frontiers | Frontiers in Communication

TYPE Original Research
PUBLISHED 05 September 2024
DOI 10.3389/fcomm.2024.1387111

OPEN ACCESS

EDITED BY
Tarla Rai Peterson,
The University of Utah, United States

REVIEWED BY
Cristi Choat Horton,
Tarleton State University, United States
Paulami Banerjee,
SUNY College of Environmental Science and Forestry, United States

*CORRESPONDENCE
Cristián Alarcón-Ferrari
✉ cristian-alarcon.ferrari@slu.se

RECEIVED 16 February 2024
ACCEPTED 13 May 2024
PUBLISHED 05 September 2024

CITATION
Alarcón-Ferrari C, Jönsson M, Do T, Gebrehiwot SG, Chiwona-Karltun L, Mark-Herbert C, Powell N, Ruete A, Hilding-Rydevik T and Bishop K (2024) Analyzing environmental communication and citizen science in the context of environmental monitoring and assessment for Agenda 2030 in rural settings of Chile and Sweden.
Front. Commun. 9:1387111.
doi: 10.3389/fcomm.2024.1387111

Analyzing environmental communication and citizen science in the context of environmental monitoring and assessment for Agenda 2030 in rural settings of Chile and Sweden

Cristián Alarcón-Ferrari[1]*, Mari Jönsson[2], Thao Do[3], Solomon Gebreyohannis Gebrehiwot[4], Linley Chiwona-Karltun[1], Cecilia Mark-Herbert[5], Neil Powell[3,6], Alejandro Ruete[7], Tuija Hilding-Rydevik[8] and Kevin Bishop[9]

[1]Department of Urban and Rural Development, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden, [2]Swedish Species Information Centre, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden, [3]Department of Women's and Children's Health, Sustainability Learning and Research Centre (SWEDESD), Uppsala, Sweden, [4]Ethiopian Institute of Water Resources, Addis Ababa University, Addis Ababa, Ethiopia, [5]Department of Forest Economics, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden, [6]Sustainability Research Centre, University of the Sunshine Coast (USC), QLD, Australia, [7]Greensway AB, Uppsala, Sweden, [8]Swedish Biodiversity Center, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden, [9]Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden

Introduction: This article offers an analysis of environmental communication (EC) and citizen science (CS) in the context of Environmental Monitoring and Assessment (EMA) for the implementation of Sustainable Development Goal 15 (Life on Land) in Chile and Sweden.

Methods: The paper is based on fieldwork in two rural study areas of Chile and Sweden where we followed different CS initiatives in relation to EMA and Agenda 2030. We conducted interviews, analyzed documentation and conducted an SDG mapping workshop to understand the implementation of SDG 15 in these two rural forest settings.

Results: Our findings suggest that CS has potential as a democratic innovation for environmental governance in both countries. However, we also found important barriers to the legitimacy of CS as a feature of EMA and local environmental governance in both countries. The paper situates CS in the wider governance and environmental communication processes in regional politics surrounding implementation of national policies for the use of natural resources.

Discussion: The article offers new insights into the barriers and possibilities for public participation in environmental governance and policy at local levels, by addressing the interlinkages between environmental communication and citizen science in rural settings.

KEYWORDS

legitimacy, agenda 2030, citizen science, democratic innovation, environmental monitoring and assessment, sustainable development goal 15 (Life on Land), tree plantations, forests

1 Introduction

Environmental communication (henceforth EC) and citizen science (henceforth CS) are two growing fields of research, and they are often associated with normative views and expectations about the role of citizens and the public participation in environmental decisions (Cox, 2007; Peterson et al., 2007; Comfort and Park, 2018; Haklay et al., 2021). These two fields of research have also contributed to the analysis and problematization of contextual barriers and possibilities for participation in knowledge production for environmental decision making (Besley, 2015; Lester, 2015; Hoover, 2020; Lorenz, 2020; Jönsson et al., 2024). In a previous conceptual article (Alarcón Ferrari et al., 2021), we analyzed the potential of citizen science to address legitimacy issues in the knowledge base used to guide transformative governance in relation to the United Nation's Sustainable Development Goals (henceforth SDGs). In that regard, we argued that "traditional" Environmental Monitoring and Assessment (EMA) is a limited tool to overcome legitimacy deficits in local environmental policy. We also argued that citizen science has the potential to strengthen the legitimacy of EMA in the local implementation of SDGs, and we conceived CS as a democratic innovation that provides a path for greater public participation in local environmental decisions. Understanding CS as a democratic innovation for public participation in environmental governance brings important questions concerning the communicative dimensions of CS and issues of public participation in environmental governance. This has been a long-standing concern in environmental communication literature (Walker, 2007; Cox, 2010; Zikargae, 2018). In this regard, key issues that have been addressed in previous EC research and that are of special relevance for understanding the challenges of developing citizen science in the process of public participation in environmental decisions are: First, it is important to understand how public participation can be centered around the *effective influence* of citizens in environmental governance (Cox, 2010) and how possibilities for *influencing decision-making* and *access for early public involvement* in environmental decisions can be fostered (Senecah, 2004). Secondly, it is important to consider *how different types of public involvement* in environmental governance, and the processes or mechanisms through which environmental decisions are taken, can *"create socially legitimate environmental policy"* (Clarke and Peterson, 2015, p. 91), and, specially, how the *use of new technologies can increase public participation* in environmental decisions (Walker and Daniels, 2019). In our view, addressing these issues in the context of CS allows a deeper understanding of the potential of CS to change the terms regarding when the public is allowed to participate and the opportunity to express public views before decisions are taken, as well as how public involvement in data production can foster public participation that facilitates transformative local governance.

This paper offers new insights into the barriers and possibilities for public participation in environmental governance and policy at local levels by addressing the interlinkages between environmental communication and citizen science in rural settings. Our empirical analysis of the implementation of Sustainable Development Goals and the role of Environmental Monitoring and Assessment in rural settings of Chile and Sweden discusses two key areas of interest for environmental communication and citizen science research alike: (1) governance and normativity issues in the understandings of environmental communication and citizen science, and (2) the links between environmental communication, citizen science and contextual factors in the production of knowledge for local environmental policy. Our empirical examples shed light on how initiatives for CS can be seen as forms of EC, and how the democratic potential of these initiatives need to be understood in relation to the wider national political circumstances where different systems for environmental monitoring and assessment are in use. From the perspective of barriers and opportunities for the incorporation of CS into EMA systems, and from the perspective of CS as a form of EC that may influence policy, we problematize two central issues in the implementation of the SDGs 15 in rural settings: (1) the potential of CS for input and output legitimacy in environmental policy making, and (2) issues of scale in policy making for the implementation of SDG 15, which are represented by the national level understanding of the SGDs and the local and contextual decisions on local resources underpinning the achievement of SDG 15. We begin our paper by highlighting the relevance of critically examining the role of Environmental Monitoring and Assessment in the implementation of the SDGs, and link this to the analysis of EC and CS.

Agenda 2030 established 17 interconnected Sustainable Development Goals. Chile and Sweden are Agenda 2030 signatories with national processes for SDG implementation. SDG 15 aims to "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss" (United Nations, 2015). SDG15 is especially relevant for countries where there are extensive forests in rural areas, and an economically important forest sector. Chile and Sweden represent two cases where forestry is being counted on as a force for sustainable development in accordance with Agenda 2030. However, assessments of what is understood as sustainable forest management are contested issues in both countries (Alarcón, 2015; Alarcón, 2019). Policy makers and practitioners rely on monitoring and assessment of forest resources for environmental governance to achieve SDG 15. Monitoring and Assessment (a more general concept than the more established Environmental Monitoring and Assessment) is often seen as supporting Agenda 2030 by providing data toward the achievement of the SDGs (Sustainable Development Solutions Network, 2015). The monitoring aspects of Environmental Monitoring and Assessment (henceforth EMA) imply repeated observation of one or more elements of the environment to detect their characteristics and changes (United Nations Environment Programme, 2019). The assessment component of EMA often consists of the evaluation and analysis of information to support environmental decision making. This relies on expert judgments to provide scientific answers to policy-relevant questions, and quantifies, where possible, the level of confidence (United Nations Environment Programme, 2019). EMA can be highly technocratic, conducted by experts reporting to central authorities (Turreira-García et al., 2018). Such expert orientated EMA is generally not sufficient for the pluralistic aspirations of Agenda 2030 (Fritz et al., 2019).

CS, defined as the involvement of citizens in "scientific endeavor, that creates new knowledge or understanding" (Robinson et al., 2018, p. 33), has emerged as an important supplemental form of EMA (Fraisl et al., 2020; Alarcón Ferrari et al., 2021). One reason for this is that the core benefits of CS are improving the scope of monitoring data as well as increasing trust between scientists, managers, and the public (Jordan et al., 2012; Volten et al., 2018). In this way, CS can bring a more profound renewal of EMA to support the realization of

Agenda 2030 (Alarcón Ferrari et al., 2021). This is particularly apparent in the SDG conflicts and synergies surrounding forests and tree plantations (Timko et al., 2018) which are characterized by issues of legitimacy and power (McDermott et al., 2019). Thus, as we have argued previously (see Alarcón Ferrari et al., 2021) one important issue to be considered here is the challenge of creating public recognition of CS data as legitimate inputs for reforming environmental governance that might impinge upon the interests of powerful local actors (Jalbert and Kinchy, 2016). In terms of legitimacy and power relations too, there is also the problem of unequal access to technological tools for participating in CS that originate from economic differences and can lead to new ways of marginalizing people in environmental governance processes.

Due to the interconnected nature of the SDGs (Nilsson, 2017), renewal of EMA through the incorporation of CS could be of particular value for public participation in policy making when implementing Agenda 2030. In our view, this type of participation should include both horizontal engagement in the co-production of knowledge (e.g., volunteering with local data and knowledge) as well as vertical engagement in decision-making (e.g., engaging with government organizations in decision-making) (Mejlgaard and Ravn, 2015).

Following this introduction, the background and conceptual framework for the article are explained in the second section. Then, the study areas, the methods and the results of the study are presented in the third, fourth and fifth sections. The sixth section discusses the main results of the study by focusing on normativity issues, namely, what is desirable and should be done in relation to the environment, in the understandings of environmental communication and citizen science, and on the interlinkages between environmental communication, citizen science, and contextual factors in the production of knowledge in local environmental policy in in rural settings of Chile and Sweden. Finally, the conclusions of the article are presented.

2 Background and conceptual framework

Transformation to achieve certain environmental goals has been based on social acceptance through traditional monitoring based on conventional and expert science forms of institutional learning, as in the case of tackling atmospheric ozone (Beron et al., 2003). These conventional forms of monitoring and institutional learning have been complemented with participatory monitoring by non-experts. However, lack of legitimacy of EMA systems for implementing SDGs at the local scale undermines the local potential for transformative governance and social-ecological transformations (see Alarcón Ferrari et al., 2021). If there is to be an evidence and knowledge base to support the enactment of SDGs at the local level, reconfiguration of EMA approaches is urgently needed by taking into account skepticism about the accuracy of data collected by participatory processes (Haklay, 2013). Overrepresentation of certain groups in "open science" participation and the public assessment of evidence also needs to be addressed (Haklay, 2013; Fritz et al., 2019).

The relevance of an evidence base to identify paths to transformation that amplify synergies and reduce trade-offs between SDGs (Nilsson et al., 2016) relies on defining evidence as information and data accepted as a legitimate basis for environmental decision making. In this regard, traditional EMA has been a key feature in the systematic efforts to secure and apply evidence to the "triple bottom line" of society, economy, and environment. This is already an integral part of Agenda 2030, whereby 17 SDGs are broken down into targets and indicators on methodological tiers certified by the UN High Level Policy Forum (henceforth HLPF) (United Nations, 2015). However, there is a large gap between the national implementation of Agenda 2030, and effective, equitable transformation in local settings (Jiménez-Aceituno et al., 2020). Critical reviews have identified multiple shortcomings in the role of EMA in facilitating transformation, including a lack of basic data, disputed facts, lack of participation, and local implementation gaps (Nilsson, 2017; Bexell, 2019; Sténs et al., 2019). This indicates that traditional data sources are often insufficient for measuring outcomes to address the SDGs or navigating conflicts and enabling SDG synergies (Nilsson et al., 2016; Nilsson, 2017; Fritz et al., 2019). Data management toward the FAIR principles for open science (findable, accessible, interoperable and reusable) is also crucial (Fritz et al., 2019). Participatory processes embody key elements that can support the renewal of EMA by integrating society and environment through building legitimacy in the evidence-base, and learning processes in governance that can use the evidence as a map for navigating between potential SDG synergies and trade-offs (Ranacher et al., 2017; Evans et al., 2018).

CS and EC are often conceived in normative terms, and in the case of EC, this means attributing a problem-solving capacity and positive pro-environmental role to EC (See for example: Jurin et al., 2010; Lindenfeld et al., 2012; Klöckner, 2015; Moser, 2015; Fähnrich and Ruser, 2021; Klöckner and Löfström, 2022). However, understanding EC only in normative terms undermines the potential of using an EC lens to analyze cases where communication on the environment is a fundamental aspect of the actions of different actors with opposing goals for, and interests in, how environmental decisions are taken and how environmental policy is shaped. Analytically speaking, in these cases, actors engage in environmental communication with different goals, and thus one can argue that environmental communication cannot be simply defined or assumed *a priori* in terms of a problem-solving process, nor simply in terms of a positive pro-environmental activity.

As stated earlier, CS can be defined as the involvement of citizens in "scientific endeavor that creates new knowledge or understanding" (Robinson et al., 2018, p. 33). We conceive citizen science as a democratic innovation that strengthens EMA as a means of implementing SDG 15, providing that citizen science can be successfully institutionalized (Alarcón Ferrari et al., 2021). By democratic innovation, we mean something "designed to increase and deepen citizen participation in the political decision-making process" (Smith, 2009). Conceptually, we conceive CS as a democratic innovation for "empowered participatory governance," as proposed by Fung and Wright (2016) to emphasize the types of governance that rely on the participation and capacities of ordinary people in reason-based decision making through action and discussion. By fulfilling procedural demands for legitimacy, CS can contribute to what Bäckstrand (2016) terms "input legitimacy." The same author also defines "output legitimacy" as the problem-solving capacity of the governance system, which CS can also contribute to. Here we complement this view by analyzing CS as a form of EC in the context of public participation in environmental policy. In this sense, we see EC as one of the practices of local actors in rural settings of

Sweden and Chile where resources for SDG 15 are politically debated and contested. These rural settings are characterized by a resource nexus where municipal and regional level politics are concerned with the use of local forests, lands, waters and other resources. This local starting point intersects national implementation of SDG15 with local politics. Thus, analysis of case studies can surface insights into the links between CS and EC to understand better both input and output legitimacy in local environmental policy making, and issues of scale in policy making for the implementation of SDG 15.

3 Case study

Sweden and Chile are among the top 10 producers and exporters of pulp for paper (FAO, 2020a). They are also countries where forest management is contested (For more comparative background see: Alarcón, 2015; Alarcón, 2019). The process by which EMA is implemented differs considerably between the two countries. Sweden has an established, publicly financed EMA and even some degree of CS is incorporated into the formal procedures. In Chile, EMA is not centralized, with considerable monitoring of forest resources done by private companies which own lands, forests and tree plantations. Chile recently implemented a system for national monitoring of forest resources. The case studies from rural forested areas of Chile and Sweden comparatively analyze the potential for CS in the context of the implementation of SDG 15.

The governance systems differ between Chile and Sweden, as well as the starting conditions in relation to EMA. These differences are particularly large regarding the use of CS. Sweden already makes considerable use of CS for biological recordings through the Swedish Species Observation System (named "*Artportalen*" in Swedish and is a university-based system for nationwide citizen science; Peterson et al., 2023). The main users of such data in Sweden include public authorities at the national, regional and local level, various non-governmental organizations (NGOs) as well as the environmental courts (Kasperowski and Hagen, 2022; Ekström, 2023). Differences are also found in relation to the existence and implementation of environmental legislation, especially at the local level. The role and power and degrees of agency of the general public in governance processes also differs. For example, Sweden ratified The Aarhus Convention in 2005 (United Nations Treaty Collection, 2024a) which mandates public access to information, participatory decision-making and access to justice in environmental matters. Chile ratified a similar regional agreement, The Escazú Agreement, only in 2022 (United Nations Treaty Collection, 2024b). Furthermore, Sweden already has a national system for CS, and while the Swedish CS data are sometimes contested, the Swedish public can use these data in environmental governance. These contrasts between Chile and Sweden provide initial insights into barriers and possibilities for the public participation in environmental policy at rural local levels, and the interlinkages between EC and CS.

Our empirical analysis in Chile includes the Ñuble region where forest conservation and industrial tree plantations are hotly contested. In Sweden, we focus on the Gävleborg region, where CS is often used as a component of EMA. Despite implementing EMA for two decades to support national environmental goals for sustainable forests, limited progress has occurred in Gävleborg and Sweden as a whole (Länsstyrelsen Gävleborg, 2022). Forest resources in rural communities exemplify many of the management dilemmas concerning SDG15 since this goal tries to combine a profitable forestry sector with environmental goals. Within this context, it is important to consider that the SDGs have sub-targets, evaluated with indicators established in a complex international process managed by the UN High-level Political Forum on Sustainable Development Under Agenda 2030, countries submit Voluntary National Reviews (VNRs) to the HLPF.

For SDG 15, the Food and Agriculture Organization of the United Nations (henceforth FAO) is the guardian agency for several sub-targets. National approaches to monitoring forest resources interact with the global system to produce and manage knowledge for SDG 15. Thus, from the perspective of CS and EC, it is important to delve into how knowledge is produced for the implementation of SDG 15 in each country and how that knowledge is used to assess progress toward Agenda 2030. We distinguish knowledge produced in three different but connected spheres of the global process of implementing SDG15 nationally. First, the international sphere of the HLPF to which countries submit their VNRs. Second, the national sphere of governments implementing SDG15. Third, the local spheres and implementing contexts where the indicators are reconfigured by contextual factors, and where SDG 15 indicators aim at reflecting how environment and society change. As SDG 15 implementation is linked to accessing information and public participation, it is also important to consider how public engagement is ensured in environmental governance and policy.

Key sources of information/data used to understand the implementation of SDG 15 is summarized in Table 1.

Table 1 documents local implementation of SDG 15 in Chile and Sweden in relation to national scale targets. The national assessments provide limited insights into local SDG 15 implementation. However, the VNRs submitted by the two countries raise issues concerning SDG15 and EMA "deficits" in the two countries. The Environmental Performance Reviews conducted by the Organization for Economic Co-operation and Development (OECD) for Chile in 2016 (OECD/ECLAC, 2016) and for Sweden in 2014 (OECD, 2014) also identified deficits in monitoring and evaluation. We have identified the following comparative aspects in our cases. First, while Chile does not have a national EMA program, Sweden initiated a national EMA program which has evolved over decades. This EMA program was formally linked to national environmental objectives in 2003 and comprises 12 programs including data on soil, water, forests, biodiversity, and climate. Secondly, while Sweden has a National Forest Inventory (NFI) dating back to 1923 (Fridman et al., 2014), it was only in 2019 that Chile established an Integrated National Monitoring and Assessment System on Forest Ecosystems (SIMEF) (Ministerio de Agricultura de Chile, 2020). A criterion for making a choice of unit of analysis in this project relates to the institutional context, the existence of a national EMA, which is the case in Sweden, and not, which is the case of Chile.

This background is the starting point for our comparative case study analysis of the barriers and possibilities for public participation in environmental policy at local levels, with a focus on the interlinkages between EC and CS in rural settings.

4 Study areas and methods

4.1 Study areas and cases

The Ñuble region in Chile and the Gävleborg region in Sweden are characterized by an abundance of forest resources, tree plantations,

TABLE 1 Documents and issues concerning implementation of SDG15 at a local level in Chile and Sweden.

SDG15 documents	Issues for local level SDG15 implementation	Document status in Chile	Document status in Sweden
Voluntary National Reviews (VNRs) submitted to the United Nations High-level Political Forum on Sustainable Development (HLPF)	Situation regarding "Progress toward sustainable forest Management" which is sub-target 15.2.1.	Chile's second and third VNR from 2019 and 2023 have not reported progress concerning target 15.2.1 (Government of Chile, 2019, 2023)	While Sweden's first VNR from 2017 did not reported progress concerning target 15.2.1 of the SDG15, its second VNR from 2021 reported that *Progress has been made, but the target has not been met.* (Government of Sweden, 2017, 2021)
Index and Dashboard Report (2018) of the Bertelsmann Stiftung and Sustainable Development Solutions Network (2018) and SDG dashboards for OECD countries (levels and trends) in Sachs et al.'s (2023) Sustainable Development Report	National score concerning SDG15	2018: Decreasing score: country is moving in the wrong direction (Sustainable Development Solutions Network, 2018) 2023: Major challenges remain. Score stagnating or increasing at less than 50% of required rate	2018: Score is holding steady and remains at or above SDG achievement (Sustainable Development Solutions Network, 2018) 2023: Major challenges remain. Score stagnating or increasing at less than 50% of required rate
Country Report Global Forest Resources Assessments 2020, FAO	SDG15 Sub-Indicator 4: Forest area under long-term forest management plan (2015 baseline)	In 2020: 0.09% of forest area has a long-term forest management plan (FAO, 2020b)	In 2020: 81.06% of forest area has a long-term forest management plan (FAO, 2020b)

forest industries and different forms of land use for agriculture. Both regions constitute regional political units including several rural municipalities. In addition, these two regions have recently elaborated policy documents that contain regional development plans and deal with environment challenges for the future (Region Gävleborg, 2013; Region Gävleborgs, 2019; Gobierno Regional de Ñuble, 2020). The maps below indicate the geographical location of the study areas (Figure 1).

The rural areas of the Ñuble region in Chile span from the Andes Mountains to the Pacific Ocean. They are characterized by intensive use of land for agriculture, conservation and local use of native forests, as well as industrial plantation forestry. Data summarized by the World Bank indicates that 17.9 million hectares are covered by tree plantations and forest in Chile, representing 23.9 percent of the territory. While native forests account for approximately 82 percent (14.6 million hectares), tree plantations account for 17 percent (3.1 million hectares), and mixed forests for 1 percent (179,125 hectares). In terms of ownership, forest land ownership is dominated by the private sector; almost all forest plantations and more than 65 percent of native forests are privately owned (World Bank, 2020).

Internationally, Chile is one of the largest exporters of chemical pulp from conifers (raw) as well as coniferous wood moldings, and one of Chile's largest industrial forestry complexes is located at the center of the Ñuble region. Native forests are mainly used for timber, as well as firewood and charcoal production. Today, the native forests are mostly found in the foothills of the Andes. In the forest plantations, exotic tree species such as pines and eucalyptus have brought biodiversity loss, local water scarcity and large forest fires (Braun et al., 2017; McWethy et al., 2018; Durán and Barbosa, 2019; Cifuentes-Croquevielle et al., 2020). In contrast, native forests, which in Chile are considered as global biodiversity hotspots (Mittermeier et al., 2004), are also places for tourism and recreation. Nationally, and contrary to views of plantation forestry as a means to address rural poverty, plantation forestry is linked to persistent rural poverty (Andersson et al., 2016). Important investments in forestry development and massive state incentives for plantation forestry have been made with the aim of bringing development and contributing to poverty alleviation. Nonetheless, the Ñuble region is still characterized by persistent poverty and inequalities in its rural areas. In addition, emigration out of rural areas is connected to the rural expansion of the forest sector.

The region of Gävleborg in Sweden has a long tradition of developing forest-related industries, e.g., timber, pulp, paper and more recently biofuels. At the same time, it encompasses several rural municipalities facing the challenges of depopulation and economic decline. Forest ownership in Sweden is characterized by a combination of family enterprises and widespread corporate ownership. Most of the state-owned forests are managed commercially and more than 60% of forest areas are environmentally certified (Official Statistics of Sweden, 2019, p. 6). Swedish citizens are free to use forests for recreation, berry and mushroom picking and other noncommercial activities due to the right of public access, something rather unique to Sweden even among its Nordic neighbors (Sténs and Sandström, 2014). Our analysis of the implementation of SDG15 in Gävleborg surfaced strongly diverging positions about how to manage forests between national, regional and local levels (Johansson and Keskitalo, 2014). Sweden adopted a set of national environmental objectives in 1999, well before Agenda 2030 and the country's commitment to the SDGs. One of those national objectives is "living forests" (sometimes translated as "sustainable forests"). A recent evaluation of the national environmental objectives revealed that the "living forests" objective is not close to being reached at the national level (Angelstam et al., 2020). An evaluation of this goal specifically for Gävleborg County Board also concluded that this goal was not being achieved regionally (Länsstyrelsen Gävleborg, 2022). Thus, while utilization of forests may provide crucial opportunities for progress toward Agenda 2030, the sustainable use of forests in Sweden as a whole, and Gävleborg in particular, cannot be taken for granted. In fact, using forests for new political objectives risks magnifying goal conflicts in the nexus of forests, biodiversity and other resources.

FIGURE 1
The Ñuble region in Chile (NordNordWest derivative work, Janitoalevic, CC BY-SA 4.0 via Wikimedia Commons) and the Gävleborg region in Sweden (Obi2canibe, CC BY-SA 4.0, both via Wikimedia Commons), regions highlighted in red.

4.2 Methods

The research was methodologically designed as qualitative environmental research (Kanazawa, 2017), as we aimed at collecting and interpreting evidence about processes, mechanisms, and actors' views about participation in environmental monitoring and assessment, and SDGs in rural settings of Chile and Sweden. Thus, the study is based on the following qualitative methods: (1) interviews, (2) collection and analysis of documents, and (3) a SDG mapping workshop. Qualitative and semi-structured interviews were deemed appropriate to gather data on relevant actors' views on the topics for the research (Kanazawa, 2017). In turn, document analysis was decided as a pertinent method to review both printed and electronic documents and examine and interpret their meaning in the context of the research and, in addition to the interviews, to obtain further understanding and empirical knowledge (Bowen, 2009). In line with Nilsson et al. (2016) and Nilsson (2017), the SDG mapping workshop was considered a relevant method to systematize views on the interactions between SDGs.

The specific qualitative methods are presented below in the sequence of their application in both the Chilean and Swedish case studies. (The timing of the research process in the two countries sometimes differed):

4.2.1 Interviews

We conducted nine interviews in Chile. The respondents were selected based on their roles in coordinating and institutionally conducting recent assessments of forest and water resources as well as their role in the government's office in charge of implementation of the SDGs nationally and their role in working with SDGs within the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) in Chile. Another criterion for the selection of respondents was their work in rural municipalities with local governance of forests in the selected study area. Research meetings with local experts and fieldwork in the study area were part of the process of identifying and contacting respondents. These respondents are presented in the Table 2 below and included:

The interviews were planned and conducted as semi-structured interviews using interview guides developed to cover issues related to EMA and SDGs implementation. For the interviews in the Ñuble region, the interview guides included topics concerning local environmental governance as well as monitoring and assessment relating to SDG implementation. The interviews in Chile were designed after an analysis of secondary data and a research workshop on the SDGs and EMA in Chile. The interview design aimed at obtaining a deeper understanding of key actors' views. The interviews (lasting an average of 1 h) were recorded and transcribed.

For the Swedish case, we conducted six interviews in a municipality of the Gävleborg region in Sweden (Municipality of Nordanstig). Research meetings with local experts and study visits were part of the process of identifying and contacting respondents. These respondents are presented in the Table 3 below and included:

TABLE 2 List of interviews conducted in Chile (CH is used to indicate Chile).

Interview 1 (CH)	Two staff members from an FAO sponsored project for Integrated National Monitoring and Assessment System of Forest Ecosystems (SIMEF)
Interview 2 (CH)	Two staff members from the project *Escenarios Hídricos* 2030 (which is translated here as "Water Scenarios Initiative")
Interview 3 (CH)	One staff member at the national secretariat for SDG implementation
Interview 4 (CH)	Three staff members at the United Nations Economic Commission for Latin America (ECLA)
Interview 5 (CH)	Officer at Municipality of San Fabian, Ñuble region
Interview 6 (CH)	Officer at Municipality of San Nicolas, Ñuble region
Interview 7 (CH)	Officer at Municipality of Cobquecura, Ñuble region
Interview 8 (CH)	One staff member at the regional office of the National Forest Corporation in the Ñuble region
Interview 9 (CH)	One local forest consultant, Ñuble region

TABLE 3 List of interviews conducted in Sweden (SW is used to indicate Sweden).

Interview 1 (SW)	Representative from a forestry company
Interview 2 (SW)	Responsible for sustainable development, business sector and culture at the Municipality of Nordanstig
Interview 3 (SW)	Municipality of Nordanstig former auditor
Interview 4 (SW)	Chair for Nordanstig water
Interview 5 (SW)	Local artist and business person living in Nordanstig
Interview 6 (SW)	Chair for Nordanstig's Board

All translations from Swedish and Spanish are our own translations.

The interview transcripts were analyzed by an iterative process including first data familiarization, secondly immersion in the data and thirdly a thematic analysis (Kanazawa Nilsson, 2017). The two members of the research team living in Chile at the time of fieldwork, analyzed the interviews by focusing on the following themes: (a) initiatives expressly framed in terms of CS (ciencia ciudadana in Spanish), (b) public participation not labeled as CS or "ciencia ciudadana," (c) monitoring and assessment of relevance for forest management and conservation, and (d) SDGs. Two members of the research team working in Sweden analyzed each interview as well, by focusing on themes concerning (a) forest management, (b) water, (c) SDGs, and, (d) production of environmental data.

4.2.2 SGDs mapping workshop

A SDG mapping workshop in Sweden was conducted on December 9, 2019 with 9 participants. In this workshop, experts participated in the mapping using the scoring system suggested by Nilsson et al. (2016) and Nilsson (2017). The mapping focused on SDG 6, 7, 13, 15 down to the sub-target level. This allowed for identification of potential conflicts and negative interactions between SDGs.

4.2.3 Analysis of documents

The empirical work also included the review and analysis of documents on national and regional environmental governance, SDG implementation and CS initiatives in the two countries. Twenty-eight (28) documents were analyzed and are referenced in the paper, including the review of background documents of relevance for the understanding of global-national issues interacting with SDG implementation. Seven (7) documents were specific to the case study in Chile, and another 12 documents were specific to the Swedish case study. These documents include reports, internet documents, regional and municipality development plans, as well as Environmental Impact Assessment documentation which are available in digital formats. These documents were identified during fieldwork and/or through online research and desk review following the analysis of official national documents on the SDGs, the interviews in Chile and Sweden and the SDG mapping workshop in Sweden.

As suggested by Bowen (2009) the documents were analyzed through an iterative process that included reading (thorough examination), and thematic analysis. We focused on a detailed reading, re-reading and examination of the documents, and a thematic analysis that was adapted to key context-specific issues that became relevant in the process of examining the data collected. Thus, in the case of Sweden we looked at the content of the documents with a focus on the following themes: (a) SLU Artdatabanken (Swedish Species Information Centre, henceforth SSIC) and Artportalen for the case of Sweden (*Artportalen* is called Swedish Species Observation System in English and we have used the acronym SSOS for its identification through the article), (b) citizen science, (c) monitoring, assessment, (d) forests and tree plantations, (e) forestry and biodiversity, (f) SDG. In this way, the documents analyzed, and those presented in Table 4, were the object of a thematic analysis to understand how the knowledge produced through CS (and in the case of Sweden through the SSOS), is produced, framed and incorporated in different processes concerning environmental governance.

In the case of Chile, we identified some rather new initiatives, as well as implementation of the National Monitoring and Assessment System of Forest Ecosystems (henceforth SIMEF). Here, the analysis of documents allowed us to identify cases of CS implemented under SIMEF. These were included in subsequent analyses focusing on the following themes: (a) initiatives expressly framed in terms of CS (ciencia ciudadana in Spanish), (b) public participation not labeled as CS or "ciencia ciudadana," (c) monitoring and assessment of relevance for forest management and conservation, and (d) SDGs.

Within these two national contexts, we wanted to understand first: how data production relevant to forest management and SDG 15 can be produced through CS, second: whether there was participation in the data production (regardless of whether it was called CS or not), and thirdly: how EMA systems can be renewed for SDG 15 by inclusion of CS and other forms of public participation. The presence or absence of citizen science within each country varies. For Sweden, as stated elsewhere, we knew in our role as researchers about the SSOS, but we analyzed more specifically how the knowledge created through CS is brought to environmental governance, as well as how this can be relevant for EMA and SDG 15.

As this research was carried out by two research consortia, we had a final meeting and workshop to discuss results in January 2020. The results were presented and discussed at a seminar with

TABLE 4 The use of knowledge provided by the Swedish species information centre (SSIC) in relation to environmental governance and public participation in the Gävleborg region, Sweden.

Documents, identification of actions, plans, programs or decision-making process where information and knowledge from SSIC and its CS platform is used in Gävleborg	Organizations or situations relying on information and knowledge from SSIC and its CS platform with regard to Gävleborg
Action program for sweet grass 2009–2013 (Naturvårdsverket, 2009)	Swedish Environmental Protection Agency (2009)
Traditional management of lower Dalälven's river meadows – economic and ecological opportunities (LEADER Nedre Dalälven, 2015)	Final report from a project with support from LEADER Nedre Dalälven in the context of the regional landscape strategy, 2015
Inventory of meadow fungi in Gävleborg County 2015 (Gävleborg County, 2016)	The County Administrative Board in Gävleborg County (2016)
County program for regional environmental monitoring in Gävleborg County 2015–2020 (County Administrative Board in Gävleborg, 2014)	The County Administrative Board in Gävleborg, 2014
Analysis of Siberian jay in Gävleborg using the Swedish Species Observation System (SSOS) (Lavskrikan i Gävleborg med Artportalen, 2024)	Report of a private person (former University professor) in the context of Siberian jay controversy in 2016
Environmental Impact Assessment for extension of concession for electricity power transmission line Stadsforsen - Hölleforsen – Untra (Svenska Kraftnät, 2012)	Assessment elaborated by the Swedish electricity transmission system operator Svenska Kraftnät in 2012
List of state forests worth of protection in Gävleborg (Naturvårdsverket and länsstyrelserna, 2004)	County Administrative Board in Gävleborg and Swedish Environmental Protection Agency in 2004
Information on species protection in Sweden and red listing and protection provided by ENGO The Swedish Society for Nature Conservation working in the municipality of Nordanstig in the Gävleborg region (Naturskyddsföreningen Nordanstig, 2024)	Online communication informing that SSIC has a page where people can search for individual species
Biosphere nomination for the Voxnadalen area in Gävleborg region (Biosfärområde Voxnadalen, 2024, 12.05)	Nomination from 2018 where SSIC data was used for identification of 274 species that are nationally red listed
Natural value inventory regarding biological diversity (NVI) in a housing project outside of Gävle. Inventory ordered by the Municipality of Gävle and realized by a private consulting firm (Ekologigruppen AB, 2015)	Use of SSIC data for identification of red listed species in 2015

other experts at the Royal Swedish Academy of Agriculture and Forestry (Bishop and Jönsson, 2020). After this seminar, the research team further discussed the findings that are the basis for this paper. Our qualitative approach focused on analysis of deficits in national EMA systems providing decision support in the context of local implementation of SDG 15 in each country. This includes comparative analysis of whether proper, centralized and public EMA systems are in place in Chile and Sweden. We also consider whether a participatory approach including citizen science can improve EMA in the context of SDG 15. Figure 2 below summarizes and visualizes the research methods used and the iterative process for the analysis of the empirical material.

This research was part of a larger project focused on the analysis of how EMA could better support the fulfillment of the SDGs in forest settings. The qualitative empirical material produced by our research design, the different methods used, and the qualitative analysis of our findings all aim to provide a basis for conclusions regarding prospects and barriers to incorporating CS into EMA in the context of SDG15 and problematizing the potential of CS for input and output legitimacy in environmental governance, and issues of scale in policy making for the implementation of SDG 15.

5 Results

In what follows, we offer an analysis of our context-specific findings for each case study separately. This provides grounds for developing our comparative analysis of the two cases. We discuss first normativity issues in the understandings of EC and CS, then, secondly the links between EC, CS and contextual factors in the production of knowledge for local environmental policy.

5.1 Chile, national SDG implementation and rural municipalities in forest settings

We found that linkages between tree plantations, water scarcity, economic inequalities and contested views on environmental data production are crucial in relation to Agenda 2030 in the Ñuble region. Local municipalities also lack resources and governance structures to participate in data production and assessment effectively. Large businesses and national organizations have far more resources for this. Thus, SDG 15 implementation is already fraught with major legitimacy deficits.

5.1.1 Local environmental governance and assessments of resources in the context of SDG15

While a greater role of municipalities and local actors in Chile may contribute to overcoming these legitimacy gaps, no coherent EMA system exists. A system of national forest monitoring and assessment was officially implemented in 2020. This is the FAO-sponsored project for Integrated National Monitoring and Assessment System on Forest Ecosystems (SIMEF). Preliminary SIMEF results were presented at a seminar on May 31, 2019, and more resources have been allocated to SIMEF by the Ministry of Agriculture. Professionals working in SIMEF stated that their work was motivated by the shortage of data on forests in the

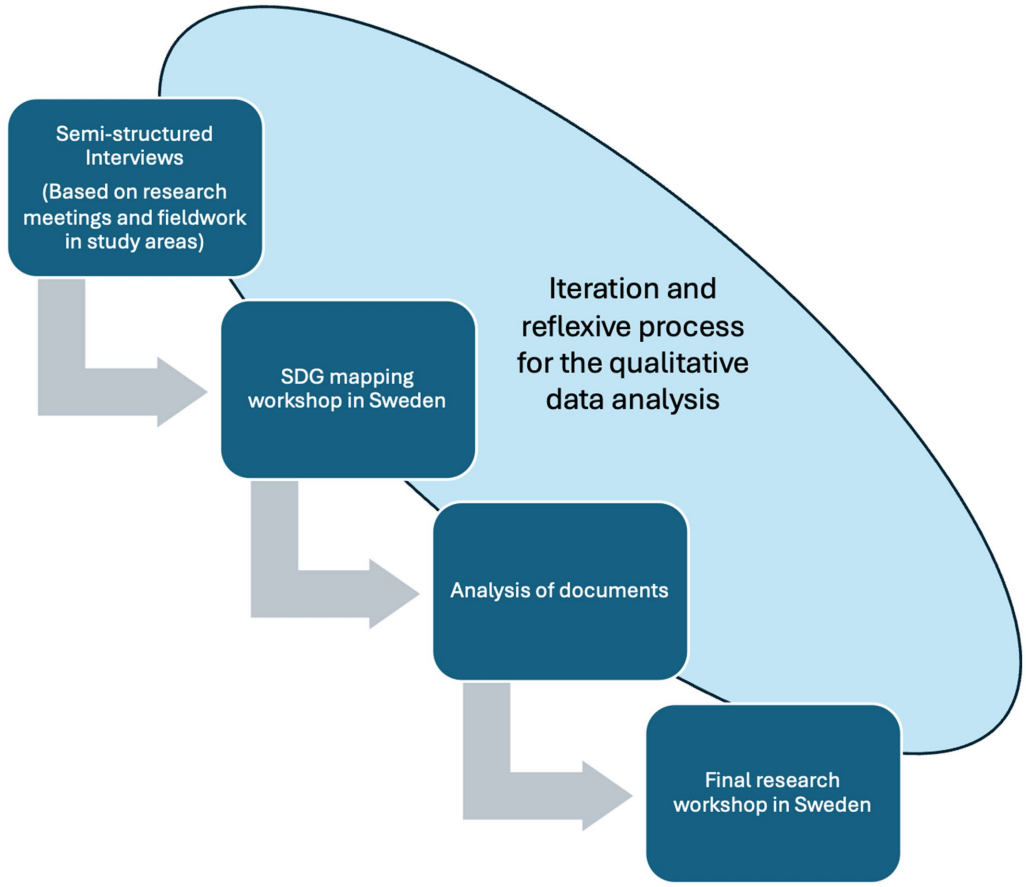

FIGURE 2
Research methods used and the iterative process for the analysis. Grey arrows indicate the sequence of the application of methods. Iteration and the reflexive process in our qualitative data analysis is also indicated in the figure.

country (all quotations are taken from interviews in Santiago and the Ñuble region conducted between October and December 2019):

> *For years and decades Chile has been committed to monitoring, evaluating and monitoring its forests. It started doing it in a way with institutional approaches that worked in an uncoordinated way, including the so-called register of native and vegetation resources and land use that was promoted by CONAF [the Chilean Forestry Agency] more than 20 years ago. On the other hand, the Forest Institute kept a national forest inventory. There was certain evidence that the parallel roads that these institutions took did not allow the country to have a consistent, integrated, and solid system that could provide figures and all the statistics of value to be used in other planning and law development processes in the country. That is why SIMEF was initiated. Obviously, there are also underlying reasons associated to the conservation of forest ecosystems where monitoring will become a tool too* (Interview, Staff at SIMEF, 2019).

In parallel to SIMEF, a private-public partnership developed the project Escenarios Hídricos 2030 (this could be translated as Water Scenarios Initiative), which published a main report in June 2019. This report is regarded as the first national assessment of the state of water resources for Chile. As stated by a professional working in this assessment:

> *All the [economic] sectors projected growth in the territories and when you reviewed their long-term visions, you saw that the mining sector, the agricultural sector, the tourism sector, the health sector, all projected growth and you looked at the data and you said: Well, and with what are they going to grow if the water [availability] is decreasing? Then there was no vision regarding the water issue, and we began to worry about it all as this could have a multiplier effect that obviously puts at risk the economic sustainability and the development of Chile* (Interview, Staff at Escenarios Hídricos, 2019).

In the interviews, the two assessments of resources were connected to the work with the SDGs in Chile. For *Escenarios Hídricos*, its role concerning the SDGs was stated:

> *[…] As the World Bank has declared recently, and also the Inter-American Development Bank and several other institutions, water is key for the fulfillment of all the objectives [SDGs]* (Interview, Staff at *Escenarios Hídricos*, 2019).

And in the case of SIMEF, indicators are directly conceived in the context of Agenda 2030:

> *SIMEF is the basis for the construction of indicators and reports associated with Agenda 2030 and also with other processes of more*

> *global scope such as the climate change convention or the convention to combat desertification…* (Interview, Staff at SIMEF, 2019).

Each assessment, however, focused on only one resource, either water or forests. These resources are also mainly conceived as solitary, independent resources in the assessments. Yet, in the interviews, it became clear that the experts working with both SIMEF and *Escenarios Hídricos* see the need for integration of the assessments since forests and waters are so interlinked.

In contrast to the national situation, for interviewees at three rural municipalities in the Ñuble region working in environmental and rural projects, the need for integrated assessment and monitoring of different resources is well recognized. Yet, the institutional capacity to develop such assessments is far beyond the technical, budgetary and regulatory possibilities of these municipalities. As the environmental officer in the Municipality of San Fabian expressed, the environmental office was only created in 2013. He was the only staff member employed to run the office, and he only worked part-time (2 days a week). He added that the municipality has no capacity to enable the EMA at the local level even though the municipality was part of a national action plan of "local environmental management" and was even granted a Municipal Environmental Certification. The municipality ended its participation in the project because of a lack of resources and the need to work with other projects of higher priority (Interview, San Fabian, 2019).

Local conflicts around the construction of an electrical power transmission line from the Punilla Dam and Hydroelectric Project in the Andes foothills in San Fabian illustrate how important it is for local citizens to have more local data on biodiversity and forests. The Punilla project is located upstream in the Ñuble River. Even though the project had been contested and opposed, it finally received environmental authorization in 2018. Construction started in 2019, although progress has since been stopped by financial problems. The project was originally conceived as an irrigation project to support agriculture in the central valley of the region, between the Andes and the coastal mountains. The central valley has historically been used for intensive agricultural production, and some local actors see the Punilla project as a solution to water scarcity attributed to climate change. The project led to open divisions in the region where one can broadly distinguish the farmers from the central valley standing together with the national state on one side. Opposing are local citizens from San Fabian and other areas close to the river.

Within this context, the Environmental Impact Assessment (EIA) for the construction of the electric power transmission line for the project was especially contested because of concerns about its impact on local biodiversity and native forests. This issue was addressed in the project by proposing a monitoring system as a compensation measure which included the creation of a baseline. During the operation of the project, annual reports based on monitored changes in the composition of species affected by the project were to be compared to that baseline (SEIA Chile, 2020a - EIA proposal-, p. 52). Thus, the EIA in fact established a monitoring system as a result of the approval of the environmental authorization for the project. This responded to one of the main concerns expressed by several local organizations and individuals in the public consultation during the EIA. In an appeal to the approval of the EIA for the dam, one argument made by some citizens was summarized as:

> *In relation to the flora, they [the citizens] affirm that there is a lack of information in relation to the impacts on certain species; that the proposed measures do not take care of the impact of the potential loss of habitat which would allow to sustain a population of threatened species; that the number of trees to be replaced would be insufficient; that the number of years of monitoring would not be adequate either; that it is not stated where or how the damaged ecosystem will be regenerated; that the measures related to the training of workers and the local population on the care and protection of terrestrial flora is not a mitigation measure; that the owner [of the project] does not provide background or scientific basis on how he intends to control alien species; that there are shortcomings in relation to CONAF [the Chilean Forestry Agency] permits; that there would be inconsistencies in mitigation measures related to the fragmentation of the native forest and the alteration of the environment for flora, fungi and lichens, the one indicated in the ICE and in the RCA being different; that the characterization of the natural forests located within the area of influence is not considered in the mitigation, compensation and repair measures; that forest regulations would not be complied with in relation to forest cutting; and that the fire risks that could be caused as a result of the puelche winds, and the power outage are not evaluated* (SEIA Chile, 2020b).

In this case, the negative aspects of the project are seen by local citizens in relation to forests and biodiversity. This is directly understood as a problem deeply connected to the lack of a proper monitoring and assessment system to evaluate the project. Also, for these citizens, there are doubts about the transparency in the monitoring system to be implemented once the project has been approved. This argument reinforces the need to promote the production of data on forests and habitats that can be available in advance of embarking on this kind of EIA. Here there is certainly potential for citizen science, and this is one of the approaches advocated by SIMEF.

5.1.2 Citizen science in the Ñuble region

Recently, and under the framework of SIMEF, several projects using CS in relation to forest resources have been initiated (Sistema Integrado de Monitoreo de Ecosistemas, 2024a, b, c). Two of these CS projects are especially relevant for the Ñuble region. The first CS initiative aims at nationwide data collection on forest resources through participatory monitoring, including forests in the Ñuble region (Sistema Integrado de Monitoreo de Ecosistemas, 2024a, b, c). The second project aims at engaging inhabitants of two municipalities located in the Andes foothills of the region to collect information about biodiversity within the UNESCO Biosphere Reserve in the area. (Sistema Integrado de Monitoreo de Ecosistemas, 2024a, b, c). In the latter case, an online platform for CS is already available. To date (2024) 11 people have participated. They have provided 59 observations including 43 species. This CS initiative has already identified one species (*Eucryphia glutinosa*), which is listed as vulnerable in the national inventory of species. The benefits of CS for the future of the Biosphere Reserve in the face of rapid expansion of tree plantation monocultures are also apparent from the Reserve's management plan. An important objective of that plan is to:

> *Advance scientific knowledge and local knowledge of physical, biological, and ecological, as well as social and cultural aspects of the territory of the Biosphere Reserve, through research and permanent monitoring of these territories* (EULA-Chile, 2024).

These two CS initiatives are still limited in scope and data production. However, their potential is significant, as the involvement of local communities gives legitimacy to key conservation initiatives in the region and the overall goal of better managing native forests. However, it is hard to know how they can be incorporated into a coherent EMA system because this would only be possible if a proper EMA system is in place for Chile. The environmental data production that does exist is also compartmentalized within different sectors and other public and private organizations, with some crucial local environmental data produced and held privately.

A main barrier for scaling up the potential of CS as input legitimacy is thus that it is not clear how that knowledge can be openly shared and incorporated in local environmental governance. In addition, as the case of the EIA above shows, monitoring of habitats and species is sometimes established as a compensation measure in approved EIAs. Though there are certain prospects for CS in order to first increase participation in the production of data and secondly to increase the use of those data concerning the state of the forests, it is not clear how such data could be integrated into established forms of policy making and the existing governance mechanisms. We could say here that in terms of input legitimacy (see above), a fundamental problem is the lack of well-defined decision-making structures that could incorporate CS knowledge.

The limited participation of municipalities in monitoring and assessment is an acknowledged political problem. The development plans for the three municipalities where we conducted interviews in 2019 all recognized the need to have better forms of local regulation for the local resources (Municipalidad de San Nicolas, 2007; Municipalidad de Cobquecura, 2014; Municipalidad de San Fabián, 2016). As stated in one of these plans:

> *It is worth mentioning that to achieve sustainable development, municipal environmental regulation is necessary, and this should be linked to the development of the production of food and agriculture in San Nicolás* (Municipalidad de San Nicolas, 2007, p. 74).

This connects with the aspiration of the municipality to promote agriculture as a source of livelihood for the local people, and in so doing, reduce industrial-scale plantation forestry.

To summarize this analysis of the Ñuble region, we note that the implementation of SDG15 gets entangled with competing views on local development, limited EMA for an evidence base, and struggles for regulatory power. Moreover, SDG15 needs to be operationalized with a greater cognizance of the local context where the meaning of sustainable forest management is problematic when tree plantations are included in the term "sustainable forest management." This is especially relevant for the resource nexus formed between land and water resources since the water demands of extensive plantations of exotic tree species can undermine the prospects for local sustainable agriculture. This resource nexus is also problematic due to the linkage of decreasing biodiversity to the expansion of industrial forestry.

5.2 Sweden, national SDG implementation and regional forest settings

Our research on the Gävleborg Region shows that transformations in line with SDG15 and the Swedish Environmental Objectives in relation to biodiversity and forest management has been an area of intensive work at the regional and municipal level. In this context, green infrastructure plans (GIP) are a novel policy instrument (European Commission, 2013; Liquete et al., 2015; Maes et al., 2015; Faivre et al., 2017). The plans are premised on participation and a long-term, holistic view of ecosystem services in the landscape. They are conceived as the basis for concrete action on natural resource use. Gävleborg region has a well-developed GIP that includes forest resources. This GIP is part of the region's commitment to the SDGs, including SDG 15:

> *The County Administrative Board's task concerning nature conservation is central to contributing to this goal [SDG15] regionally and locally. The County Administrative Board's new green infrastructure plan will also be an important tool for this sub-goal, as will the application of ecosystem services* (Länsstyrelsen Gävleborg, n.d.).

5.2.1 Local environmental governance and assessments of resources in the context of SDG15

At the time of our research, there were political expectations that GIPs will mobilize both urban and rural actors in the region, but there was little experience with actually integrating GI into local governance and forestry. Nonetheless, forests figure prominently in the region's GI planning where the linkages between forest production, social welfare and biodiversity lead to synergies and conflicts among SDGs (Enflo and Rosés, 2015; Gävleborg County, 2019a). To better understand this, one needs to assess both the national and local implementation of the SDGs regarding forest use. In this regard, the SDG mapping workshop conducted in 2019 shows a conflict between SDG 15.2 and SDG 15. 5:

> *SDG 15.2 sustainable management of forests* vs. *SDG 15.5 natural habitats, biodiversity and species.*
>
> *This interaction is expected to be reinforcing in most circumstances. Making unsustainable forestry sustainable can only improve the possibilities to reach target 15.5. There is however also a risk of a negative interaction, if target 15.2 leads to the transformation of natural forests into managed forests, which even if managed in a sustainable manner may lead to the loss of biodiversity at landscape level, as a mix of natural forests in the managed forest landscape is necessary for the most demanding species.*

Potential conflicts and synergies between SDG15 Targets 5 and 2 mean that even within a single SDG it is possible to identify potential trade-offs and synergies. Even when a forest is managed in what is considered to be a sustainable manner by some, this can still mean conflicts with biodiversity and judgments by others that hold that the management is not sustainable. In addition, the case of Nordanstig exemplifies the importance of considering which knowledge is dominant, marginalized, or discredited. Interviews revealed that local decision-makers chose to prioritize data provided by a local anglers' association to motivate the removal of small-scale dams used to provide hydroelectricity in order to support the restoration of aquatic and terrestrial biodiversity. Many small dams date back to the 1700s and have cultural significance. Moreover, scientific data for the county level indicates that unregulated flows will increase the incidence of

extreme flooding, causing root damage in extensive tracts of forest and the leaching of poisonous sediments from river beds.

These insights allow us to further analyze the potential of CS in relation to forest resources and the role of local governance in EMA for Gävleborg. The potential of CS here lies in the following interconnected factors. First, Sweden counts on well-developed CS platforms to provide data on the protection of habitats and species. These CS inputs to the national EMA are coordinated by the Swedish University of Agricultural Sciences (SLU) Swedish Species Information Centre (SSIC) (Artdatabanken, 2024). SLU is a public university with a specific mandate for EMA focused on the Swedish Environmental Objectives adopted by the Parliament. The SSIC works with tasks from the government and other authorities responsible for biodiversity issues. The SSIC also cooperates with several NGOs. Thus, the SSIC provides an infrastructure with data and knowledge on biodiversity to support the work of public and private organizations.

For over 20 years the SSIC has promoted and hosted the bottom-up development of the Swedish SSOS (in Swedish Artportalen Artportalen, 2024) with funding from the Swedish Environmental Protection Agency (EPA) and SLU. The SSOS has attracted a significant user base with 17,000 users reporting species observations each year. To date, the database consists of >100,000,000 observations together with millions of images, video or sound files. Over 6,000,000 new observations are reported each year, the majority from the general public and biological societies. These data are harvested by the Global Biodiversity Information Facility (GBIF) where it comprises a large proportion of the georeferenced data from around the world. The SSOS platform not only gathers biodiversity data from the general public but is also the main repository of data from professional, nationally financed inventories of biodiversity and other environmental parameters. These data are collected systematically under contract to universities or consultants.

A second factor relating to the potential of CS for EMA in Gävleborg is that the national government funds regional administrations and local municipalities to conduct their own EMA programs to address local and regional priorities. Thirdly, several environmental NGOs and individuals are actively promoting the work of citizen scientists in using the SSOS.

The institutionalized infrastructure for CS means that any person can provide observations, and this system is widely used today. For example, during 2023, >149,000 observations of species were registered for the Gävleborg region. Yet, these data need considerable analysis to be used in forest management. For example, to characterize and assess forests, habitat structures are needed in addition to the species. This indicates that in assessing the CS knowledge produced through SSOS in Sweden, we must pay special attention to the applications where this knowledge is used. It is crucial to analyze how assessments based on this knowledge can be contested because of methodological issues surrounding this knowledge and the contexts where this knowledge is used.

5.2.2 Citizen science in the Gävleborg region

To look at the contexts where biodiversity knowledge and data are used, we looked in detail at the use of information from the SSIC and SSOS in the Gävleborg region. Table 4 summarizes our findings which we have identified and analyzed in relation to environmental governance and public participation.

An initial finding is that SSIC information is widely used by different organizations, institutions and individuals. One example from the table is the EIA for extension of the concession for the electrical power transmission line Stadsforsen – Hölleforsen, called "Untra." This contrasts to the EIA on the somewhat similar Punilla project in Chile that was presented in Section 4.1. In the Untra case from Sweden, data and knowledge provided by the SSIC were available at the time of the EIA. This was incorporated into the description of the possible effects of the project on biodiversity. This case indicates that there is potential to use the knowledge and data produced by citizens in the environmental decision making of the Gävleborg region which is relevant for SDG15.

Two other cases from Table 2, the natural value inventories and the Voxnadalen UNESCO Biosphere Reserve deepen our analysis of the potential for CS in environmental governance. The Natural Value Inventory regarding biological diversity (*Naturvärdesinventering avseende biologisk mångfald* – henceforth NVI) is based on the prescription in the Swedish Environmental Code concerning the protection of valuable natural environments and the preservation of biological diversity. When planning new projects, there is a requirement for an NVI based on the knowledge about biodiversity in the affected area. The concept of NVI is defined for biological diversity and its purpose is to identify and delimit the geographical areas in the landscape that are of particular importance for biological diversity. The results of NVIs are primarily intended for physical planning, but they can also be used in other contexts such as planning and prioritization of nature conservation initiatives. The result of an NVI is a crucial prerequisite for being able to make assessments of consequences for biodiversity. According to the standard practice for NVIs when assessing the existence of species, CS knowledge gathered in the SSOS can support the assessment of the nature value of the area where a project is intended, as well as provide a description of the different habitat types in the ecosystems that might be affected by the project. Thus, the wide use of these inventories makes the knowledge provided through CS (and organized in the SSOS) a part of the knowledge base for environmental governance throughout Sweden.

Something similar can be observed in the process of creating and managing the Voxnadalen UNESCO biosphere reserve. In this case, the use of knowledge provided by the SSOS supported the project from its inception. We can observe here that the justification of the reserve was partly based on the existence of red listed species according to data from the SSOS. The plan for developing this biosphere reserve during the period 2020–2035 is centered around the SDGs. Concerning SDG15, it is interesting to note how the future of forestry is conceived in relation to the reserve:

> *Based on the biosphere reserve's natural and cultural conditions, the Voxnadalen Biosphere Reserve wants to promote a* varied *use of the forest, for the benefit of the people who live here and for biological diversity. Among other things, by highlighting various quality aspects in today's mainly volume-based forestry, but also by highlighting alternative livelihood opportunities in addition to traditional forestry* (Biosfärområde Voxnadalen, Juridisk Ovanåkers Kommun, 2020).

In these two cases, CS knowledge provided what we term input legitimacy to the monitoring and assessment of resources that was

used to justify the adoption of conservation measures. In other cases, legitimacy issues concerning CS play out in more diffuse ways. For example, when decision makers use the SSOS data in their daily work, data legitimacy depends to an important degree on personal contacts with the people responsible for the records, follow-ups with local experts, and the use of local metadata to evaluate the records. In other cases, as in the implementation of the Swedish Species Protection Ordinance (where European Union provisions on species protection are transposed), many participants have felt unsure of how to evaluate CS records in the legal terms of the ordinance. Thus, several experts have felt that though they are ecologists, they have to act as lawyers. This regulation has been tested by both the Siberian Jay *Perisoreus infaustus* case and the Witches Cauldron *Sarcosoma globosum* case. In both cases, legitimacy issues concerning the use of CS are central to the issues before the courts (Naturvårdsverket and Skogsstyrelsen, 2017; Sténs and Mårald, 2020). In these two cases the discussion centered around logging of forests where citizens have found protected species where logging was planned, and that information provided a justification to stop those planned loggings.

Our empirical analysis of the interactions between CS and environmental governance in the Gävleborg region shows that the use of knowledge produced to an important degree by CS through the SSOS is widely used in the region. This knowledge is also brought to bear at different points in local environmental governance. This can be understood as a case of data produced in participatory ways where CS provides input legitimacy. Yet, the assessment of the more general situation with forest resources in the region shows that despite the varied and extensive use of CS, serious problems persist since the national goals for the forest landscape are not being reached at the regional level (Gävleborg County, 2019b). In addition, the role of CS as valid knowledge has been questioned in a court decision on the national controversy concerning the Siberian Jay case where the Swedish forestry service did not authorize tree felling by private forest owners on their own property because CS had identified protected forest birds on that property. The controversy originated in planned logging activities in a municipality of the Gävleborg region and resulted in a ruling where an environmental court found that: *Information provided by private individuals can hardly be used as a basis for a decision to ban felling…* (Östersunds Tingsrätt, 2019).

As observed by several actors, a decision like this means an important barrier for CS becoming a more relevant input in sustainable forest management for the region, and possibly nationally (Roos et al., 2019). It was also argued during the public controversy concerning this case that the 2019 court judgment of that court (*Östersunds tingsrätt*) goes against a government policy that explicitly promotes the use of CS for EMA in Sweden. In 2020 a higher court (*Svea hovrätt*) overturned that first (2019) ruling. What we can observe here is an interesting case where the potential input legitimacy of CS promoted by the state is questioned by the judiciary. The analysis of the decisions by the different courts, along with the assessment of the Swedish Environmental Objective for sustainable forests, shows that the potential of CS in providing legitimacy for environmental governance and EMA in the region can also mean contestation about the quality of the data produced through CS. We can state from this that although CS has effectively provided more input legitimacy, there is an important gap in terms of output legitimacy concerning the management of forest resources.

6 Discussion: analyzing the link between citizen science and environmental communication across different geographical and socio-economic contexts

In comparison to other studies exploring the potential of CS in EMA (See for example Rathnayake et al., 2020), we have delved more deeply into the local contexts. These contexts both create and constrain the potential of CS to enhance the input legitimacy of EMA. We found that public participation can contribute to more democratic environmental governance in navigating conflicts and synergies between SDGs. The added legitimacy from CS could thus renew EMA as a force in transformative policy for sustainability in local rural settings. This focus on local contexts also shows that EC practices are a key aspect of how both at the micro land macro level of decision making, environmental governance is negotiated and often contested.

Compared to other recent contributions assessing the potential of scaling up CS in data production (see for example Maccani et al.'s, 2020, report to the European Commission), we have geographically expanded and conceptually strengthened the analysis of CS by conceiving of it as a democratic innovation underlying empowered participatory governance. In terms of democratic innovation and EC, CS is discussed below in light of the politics of CS, and how these politics interact with the current governance systems for implementing Agenda 2030 identified in our study cases. Thus, this article contributes to the literature on the potential of CS in relation to legitimacy issues and environmental justice (Dhillon, 2017) as well as in the context of forest landscapes (Hovis et al., 2020). As suggested in our cases, the communicative dimension of CS indicates that participation and engagement in CS shapes and is shaped by EC practices.

The analysis of the links between EC and CS has been done in two contrasting contexts for SDG implementation in forest settings, which raises important issues for discussing public participation in local environmental policy. In Chile, previous research has identified the difficulties for local governments to enforce environmental legislation where powerful forest companies operate (Gonzalez-Navarro et al., 2018). In Sweden, on the other hand, local challenges for SDG implementation are due to lack of local resources, lack of support from national authorities, and gaps in data about the use of local resources (Sánchez Gassen et al., 2018; Engström et al., 2019). In the following discussion, we add an EC perspective to the analysis of CS in the context of SDGs and the potential for scaling up CS in implementation of specific SDG targets (West, 2017), the effective transformation of EMA through CS (Conrad and Hilchey, 2011), and the usefulness of CS in relation to specific resources as well as specific SDGs (Njue et al., 2019; Quinlivan et al., 2020).

In both the Chilean and Swedish settings, the interrelations between the use of forests and other resources are key for navigating synergies and conflicts between SDG 15's different targets, and also other SDGs. In the case of Gävleborg in Sweden, the potential democratic innovation of CS in policy and governance arises from the already existing infrastructure for CS in the country. This currently offers knowledge for practical monitoring and assessment at local levels, and it brings input legitimacy to environmental governance at the regional level. There is in fact a cluster of knowledge where CS is

already present, most significantly, in the way the SSOS is used by different actors.

6.1 Citizen science as a democratic innovation and as a form of environmental communication

The potential of CS as a democratic innovation here has to do with how these data are recognized in institutional (local) contexts and manifested in local regulation. This is seen in various contexts as elements of participation or public engagement on an individual level or in more organized forms (NGOs, associations, clubs…). These empirical examples of participatory organizational arrangements illustrate conditions that enable the incorporation of CS into EMA. National funding given to regional actors, and the creation of a national infrastructure for making use of CS are two such "enabling" conditions for CS. Yet, this does not ensure that people get involved in decision making or the provision of data. A strong public interest in the issue (which is the case for biodiversity issues), a societal need for central storage of biodiversity data that is also available for personal use (e.g., storage of one's own data, interaction with likeminded people, education) and societal gains (e.g., conservation work), were key aspects in the bottom-up development of the SSOS and its integration with EMA in Sweden. Analyzing this in terms of EC practices indicates the key role of a bottom-up approach and public interest in data production as enablers of the incorporation of CS into environmental governance.

The emergent governance actions represented by the green infrastructure plan for Gävleborg is also conceived as contributing to the implementation of SDG15 in connection to biodiversity, water and rural development in the region. In this context, CS is already a vehicle for navigating the conflicts and synergies in the use of resources at the local scale. By enabling participation of a diverse group of local actors, including municipalities, NGOs and interest organizations in environmental governance, a multiplicity of local perspectives were surfaced by CS that added more input and legitimacy to decision-making.

Furthermore, the use of CS in Gävleborg shows the contextual specificity of learning processes for local actors and decision-makers through the combination of already existing governance mechanisms for the implementation of Agenda 2030 and the SDGs. Taken together, the different instances where CS is enacted in the region show a path to empowering actors to transform governance for a transition to sustainable local development. This can also serve to conceive the implementation of SDG15 as an EC process that can foster the participation and capacities of ordinary people in reason-based decision-making through action and discussion. This process, which is defined by Fung and Wright (2016) as empowered participatory governance, can counteract the current structural limits on accepting the legitimacy of CS when solving conflicts in the legal and judiciary arena.

It is still unclear, though, whether the CS-enhanced evidence base can overcome the problems facing the achievement of SDG15 targets at the regional level of Gävleborg. This is to an important extent a matter of CS getting immersed in conflict-filled contexts with diverging political interests concerning the use of forest resources. Furthermore, the challenges to attain objectives related to SDG15 can be related to goals conflicts relating to other SDGs. CS cannot escape from the politicization of the knowledge it produces. Yet to see CS as a democratic innovation and EC process supporting empowered participatory governance means to recognize that the input legitimacy created through CS knowledge cannot be analyzed without considering the politics of CS. This argument challenges traditional views of EMA as an apolitical process and calls for a more open discussion of the political processes involved in producing EMA data for the SDGs.

The politics of CS are also evident in Chile. Rural municipalities there lack resources to scale up participatory monitoring of resources and to contribute to EMA, but CS initiatives are seen as a means to overcome barriers standing in the way of a more empowered participatory governance. This would potentially allow a better recognition of the knowledge of marginalized rural people in the local decisions on resources. That could help empower both local inhabitants and municipalities in areas with growing power asymmetries concerning data production on water, forest and land resources. The inception phases of two relevant CS initiatives in the region show already that a more coherent and participatory EMA system is needed in Chile. The opportunity to advance such EMA arises from the recent recognition of serious flaws in the data produced for water and forest resources, including a lack of coordination between different actors producing data on these resources. Within this context, new discussions on local environmental governance are occurring where knowledge of the local CS initiatives is already bringing new political opportunities for greater input legitimacy in local environmental governance.

Taken together, these two cases show that CS holds promise as a democratic innovation to renew EMA. The strength of CS in co-producing knowledge is being incorporated into local government institutions in both regions. This helps strengthen the input and output legitimacy of EMA. This has the potential of not only improving the EMA evidence-base for SDG15, but can also serve to renew EMA systems more generally. Thus, CS is helping to overcome the legitimacy deficits of traditional EMA when contributing to social-ecological transformations in local forest settings such as those represented by the Gävleborg region in Sweden and the Ñuble region in Chile. In terms of environmental communication, the potential of CS to renew EMA lies in the paths CS open for empowering citizens, rural dwellers and rural communities not only in the generation of environmental data, but also in the engagement to produce knowledge that can politically influence environmental governance and policy.

6.2 Legitimacy and production of knowledge for local environmental policy

In the case of Chile, where there are clear legitimacy deficits in environmental governance and there is also little in the way of a unified EMA evidence base, the new CS initiates we have analyzed might be able to create grounds for implementing a more coherent and democratic EMA system. Yet, as our case also shows, CS in Chile is not a process of just getting data, as usually thought of in traditional EMA. Thus, to move toward a more legitimate EMA system in Chile, these novel CS initiatives and community involvement in participatory data production need to be coupled with local and regional changes in governance. Here, the politics of CS need to be understood as a situated process that responds to specific legitimacy deficits in local environmental governance where powerful actors, as for example, large forest corporations, produce and control important data on resources and also engage in EC.

The Swedish case is a cautionary tale though, since our analysis of CS paths in the Gävleborg region shows how even when there is a solid evidence base and a strong CS platform, key environmental goals concerning forest use have not been achieved after two decades of concerted efforts. Taking into account that Agenda 2030 has only 6 years left, with some SDG targets that should have been reached by 2020, there is a need to scale up participation in assessment processes and decision making to strengthen the legitimacy of the EMA evidence base concerning the use of forests. There is also a need for deeper political inclusion of CS knowledge in environmental governance.

Within this context, there are two fundamental problems that must urgently be addressed in the context of SDG implementation. The first is an issue of scale: achieving SDGs at the national level does not necessarily imply the realization of Agenda 2030 at the local level. Thus, the SDGs promise of "triple bottom line" benefits are jeopardized unless they are applied locally, with all the demands implied for an evidence-base to guide local transformative governance. The second problem is that Agenda 2030 is predicated on a data revolution, but it takes more than just data and indicators: these need to be considered legitimate by a diverse set of public and private stakeholders before they can be used to guide the implementation of the SDGs (Kasperowski and Hagen, 2022; Ekström, 2023). Even that, however, is not a guarantor of transformative change since public and private governance systems capable of using an evidence base to achieve the aspirations of Agenda 2030 are also needed. Thus, the key steps in renewing EMA for Agenda 2030 are first the creation of legitimacy, and then participatory policy processes that leverage knowledge from the evidence base into local, transformative change.

7 Conclusion

The comparative analysis of two case studies highlights the relevance of a combined analysis of citizen science (CS) and environmental communication (EC) processes in the context of public participation in environmental governance and policy. Our analytical and empirical approach has helped identify prospects to incorporate CS into EMA, and it also highlights the value of fostering CS as a democratic innovation and EC process for greater legitimacy for the evidence base needed by local actors to navigate SDG15 targets in rural settings. The detailed analysis of interactions between CS, EMA and SDG15 implementation in the two case studies revealed that political barriers stand in the way of CS realizing more of its potential contribution to more legitimate local governance regarding SDG15. By placing CS and EC into the wider governance context of regional politics and implementation of national policies concerning the use of resources, we have advanced an approach that acknowledges the politics surrounding CS adds and added an EC perspective to the understanding of CS. Such politics and EC processes are an important feature in the quest for legitimate and democratic resource governance in both Chile and Sweden.

We hope that this paper reveals the value of treating CS as a democratic innovation and as a form of EC when pursuing comparative research into the local interactions between power, democracy and governance underlying the achievement of SDGs in rural settings. We feel it is important to emphasize that our cases show that the national level implementation of the SDGs depends heavily on how local structures of power and EC practices in the governance of resources interact in context-specific ways. Furthermore, national policies for SDGs need to be analyzed with a clear focus on practical local action and contestation concerning the use of forests and other interconnected resources.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

CA-F: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. MJ: Conceptualization, Formal analysis, Investigation, Methodology, Writing – review & editing. TD: Conceptualization, Investigation, Methodology, Writing – review & editing. SG: Conceptualization, Investigation, Methodology, Writing – review & editing. LC-K: Conceptualization, Investigation, Methodology, Writing – review & editing. CM-H: Conceptualization, Investigation, Methodology, Writing – review & editing. NP: Conceptualization, Investigation, Methodology, Writing – review & editing. AR: Conceptualization, Investigation, Methodology, Writing – review & editing. TH-R: Conceptualization, Investigation, Methodology, Writing – review & editing. KB: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing, Resources.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This research was funded by FORMAS, grant number 2018-02341.

Acknowledgments

The authors thank fellow project participant Torbjörn Ebenhard, for leading the workshop and other project discussions. We also thank fellow project participant Daniela Manuschevich for inputs and discussions for a previous manuscript from which this paper draws from.

Conflict of interest

AR was employed by Greensway AB.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

Publisher's note

References

Alarcón, C. (2015). *Forests at the limits. Forestry, land use and climate change from political ecology and environmental communication perspectives: the case of Chile and Sweden*". Doctoral thesis no. 2015: 5, Faculty of Natural Resources and Agricultural Sciences, Swedish University of Agricultural Sciences.

Alarcón, C. (2019). Transforming wood energy in Sweden and Chile: climate change, environmental communication and a critical political ecology of international forestry companies. *Crit. Perspect. Int. Bus.* 16, 361–377. doi: 10.1108/cpoib-05-2018-0039

Alarcón Ferrari, C., Jönsson, M., Gebreyohannis Gebrehiwot, S., Chiwona-Karltun, L., Mark-Herbert, C., Manuschevich, D., et al. (2021). Citizen science as democratic innovation that renews environmental monitoring and assessment for the sustainable development goals in rural areas. *Sustain. For.* 13:2762. doi: 10.3390/su13052762

Andersson, K., Lawrence, D., Zavaleta, J., and Guariguata, M. R. (2016). More trees, more poverty? The socioeconomic effects of tree plantations in Chile, 2001–2011. *Environ. Manag.* 57, 123–136. doi: 10.1007/s00267-015-0594-x

Angelstam, P., Manton, M., Green, M., Jonsson, B.-G., Mikusiński, G., Svensson, J., et al. (2020). Sweden does not meet agreed national and international forest biodiversity targets: a call for adaptive landscape planning. *Landsc. Urban Plan.* 202:103838. doi: 10.1016/j.landurbplan.2020.103838

Artdatabanken. (2024). *Artdatabanken. Ett kunskapscentrum för arter och naturtyper SLU*. Available at: https://www.artdatabanken.se/ (Accessed February 12, 2024).

Artportalen. (2024). *Artportalen*. Available at: https://www.artportalen.se/ (Accessed February 12, 2024).

Bäckstrand, K. (2016). Multi-stakeholder partnerships for sustainable development: rethinking legitimacy, accountability and effectiveness. *Eur. Environ.* 2006, 290–306. doi: 10.1002/eet.425

Beron, K. J., Murdoch, J. C., and Vijverberg, W. P. M. (2003). Why cooperate? Public goods, economic power, and the Montreal protocol. *Rev. Econ. Stat.* 85, 286–297. doi: 10.1162/003465303765299819

Bertelsmann Stiftung and Sustainable Development Solutions Network. (2018). *Index and Dashboards Report*.

Besley, J. (2015). Making environmental communication work: creating useful guidance. *Environ. Commun.* 9, 398–403. doi: 10.1080/17524032.2015.1044006

Bexell, M. (2019). "Power and legitimacy" in *Routledge handbook of global sustainability governance.* eds. A. Kalfagianni, D. Fuchs and A. Hayden (Abingdon: Routledge), 13–25.

Biosfärområde Voxnadalen. (2024). *Unescoansökan*. Available at: https://www.ovanaker.se/boendeochmiljo/klimatochmiljo/biosfaromradevoxnadalen/publikationer/unescoansokan.2290.html (Accessed February 12, 2024).

Biosfärområde Voxnadalen, Juridisk Ovanåkers Kommun. (2020). *Biosfärområde Voxnadalen Utvecklingsplan 2020–2025*.

Bishop, K., and Jönsson, M. (2020). *Skogen och agenda 2030 med miljöanalys som verktyg. (forests and agenda 2030 with environmental monitoring and assessment as a tool, in Swedish). KSLA (Kungl. Skogs-och Lantbruksakademiens) Nytt 2020 4–5*.

Bowen, G. (2009). Document analysis as a qualitative research method. *Qual. Res. J.* 9, 27–40. doi: 10.3316/QRJ0902027

Braun, A. C., Troeger, D., Garcia, R., Aguayo, M., Barra, R., and Vogt, J. (2017). Assessing the impact of plantation forestry on plant biodiversity: a comparison of sites in Central Chile and Chilean Patagonia. *Glob. Ecol. Conserv.* 10, 159–172. doi: 10.1016/j.gecco.2017.03.006

Cifuentes-Croquevielle, C., Stanton, D. E., and Armesto, J. (2020). Soil invertebrate diversity loss and functional changes in temperate forest soils replaced by exotic pine plantations. *Sci. Rep.* 10:7762. doi: 10.1038/s41598-020-64453-y

Clarke, T., and Peterson, T. R. (2015). *Environmental conflict management*. Newcastle upon Tyne: Sage.

Comfort, S. E., and Park, Y. E. (2018). On the field of environmental communication: a systematic review of the peer-reviewed literature. *Environ. Commun.* 12, 862–875. doi: 10.1080/17524032.2018.1514315

Conrad, C. C., and Hilchey, K. G. (2011). A review of citizen science and community-based environmental monitoring: issues and opportunities. *Environ. Monit. Assess.* 176, 273–291. doi: 10.1007/s10661-010-1582-5

County Administrative Board in Gävleborg. (2014). *Länsprogram för regional miljöövervakning i Gävleborgs län 2015–2020*.

Cox, R. (2007). Nature's "crisis disciplines": does environmental communication have an ethical duty? *Environ. Commun.* 1, 5–20. doi: 10.1080/17524030701333948

Cox, R. (2010). *Environmental communication and the public sphere*. Newcastle upon Tyne: Sage.

Dhillon, C. M. (2017). Using citizen science in environmental justice: participation and decision-making in a Southern California waste facility siting conflict. *Local Environ.* 22, 1479–1496. doi: 10.1080/13549839.2017.1360263

Durán, A. P., and Barbosa, O. (2019). Seeing Chile's forest for the tree plantations. *Science* 365:1388. doi: 10.1126/science.aaz2170

Ekologigruppen AB. (2015). *Naturinventering vid Gavlehov, Gävle kommun*.

Ekström, B. (2023). Thousands of examining eyes: credibility, authority and validity in biodiversity citizen science data production. *Aslib J. Inf. Manag.* 75, 149–170. doi: 10.1108/AJIM-10-2021-0292

Enflo, K., and Rosés, J. R. (2015). Coping with regional inequality in Sweden: structural change, migrations, and policy, 1860–2000. *Econ. Hist. Rev.* 68, 191–217. doi: 10.1111/1468-0289.12049

Engström, R. E., Destouni, G., Howells, M., Ramaswamy, V., Rogner, H., and Bazilian, M. (2019). Cross-scale water and land impacts of local climate and energy policy–a local Swedish analysis of selected SDG interactions. *Sustain. For.* 11:1847. doi: 10.3390/su11071847

EULA-Chile. (2024). *Diagnóstico Plan de Gestión Reserva de La Biósfera Nevados de Chillán-Laguna del Laja*.

European Commission. (2013). *Communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions green infrastructure (GI)–Enhancing Europe's natural capital*.

Evans, K., Guariguata, M. R., and Brancalion, P. H. S. (2018). Participatory monitoring to connect local and global priorities for forest restoration. *Conserv. Biol.* 32, 525–534. doi: 10.1111/cobi.13110

Fähnrich, B., and Ruser, A. (2021). "Environmental communication and policymakers" in *Handbook of international trends in environmental communication*. eds. B. Takahashi, J. Metag, J. Thaker and S. E. Comfort (London: Routledge).

Faivre, N., Fritz, M., Freitas, T., de Boissezon, B., and Vandewoestijne, S. (2017). Nature-based solutions in the EU: innovating with nature to address social, economic and environmental challenges. *Environ. Res.* 159, 509–518. doi: 10.1016/j.envres.2017.08.032

FAO. (2020a). *Forest products trade*. Major exporters of forest products. (FAOSTAT-Forestry database).

FAO. (2020b). *Forest Resources Assessments 2020*. Country Reports. Available at: https://www.fao.org/forest-resources-assessment/fra-2020/country-reports/en/.

Fraisl, D., Campbell, J., See, L., Wehn, U., Wardlaw, J., Gold, M., et al. (2020). Mapping citizen science contributions to the UN sustainable development goals. *Sustain. Sci.* 15, 1735–1751. doi: 10.1007/s11625-020-00833-7

Fridman, J., Holm, S., Nilsson, M., Nilsson, P., Ringvall, A. H., and Ståhl, G. (2014). Adapting National Forest Inventories to changing requirements–the case of the Swedish National Forest Inventory at the turn of the 20th century. *Silva Fennica* 48, 1–29. doi: 10.14214/sf.1095

Fritz, S., See, L., Carlson, T., Haklay, M., Oliver, J. L., Fraisl, D., et al. (2019). Citizen science and the United Nations sustainable development goals. *Nat. Sustain.* 2, 922–930. doi: 10.1038/s41893-019-0390-3

Fung, A., and Wright, E. O. (2016). Deepening democracy: Innovations in empowered participatory governance. *Polit. Soc.* 29, 5–41. doi: 10.1177/0032329201029001002

Gävleborg County. (2016). *Inventering av ängssvampar i Gävleborgs län 2015*.

Gävleborg County. (2019a). *Gävleborg, Handlingsplan för grön infrastruktur*. Del 2: Kunskapsunderlag.

Gävleborg County. (2019b). *Årlig uppföljning av miljökvalitetsmålen i Gävleborg 2019*.

Gobierno Regional de Ñuble. (2020). *Estrategia Regional de Desarrollo de la Región de Ñuble 2020–2028*.

Gonzalez-Navarro, V., Tomei, J., and Flores-Oyarzo, G. (2018). Analysing the outcomes of the forestry sector on the sustainable development goals for rural communities: a case study of Cabrero, Chile. *J. Sustain. Dev.* 11, 194–211. doi: 10.5539/jsd.v11n5p194

Government of Chile. (2019). Voluntary National Reviews Chile. Sustainable Development Knowledge Platform.

Government of Chile. (2023). *Informe Nacional Voluntario sobre los Objetivos de Desarrollo Sostenible en Chile*. Sustainable Development Knowledge Platform.

Government of Sweden. (2017). *Voluntary National Reviews Sweden*. Sustainable Development Knowledge Platform.

Government of Sweden. (2021). *Report on the implementation of the 2030 agenda for sustainable development*. Sustainable Development Knowledge Platform.

Haklay, M. (2013). "Citizen science and volunteered geographic information: overview and typology of participation" in *Crowdsourcing geographic knowledge*. eds. D. Sui, S. Elwood and M. Goodchild (Berlin: Springer), 105–122.

Haklay, M. M., Dörler, D., Heigl, F., Manzoni, M., Hecker, S., and Vohland, K. (2021). "What is citizen science? The challenges of definition" in *The science of citizen science*. eds. K. Vohland, A. Land-Zandstra, L. Ceccaroni, R. Lemmens, J. Perelló and M. Ponti, vol. *13* (Berlin: Springer).

Hoover, E. (2020). "Whose citizenship in "citizen science"?: Tribal identity, civic dislocation, and environmental health research" in *Toxic Truths*. ed. E. Hoover (Manchester, England: Manchester University Press), 242–266.

Hovis, M., Cubbage, F., and Rashash, D. (2020). Designing a citizen science project for Forest landscapes: a case from Hofmann Forest in eastern North Carolina. *Open J. Forest.* 10, 187–203. doi: 10.4236/ojf.2020.102013

Jalbert, K., and Kinchy, A. J. (2016). Sense and influence: environmental monitoring tools and the power of citizen science. *J. Environ. Policy Plann.* 18, 379–397. doi: 10.1080/1523908X.2015.1100985

Jiménez-Aceituno, A., Peterson, G. D., Norström, A. V., Wong, G. Y., and Downing, A. S. (2020). Local lens for SDG implementation: lessons from bottom-up approaches in Africa. *Sustain. Sci.* 15, 729–743. doi: 10.1007/s11625-019-00746-0

Johansson, J., and Keskitalo, E. C. H. (2014). Coordinating and implementing multiple systems for forest management: implications of the regulatory framework for sustainable forestry in Sweden. *J. Nat. Resour. Policy Res.* 6, 117–133. doi: 10.1080/19390459.2014.913363

Jönsson, M., Kasperowski, D., Coulson, S. J., Nilsson, J., Bína, P., Kullenberg, C., et al. (2024). Inequality persists in a large citizen science programme despite increased participation through ICT innovations. *Ambio* 53, 126–137. doi: 10.1007/s13280-023-01917-1

Jordan, R. C., Ballard, H. L., and Phillips, T. B. (2012). Key issues and new approaches for evaluating citizen-science learning outcomes. *Front. Ecol. Environ.* 10, 307–309. doi: 10.1890/110280

Jurin, R., Roush, D., and Danter, J. (2010). *Environmental communication.: Skills and principles for natural resource managers, scientists, and engineers*. Berlin: Springer.

Kanazawa, M. (2017). *Research methods for environmental studies: A social science approach*. London, UK: Routledge.

Kasperowski, D., and Hagen, N. (2022). Making particularity travel: trust and citizen science data in Swedish environmental governance. *Soc. Stud. Sci.* 52, 447–462. doi: 10.1177/03063127221085241

Klöckner, C. A. (2015). *The psychology of pro-environmental communication: Beyond standard information strategies*. Berlin: Springer.

Klöckner, C., and Löfström, E. (2022). "What is disruptive communication, and why might it be necessary?" in *Disruptive environmental communication*. eds. C. A. Klöckner and E. Löfström (Berlin: Springer), 1–17.

Länsstyrelsen Gävleborg. (2022). *Grön infrastruktur*. Available at: https://www.lansstyrelsen.se/gavleborg/samhalle/planering-och-byggande/gron-infrastruktur.html (Accessed October 31, 2020).

Lavskrikan i Gävleborg med Artportalen. (2024). Available at: https://docplayer.se/48454394-Lavskrikan-i-gavleborg-med-artportalen.html (Accessed February 12, 2024).

LEADER Nedre Dalälven. (2015). *Final report from a project with support from LEADER Nedre Dalälven in the context of the regional landscape strategy*.

Lester, L. (2015). Three challenges for environmental communication research. *Environ. Commun.* 9, 392–397. doi: 10.1080/17524032.2015.1044065

Lindenfeld, L., Hall, D., McGreavy, B., Silka, L., and Hart, D. (2012). Creating a place for environmental communication research in sustainability science. *Environ. Commun.* 6, 23–43. doi: 10.1080/17524032.2011.640702

Liquete, C., Kleeschulte, S., Dige, G., Maes, J., Grizzetti, B., Olah, B., et al. (2015). Mapping green infrastructure based on ecosystem services and ecological networks: a Pan-European case study. *Environ. Sci. Pol.* 54, 268–280. doi: 10.1016/j.envsci.2015.07.009

Lorenz, L. (2020). Addressing diversity in science communication through citizen social science. *J. Sci. Commun.* 19:A04. doi: 10.22323/2.19040204

Maccani, G., Goossensen, M., Righi, V., Creus, J., and Balestrini, M. (2020). *Scaling up citizen science - what are the factors associated with increased reach and how to lever them to achieve impact*. Luxembourg: Publications Office of the European Union.

Maes, J., Barbosa, A., Baranzelli, C., Zulian, G., Batista, E., Silva, F., et al. (2015). More green infrastructure is required to maintain ecosystem services under current trends in land-use change in Europe. *Landsc. Ecol.* 30, 517–534. doi: 10.1007/s10980-014-0083-2

McDermott, C. L., Acheampong, E., Arora-Jonsson, S., Asare, R., Menton, M., Nunan, F., et al. (2019). "SDG 16: peace, justice and strong institutions–a political ecology perspective" in *Sustainable development goals: their impacts on forests and people*. eds. P. Katila, C. Pierce Colfer, W. de Jong, G. Galloway, P. Pacheco and G. Winkel (Cambridge, UK: Cambridge University Press).

McWethy, D. B., Pauchard, A., García, R. A., Holz, A., González, M. E., Veblen, T. T., et al. (2018). Landscape drivers of recent fire activity (2001-2017) in south-Central Chile. *PLoS One* 13:e0201195. doi: 10.1371/journal.pone.0201195

Mejlgaard, N., and Ravn, T. (2015). *Monitoring the evolution and benefits of responsible research and innovation (MoRRI)*. Analytical Report on the Dimension of Citizen Engagement and Participation of Societal Actors in Research and Innovation.

Ministerio de Agricultura de Chile. (2020). *SIMEF. Sistema de Monitoreo de Ecosistemas Nativos Forestales Nativos*.

Mittermeier, R., Gil, P., Hoffmann, M., Pilgrim, J., Brooks, T., Mittermeier, C., et al. (2004). *Hotspots revisited. Earth's biologically richest and Most endangered terrestrial ecoregions*.

Moser, S. (2015). "Prospects for a humanistic turn in environmental communication as the world changes darkly" in *The Routledge handbook of environment and communication*. eds. A. Hansen and R. Cox (London, UK: Routledge), 402–413.

Municipalidad de Cobquecura. (2014). *Municipal Development Plan (Plan de Desarrollo Comunal/PLADECO) 2014–2019*. Municipalidad de Cobquecura.

Municipalidad de San Fabián. (2016). *Municipal Development Plan (Plan de Desarrollo Comunal/PLADECO) 2016–2017*. Municipalidad de San Fabián.

Municipalidad de San Nicolas. (2007). *Municipal Development Plan Plan de Desarrollo Comunal/PLADECO 2008–2015*. Municipalidad de San Nicolas.

Naturskyddsföreningen Nordanstig. (2024). *Artskyddet i Sverige – rödlistning och fridlysning*. http://ns1.bergsjodata.com/naturskyddsforeningen/NATURKUNSKAP/Fridlysning/fridlysning.htm (Accessed February 12, 24).

Naturvårdsverket. (2009). *Åtgärdsprogram för sötgräs*. Naturvårdsverketr.

Naturvårdsverket and länsstyrelserna. (2004). *Skyddsvärda statliga skogar i mellersta Sverige*. Naturvårdsverket. Available at: https://www.naturvardsverket.se/vagledning-och-stod/skyddad-natur/skyddsvarda-statliga-skogar/#:~:text=Genom%20inventeringen%20identifierades%201%20078,ligger%20i%20de%20två%20länen. (Accessed April 5, 2024).

Naturvårdsverket and Skogsstyrelsen. (2017). *Gemensamma tolkning av bombmurkledomens konsekvenser för artskyddet*.

Nilsson, M. (2017). *Important interactions among the sustainable development goals under review at the high-level political forum 2017*. Stockholm Environment Institute. Working paper 2017–06.

Nilsson, M., Griggs, D., and Visbeck, M. (2016). Policy: map the interactions between sustainable development goals. *Nat. News* 534, 320–322. doi: 10.1038/534320a

Njue, N., Stenfert Kroese, J., Gräf, J., Jacobs, S. R., Weeser, B., Breuer, L., et al. (2019). Citizen science in hydrological monitoring and ecosystem services management: state of the art and future prospects. *Sci. Total Environ.* 693:133531. doi: 10.1016/j.scitotenv.2019.07.337

OECD (2014). *OECD environmental performance reviews*. Sweden: OECD.

OECD/ECLAC. (2016). *OECD Environmental Performance Reviews: Chile* 2016.

Official Statistics of Sweden. (2019). *Voluntary set-asides and forest land under forest management certification schemes*. https://www.skogsstyrelsen.se/en/statistics/subject-areas/voluntary-set-aside-and-certified-forest-area/#:~:text=According%20to%20the%20Swedish%20Forest,a%20plan%20or%20other%20document. (Accessed April 5, 2024).

Östersunds Tingsrätt. (2019). *Dom Mål nr M 2163–18 Mark-och miljödomstole*.

Peterson, J. D., Kasperowski, D., and van der Wal, R. (2023). Bringing together species observations: a case story of Sweden's biodiversity informatics infrastructures. *Minerva* 61, 265–289. doi: 10.1007/s11024-023-09491-2

Peterson, N., Peterson, M. J., and Rai Peterson, T. (2007). Environmental communication: why this crisis discipline should facilitate environmental democracy. *Environ. Commun.* 1, 74–86. doi: 10.1080/17524030701334292

Quinlivan, L., Chapman, D. V., and Sullivan, T. (2020). Applying citizen science to monitor for the sustainable development goal Indicator 6.3. 2: a review. *Environ. Monit. Assess.* 192, 1–11. doi: 10.1007/s10661-020-8193-6

Ranacher, L., Lähtinen, K., Järvinen, E., and Toppinen, A. (2017). Perceptions of the general public on forest sector responsibility: a survey related to ecosystem services and forest sector business impacts in four European countries. *Forest Policy Econ.* 78, 180–189. doi: 10.1016/j.forpol.2017.01.016

Rathnayake, C., Joshi, S., and Cerratto-Pargman, T. (2020). Mapping the current landscape of citizen-driven environmental monitoring: a systematic literature review. *Sustainability* 16, 326–334. doi: 10.1080/15487733.2020.1829845

Region Gävleborg. (2013). *Regional utvecklingsstrategi för Gävleborg 2013–2020*.

Region Gävleborgs. (2019). *Regional utvecklingsstrategi för Gävleborgs län 2020–2030*. Remissförslag.

Robinson, L. D., Cawthray, J. L., West, S. E., Bonn, A., and Ansine, J. (2018). "Ten principles of citizen science" in *Citizen science: innovation in open science, society and policy*. eds. S. Hecker, M. Haklay, A. Bowser, Z. Makuch, J. Vogel and A. Bonn (London: UCL Press), 27–40.

Roos, S., Skarp, L. S., Svensson, M., and Tranvik, L. (2019). *Domstol underkänner ideella naturvårdens trovärdighet*. Available at: https://www.dn.se/debatt/domstol-underkanner-ideella-naturvardens-trovardighet/.

Sachs, J. D., Lafortune, G., Fuller, G., and Drumm, E. (2023). *Implementing the SDG stimulus. Sustainable development report 2023. Paris: SDSN*. Dublin: Dublin University Press.

Sánchez Gassen, N., Penje, O., and Slätmo, E. (2018). *Global goals for local priorities: the 2030 agenda at local level*. Nordregio.

SEIA Chile. (2020a). *Ficha del Proyecto: Línea de transmisión 1x220 kV Punilla - San Fabián*. Available at: https://seia.sea.gob.cl/expediente/ficha/fichaPrincipal.php?modo=normal&id_expediente=2132497539 (Accessed April 5, 2024)

SEIA Chile. (2020b). *EIA proposal*. Available at: https://seia.sea.gob.cl/expediente/ficha/fichaPrincipal.php?modo=normal&id_expediente=2132497539 (Accessed April 5, 2024)

Senecah, S. (2004). "The trinity of voice: the role of practical theory in planning and evaluating the effectiveness of environmental participatory processes" in *Communication and public participation in environmental decision making*. eds. S. P. Depoe, J. W. Delicath and M. F. Aepli Elsenbeer (Albany: State University of New York Press), 13–33.

Sistema Integrado de Monitoreo de Ecosistemas. (2024a). *Ciencia Ciudadana*. Available at: http://cienciaciudadana.cl/project/simef/ (Accessed April 5, 2024).

Sistema Integrado de Monitoreo de Ecosistemas. (2024b). *Monitoreo Participativo SIMEF*. iNaturalist. Available at: https://www.inaturalist.org/projects/monitoreo-participativo-simef (Accessed April 5, 2024).

Sistema Integrado de Monitoreo de Ecosistemas. (2024c). *Biodiversidad Reserva de la Biosfera Ñuble*. Available at: https://www.inaturalist.org/projects/biodiversidad-reserva-de-la-biosfera-nuble-simef (Accessed April 5, 2024).

Smith, G. (2009). *Democratic innovations: Designing institutions for citizen participation*. Cambridge, UK: Cambridge University Press.

Sténs, A., and Mårald, E. (2020). "Forest property rights under attack": actors, networks and claims about forest ownership in the Swedish press 2014–2017. *Forest Policy Econ.* 111:102038. doi: 10.1016/j.forpol.2019.102038

Sténs, A., Roberge, J.-M., Löfmarck, E., Beland Lindahl, K., Felton, A., Widmark, C., et al. (2019). From ecological knowledge to conservation policy: a case study on green tree retention and continuous-cover forestry in Sweden. *Biodivers. Conserv.* 28, 3547–3574. doi: 10.1007/s10531-019-01836-2

Sténs, A., and Sandström, C. (2014). Allemansrätten in Sweden: a resistant custom. *Landscapes* 15, 106–118. doi: 10.1179/1466203514Z.00000000029

Sustainable Development Solutions Network. (2015). *Indicators and a monitoring framework for the sustainable development goals*. Launching a data revolution for the SDGs.

Sustainable Development Solutions Network. (2018). *SDG index and dashboards 2018*. Available at: https://www.sustainabledevelopment.report (Accessed October 31, 2020).

Svenska Kraftnät. (2012). *Förlängning av koncession 220 kv kraftledning stadsforsen - hölleforsen - untra*.

Swedish Environmental Protection Agency. (2009). *Åtgärdsprogram för sötgräs 2009–2013 (Cinna latifolia), Rapport 5988, Juni 2009*. (Naturvårdsverket).

Timko, J., Le Billon, P., Zerriffi, H., Honey-Rosés, J., de la Roche, I., Gaston, C., et al. (2018). A policy nexus approach to forests and the SDGs: tradeoffs and synergies. *Curr. Opin. Environ. Sustain. Sustain. Sci.* 34, 7–12. doi: 10.1016/j.cosust.2018.06.004

Turreira-García, N., Lund, J. F., Domínguez, P., Carrillo-Anglés, E., Brummer, M. C., Duenn, P., et al. (2018). What's in a name? Unpacking "participatory" environmental monitoring. *Ecol. Soc.* 23:224. doi: 10.5751/ES-10144-230224

United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development, a/RES/70/1*. United Nations.

United Nations Environment Programme (2019). *Guidelines for conducting integrated environmental assessments*. Nairobi, Kenya: United Nations Environment Programme.

United Nations Treaty Collection. (2024a). *Aarhus convention*. Available at: https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-18&chapter=27&clang=_en (Accessed April 5, 2024).

United Nations Treaty Collection. (2024b). *Escazú Agreement*. Available at: https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-18&chapter=27&clang=_en (Accessed April 5, 2024).

Volten, H., Devilee, J., Apituley, A., Carton, L., Grothe, G., Keller, C., et al. (2018). "Enhancing national environmental monitoring through local citizen science" in *Citizen science: Innovation in Open Science, Society and Policy*. eds. S. Hecker, M. Haklay, A. Bowser, Z. Makuch, J. Vogel and A. Bonn (London: UCL Press).

Walker, G. (2007). Public participation as participatory communication in environmental policy decision-making: from concepts to structured conversations. *Environ. Commun.* 1, 99–110. doi: 10.1080/17524030701334342

Walker, G., and Daniels, S. (2019). Collaboration in environmental conflict management and decision-making: comparing best practices with insights from collaborative learning work. *Front. Commun.* 4:2. doi: 10.3389/fcomm.2019.00002

West, S. (2017). *How could citizen science support the sustainable development goals?* Sweden: Stockholm Environment Institute.

World Bank (2020). *Chile Forest note*. Washington, DC: World Bank.

Zikargae, M. H. (2018). Analysis of environmental communication and its implication for sustainable development in Ethiopia. *Sci. Total Environ.* 634, 1593–1600. doi: 10.1016/j.scitotenv.2018.04.050