jürgen Habermas describes as ‘communicative action,’ in contrast to ‘strategic action’ and instrumental rationality (Habermas, 1984). Sustainable NRM requires space for communicative action designed to share intersubjectively validated explanations of actual situations as well as to achieve the co-articulation of purpose and means

required for transforming current norms, rules, and power relations, thus achieving sustainable development (Rist et al., 2007). In this context, this study does not intend to decisively determine the best models or archetypes, rather it seek to understand the existing archetypes, identifying the conditions under which they prosper. This study also highlighted SL models that may be invisible to the broader world given their peripheral/neglected territories of origin. It is also critical to emphasize that the idea is not to dichotomize, but rather to indicate that archetypes and learning processes can be complementary, as suggested by existing evidence and remembering that “there are Souths in the geographic North and Norths in the geographic South” (Mahler, 2018, p. 32),

Finally, interfaces between SL processes here analyzed, endogenous development, and institutional changes (IC) theories might exist in NRM literature. This literature emphasizes common management processes at different levels of governance and theorizes about participatory and community-based arrangements and practices that imply SL processes for social transformation (Pahl-Wostl and Hare, 2004; Romina, 2014; Thiel et al., 2015). This article also contributes to a better understanding of the mechanism of social transformation and collective action related to NRM especially to analysis of in which circumstances they occurred. Other schools of scientific knowledge conceptualize these related processes differently, but the mechanisms identified here point to clear theoretical interfaces. For example, from an institutional economic perspective, Thiel et al. (2015) explain that institutional change can be the product of two distinct processes, objective institutional design (OID) and subjective institutional design (SID). This study might contribute to Thiel's (et al., 2015) findings to understand how the collective action process can be differentiated.

There is a dynamic and close relationship between changes in thinking and changes in social behavior, resulting in the development of social institutions and knowledge-creation processes (Wehn and Montalvo, 2018). In the literature on NRM, social learning processes and institutional change are linked, as this literature, especially that related to the management of common goods at different levels of governance, often theorizes about participatory arrangements and practices that involve collective learning processes for social transformation. These processes involve the co-creation of knowledge between actors with different interests, rationalities, and knowledge, collaborative and sustainable learning, and the development of social institutions that support socio-ecological sustainability (Bodin and Tengö, 2012; Chitata et al., 2021; Romina, 2014). Furthermore, emerging evidence in the NRM literature highlights the relationship between collective action, a common focus of institutional change studies, and social learning (Assuah and Sinclair, 2019; Bodin, 2012, 2017). In considering collaboration for social-ecological sustainability, Bodin (2017) emphasizes collaboration as the foundation of knowledge processes and key to collective action, suggesting that collaboration is a means to (i) enhance the generation of new knowledge through social learning, (ii) better integrate valuable insights from different knowledge systems, and (iii) disseminate knowledge and best practices among a wide range of actors (p. 2).

Further research needs are identified that align with the idea of investigating other categories of analysis such as governance systems, different levels of social learning, or sub-archetypes, which can occur during NRM. Bos et al. (2013) point out the need for a broader understanding of social learning by applying experimental processes that: (i) define whether all participating actors need to learn the same information about a socio-technical system, and (ii) critically assess the learning needs of different actors at different process points to empower these actors to act

as change agents. With further elaboration this can facilitate a better understanding of the relationship between conflicts and social learning.

In terms of limitations, this study acknowledges that many social learning cases may be described using different terms, such as collective learning or transformative learning. The use of the term “sustainable natural resource management” also represents a limitation, considering that several natural resource management cases could be described as adaptive climate change, sustainable development, and NR governance, among others. Furthermore, it is important to note that social learning models from the Global South, such as indigenous or grassroots movements learning systems, may be underrepresented in this study because endogenous SL approaches are unlikely to be reported in scientific articles.

Conclusions

In this work, the case studies analyzed contribute to expanding upon Reed et al.'s, and Cundill et al.'s explanations of ‘what’ social learning is by understanding under which conditions social learning emerges and how it can be facilitated in specific contexts. In order to better develop pathways for co-creation in natural resources management, it is crucial to enrich the current literature in SL by providing evidence for alternative, invisible models of social learning that emerge from different contexts. From here, with this first evidence generated, further research should be undertaken to understand the governance systems and pedagogies used in different models and relations between types of social learning and governance systems.

Identifying archetypes of social learning that originated in the Global South could also shed light on how vulnerable social groups themselves address intersectional issues (racism, gender, and so on) alongside their processes of sustainable NRM. Communities facing failings or an absence of, functional governance systems and inadequate or missing public policies may be developing innovative systems of self-constructed knowledge based on collective learning centered on community needs, their significant universe, and the construction of identity as empowerment process. This includes a critical analysis of the state of vulnerability and neglect within which they live, as well as, currently, natural resource self-management.

These community-based development cases reveal a variety of SL mechanisms, leading to transformative natural resource management in the context of multiple socio-environmental crises, a typical scenario of the Global South. In the Global South, endogenous social learning should be better tapped as an instrument of development and catalyzer of deliberative processes for sustainable natural resource management. In this era of multiple environmental crises, research based on transdisciplinary networks of researchers should embrace and value different identities and learning models. As it advances, robust situated south learning models must be supported, with intentional efforts made to engage smaller institutions, thus avoiding an over-investment in a limited number of better-known organizations that apply exogenous structures where the endogenous might be more adequate or already operating.

Data availability

This manuscript is based on a systematic literature review. In this approach, all data generated or analyzed during this study are included in the manuscript and its supplementary information file (including references and data-generated Excel table) attached in the submission process.

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Author contributions

MB: Conceptualized the study, developed the methodology, led the writing process, reviewed and edited the manuscript, and supervised the project; ML: Contributed to

data analysis and interpretation, reviewed and edited the manuscript; LM: Assisted with data collection and analysis, contributed to writing the original draft; PC: Data analysis, provided technical support and contributed to data visualization; CB: Participated in fieldwork, data collection, and analysis; CE: Assisted with literature review and contributed to writing specific sections; PG: Assisted with literature review; TdSR: Assisted with methodology and literature review; LE: Assisted with methodology development and data validation; TRS: Provided expertise on context and contributed to discussion section; JB: Assisted with data collection and contributed to writing the results section; CM: Assisted with data collection and contributed to writing the results section.; SS: Contributed to the conceptual framework and manuscript review.; RI: Provided theoretical guidance and critical review of the manuscript.; KE: Supervised the research process and contributed to the final manuscript revision.; JH: Contributed to the conceptual framework and manuscript review; GP: Contributed to the conceptual framework and manuscript review; VV: Contributed to the conceptual framework and manuscript review; JB: Contributed to the conceptual framework and manuscript review; AD: Contributed to methodology development and data collection protocols; SS: Provided overall project supervision, secured funding, and contributed to final manuscript review.

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