

Participation and transdisciplinarity in Ecohealth: a social network analysis perspective

Participação e transdisciplinaridade em Ecosaúde: a perspectiva da análise de redes sociais¹

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Abstract

Ecohealth uses participatory and transdisciplinary approaches to understand the relationships between the components of socio-ecological systems and how these interactions influence the health of human populations. This article aims to use Social Network Analysis (SNA) to understand the role of collaborative relationships between the various actors involved in participatory and transdisciplinary processes in Ecohealth projects. We present a set of SNA indicators to characterize the evolution and equity of participation and to differentiate inter- and transdisciplinarity. The analysis was based on the collaboration network among the members of the Iniciativa Para el Liderazgo y Desarrollo del Campo de Ecosalud y Enfermedades Transmitidas por Vectores (ETV) en América Latina y el Caribe. The participatory process intensified throughout the project, with more individuals involved and increasing collaborations. Cooperation between members from social, environmental, and health sciences is unbalanced and health scientists predominate. The few environmental scientists are, however, actively involved in interdisciplinary collaborations. The proposed approach has wide application to study participation and transdisciplinarity in projects about health and environment.

Keywords: Social Network Analysis; Ecohealth; Participation; Interdisciplinarity; Transdisciplinarity.

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Resumo

A Ecosaúde usa abordagens participativas e transdisciplinares com o intuito de compreender as inter-relações entre os componentes dos sistemas socioecológicos e como estas interações influenciam a saúde das populações humanas. O objetivo do artigo é usar a Análise de Redes Sociais (ARS) para entender o papel das relações de colaboração entre os diversos atores envolvidos nos processos participativos e transdisciplinares em projetos de Ecosaúde. Apresentamos um conjunto de indicadores de ARS para caracterizar a evolução e a equidade de participação e diferenciar a inter e a transdisciplinaridade. A análise foi feita com base na rede de colaboração entre os atores da Iniciativa de Liderança em Ecosaúde para as Doenças Transmissíveis por Vetores (ETV) na América Latina e Caribe. O processo participativo ficou mais intenso ao longo do projeto, com mais sujeitos envolvidos e um número crescente de colaborações. A cooperação entre os atores das ciências sociais, ambientais e da saúde é pouco equitativa; assim, predominam as ciências da saúde. Os poucos cientistas ambientais presentes estão, porém, ativamente envolvidos em colaborações interdisciplinares. A abordagem tem aplicação ampla para estudar a participação e a transdisciplinaridade em projetos sobre saúde e meio ambiente.

Palavras-chave: Análise de Redes Sociais; Ecosaúde; Participação; Interdisciplinaridade; Transdisciplinaridade.

Introduction

The complex interactions and feedback between human activities and the changes in ecosystems and climate are increasingly standing out as determining factors of individual and collective risks to population health (Watts *et al.*, 2017). Ecosystem approaches in human health, here called Ecohealth, focus on participatory and transdisciplinary aspects to understand the interrelations between the various components of socioecological systems and how these interactions influence the health of human populations (Lebel, 2003). In Ecohealth research, participatory processes contribute to identify research objectives relevant for society and to promote solutions adapted to the social and environmental contexts of affected populations (Charron, 2012). A transdisciplinary approach creates new knowledge from a dialogue between academic knowledge and knowledge of local actors (Méndez; Abrahams; Riojas, 2016; Weihs; Mertens, 2013). Participation and transdisciplinarity are therefore anchored in collaborative processes in which men and women from communities, various social groups, governments, or enterprises as well as researchers from various disciplines can dialogue, exchange information, share resources, and cooperate with each other (Charron, 2012; Gómez; Minayo, 2006; Saint-Charles *et al.*, 2014). Studying collaborative processes among the various actors involved thus allows characterizing and evaluating participation and transdisciplinarity.

This article aims to examine the contributions of Social Network Analysis (SNA) in the understanding of the role of collaborative relationships in participatory and transdisciplinary processes in Ecohealth projects. The study is structured as follows: first, we present a brief review of the conceptual and methodological framework of SNA and its application to the analysis collaborative relationships. Next, we present and develop a proposal to use SNA to characterize participatory and transdisciplinary processes in Ecohealth projects. For this, we have identified a set of SNA measures that can be used as indicators. Finally, we illustrate

our proposal with a case study in which we used SNA to characterize collaboration networks within the group of actors involved in an Ecohealth project.

Social network analysis

SNA is a conceptual and methodological approach that aims to explain the role of relationships and their structural patterns on individual and collective behaviors (Marin; Wellman, 2010). The foundation of SNA theories is that individual positions and relational patterns in social networks are essential to understand social life. SNA is based on empirical studies that integrate two categories of data: (1) attributive data, which correspond to the characteristics of individuals, such as gender, age, socioeconomic status, academic discipline, professional activity, etc.; and (2) relational data, which allow characterizing ties between people, such as contact, information exchange, collaboration, trust, friendship, kinship, etc. (Scott, 2012). Relational data are essential in SNA since they reveal the interaction pattern between individuals.

SNA has been widely used in several areas of knowledge to explain social phenomena, such as the generation of knowledge in organizations, health promotion, community mobilization, access to the labor market, and the dissemination of innovations, among others (Marin; Wellman, 2010). At the individual level, SNA allows studying how changes in knowledge, attitudes, and behaviors are related to the social structures in which individuals are embedded (Aboim, 2011; Perkins; Subramanian; Christakis, 2015); at the community level, the study of the interaction patterns between members of the social group allows understanding processes such as collective action, the generation of consensus, the emergence of conflicts, or the dynamics of governance systems (Borgatti *et al.*, 2009).

SNA's characterization of collaborative networks has significantly advanced knowledge on diverse topics such as environmental governance (Bodin, 2017), the role of natural resource management in food security (Mertens *et al.*, 2015), health prevention (Triana *et al.*, 2016), community-based tourism

(Burgos; Mertens, 2017), scientific collaboration (Newman, 2001), or academic team performance (Li *et al.*, 2018). SNA also studies the collaborative production of inter- or transdisciplinary knowledge, examining co-authorship relationships in scientific articles (Rafols; Meyer, 2010) or academic production in journals (Leydesdorff, 2007). It is also used to understand the role of collaboration networks in participatory and transdisciplinary processes in research projects (Haines; Godley; Hawe, 2011).

SNA to study participation and transdisciplinarity in Ecohealth

Ecohealth emerged from a dialogue between classical research in environmental health and participatory action-research, incorporating participation and transdisciplinarity as fundamental principles from the first stages of its conceptual and methodological formulation (Forget; Lebel, 2001; Gómez; Minayo, 2006). Examining Ecohealth projects with SNA lens allows focusing on collaborative research processes. The SNA perspective analyzes participation and transdisciplinarity from the involvement of several categories of actors in collaborative networks that aim to generate knowledge and develop actions to improve human health and ensure the sustainability of ecosystems.

Two of the characteristics of collaborative networks stand out in studies: evolution of and equity in participation. Studying the evolution of participation throughout the research process is relevant since the various categories of actors have different roles in each phase of the research: from identifying the problem to formulating objectives, collecting and analyzing data, interpreting results, and implementing solutions (Mertens *et al.*, 2005). As an example, when communities participate in the project from the beginning, with an approach that facilitates a collaborative practice over a merely instrumental participation (Arnstein, 2019), this increases the chances of developing studies that consider the priorities and interests of populations affected by health problems (Charron, 2012). The participation of actors from organized civil society

and the public sector throughout the research increase the likeliness of generating knowledge usable in the formulation and implementation of public policies (Charron, 2012).

The participatory research approach of Ecohealth, however, is overall more time-consuming than in non-participatory research, as it faces challenges such as overcoming divergent interests among actors and developing collaborations between actors from various jurisdictional levels (Charron, 2012). Moreover, the involvement level of actors in participatory processes can vary widely during the various phases of research - from a consultative approach in which actors merely provide information to a collaborative practice in which communities, administrators, and researchers cooperate in research and share decision-making power (Mertens *et al.*, 2005). Participation is therefore a dynamic process that evolves during the research process. SNA offers tools to analyze the evolution of the participation of the categories of actors in the important moments of research and to help differentiate these levels of participation.

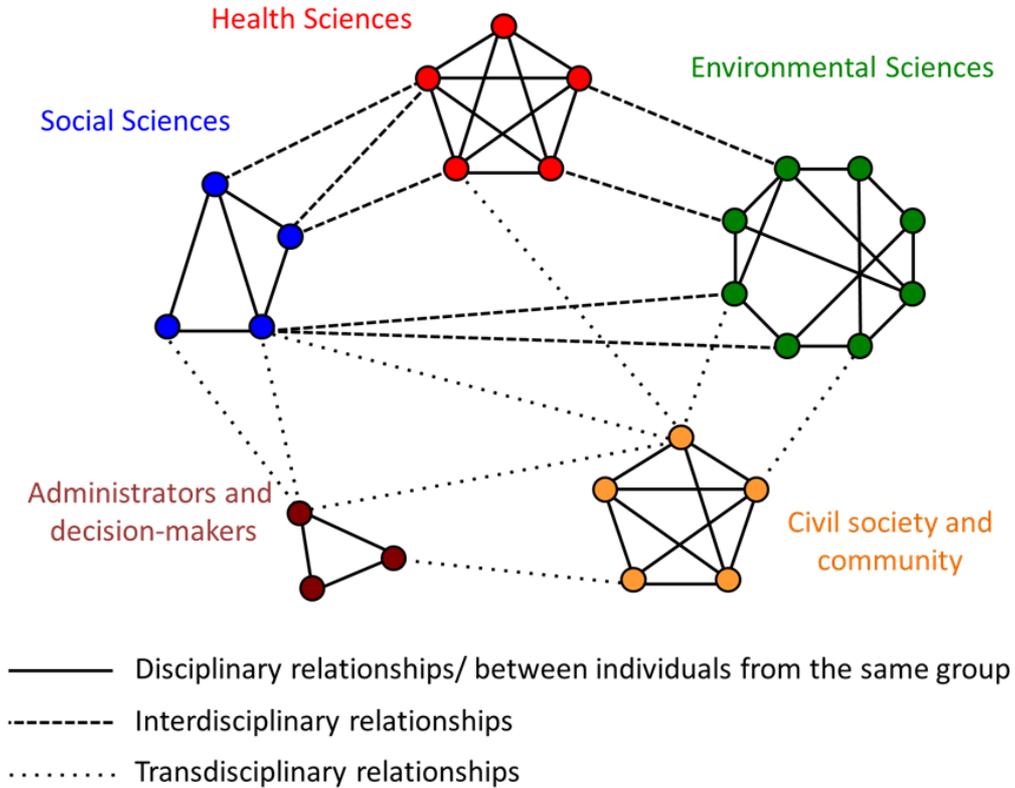
The consideration of equity in participation among the several categories of actors in the research process is also significant in Ecohealth (Lebel, 2003). A recurring risk of research projects that seek to improve the living conditions of populations is for development actions to favor certain social groups (Forget; Lebel, 2001). Despite achieving results globally positive for the community, projects can increase inequalities between those actively involved in the participatory process and those distant from, especially if the process does not promote structural changes (Dakubo, 2010). As an example, empowering women in agricultural activities without also addressing gender relations can result in work overload, with women adding activities in the field to their activities at home or in family health (Saint-Charles *et al.*, 2012). Thus, projects that seek inclusive and balanced participation of men and women, as well as various social groups are more likely to distribute research benefits equally among participants (Brisbois *et al.*, 2017; Mertens *et al.*, 2005). Furthermore, with an equitable participation among researchers, community members, and administrators, research results are more likely to generate knowledge which responds to the concerns

and priorities of the various actors and can be used to formulate public policies (Burgos; Mertens, 2017). As we will see, SNA offers great potential to help understand how collaboration relationships between social groups are distributed and to analyze participation in the research process.

Transdisciplinarity involves the creative process used to achieve integrative knowledge from a systemic perspective on a socially relevant issue (Pohl, 2011). Two levels can be differentiated: the first, often called interdisciplinarity, is based on research practices that seek to integrate data, methods, tools, concepts, and theories of different disciplines to study and understand a complex problem that cannot be apprehended satisfactorily from purely disciplinary perspectives (Wagner *et al.*, 2011). The second level surpasses the disciplinary paradigm and proposes the integration between scientific knowledge and other knowledges, usually defined as popular, community, local, or indigenous (Kötter; Balsiger, 1999; Méndez; Abrahams; Riojas, 2016; Wagner *et al.*, 2011). In this case, the generation of knowledge is anchored in a collaborative process involving scientists from various disciplines and non-academic actors, such as members of civil society, political sectors, and communities. This integration between forms of knowledge can create a shared view of the world and consensual solutions to the identified problems (Méndez; Abrahams; Riojas, 2016). To differentiate the two levels of transdisciplinarity in this study, we will call the first interdisciplinarity and the second transdisciplinarity.

Figure 1 represents a collaborative network that shows how SNA allows differentiating the relationships involved in processes of disciplinary, interdisciplinary, and transdisciplinary knowledge generation. Disciplinary relationships are those between researchers of the same discipline or between individuals from the same group of knowledge generation, such as administrators or communities and other actors of civil society. The approach also allows characterizing the interdisciplinary relations between academic actors from different disciplines and the transdisciplinary relations between academic actors and members of other knowledge generation groups.

Figure 1 – Representation of a collaborative network showing processes of disciplinary, interdisciplinary, and transdisciplinary knowledge generation



SNA indicators to characterize participation and transdisciplinarity

Chart 1 shows eight SNA measures that can be used as indicators to characterize patterns of collaboration between actors. For each indicator, we present the definition of the measure and its application to examine participation and transdisciplinarity in Ecohealth projects.

Network size (indicator 1) can be measured throughout the research to monitor the evolution of the number of individuals involved in the participatory process. Actors can also be characterized with attributes that define categories relevant to understand the participatory process, such as their area of activity (academia, community, civil society, political sector, etc.), social group in the community

(gender, professional activity, religious affiliation, associativism, etc.), or level of administrative or judicial organization (municipal, state, national, international). Indicator 2 - the diversity of groups of actors - allows verifying if the several categories of individuals included in the participatory process are effectively collaborating within the project. The average number of relationships per individual (indicator 3) can be used to track the intensity of the collaborative process among group members. The number of components, that is, the number of disconnected subgroups and isolated individuals (indicator 4), permits to characterize the fragmentation of the collaboration network. The relative size of the groups of actors (indicator 5) allows assessing the balance between the presence of the various categories in the project. The distribution

of the number of relationships of individuals (indicator 6) allows characterizing equity in the distribution of collaboration relationships among network members, verifying if all participants have around the same number of collaborations or if some individuals centralize most of these relationships. The average number of relationships between individuals in the same group (indicator 7) and from different groups (indicator 8) allow characterizing the equity of participation at the level of the groups of actors. Balance between the average number of relationships within groups and between them indicates a horizontal process of participation. Imbalance in the distribution of collaborative relationships indicates a non-equitable participatory

process, in which some groups are dominant and can control collaborative action whereas others are on the sidelines or isolated. Indicators 7 and 8 can also differentiate the processes of disciplinary, interdisciplinary, and transdisciplinary knowledge generation. Indicator 7 allows quantifying the relationships between researchers of the same discipline or between individuals from the same group of knowledge generation, such as decision makers or communities. Indicator 8 quantifies the interdisciplinary relationships between academic actors from different disciplines and the transdisciplinary relationships between academic actors and members of other knowledge generation groups.

Chart 1 – Indicators of participation and transdisciplinarity in collaboration networks in Ecohealth projects

Indicator	Measure definition according to SNA	Interpretation and application in Ecohealth projects
1 Network size	Number of individuals in the study population.	This indicator can be used to assess whether the number of individuals involved in the participatory process of collaboration changes during the research.
2 Diversity of groups of actors	Number of groups of individuals. Groups are defined according to attributes shared by their members. The attributes used to determine the groups must be defined according to the relevant theoretical framework and the objectives of the study. If the study focuses on transdisciplinary collaboration, for example, groups of actors will be defined according to their academic disciplines as well as other forms of knowledge.	The diversity of groups of actors is positively associated with participation and transdisciplinarity. The greater the diversity of these groups in the collaboration network, the greater the representativeness of the various interests and priorities in the participatory process and the more disciplines and knowledge involved in the transdisciplinary process.
3 Average number of relationships per individual	Total number of relationships in the network, divided by the total number of individuals.	A high average number of relationships per individual indicates a more intense collaborative process. It indicates strengthening of the collaborative process.
4 Number of components and isolated individuals	Number of components, that is, groups of individuals connected directly or indirectly by other individuals. If the network has multiple components, it is considered fragmented. The component has a minimum size of two individuals. Isolated individuals are those without any relationship.	Negatively associated with collaborative participation and transdisciplinarity. To participate in the collective collaborative process, the several groups of actors must be connected. A fragmented network and/or with many isolated individuals represents a fragile collaboration.
5 Relative size of groups of actors	Number of individuals in different groups (defined according to certain attributes), divided by the total number of individuals in the network.	A homogeneous distribution of group sizes indicates equity of participation in the collaborative process. A heterogeneous distribution indicates that one or a few groups may be controlling the collaboration process. Balance between the sizes of the groups of actors of various disciplines and knowledge should favor the transdisciplinary collaborative process.

continue...

Chart 1 – Continuation

Indicator	Measure definition according to SNA	Interpretation and application in Ecohealth projects
6 Distribution of the number of relationships of individuals	The distribution of the number of relationships is defined as the relative frequency of individuals with 0, 1, 2, 3, etc. relationships, that is, the number of individuals with one count of relationships divided by the total number of individuals in the network.	A homogeneous distribution of the number of relationships, in which most individuals have a similar number of collaborative relationships, is an indicator of a horizontal collaborative process, in which the various actors can contribute to knowledge generation. A heterogeneous distribution of the number of relationships, in which most individuals have few relationships and few individuals have many relationships, is an indicator of a hierarchical and centralized collaborative process, in which some actors can control and direct knowledge generation.
7 Average number of bonding ties per individual	Bonding ties are the links between individuals in the same group (defined according to certain attributes). These relationships are generally associated with trust and reciprocity, favor the establishment of shared norms, and increase the ability to reach consensus and manage conflicts. The average number of bonding ties is estimated between the individuals belonging to each group.	In transdisciplinary research, bonding ties correspond to collaboration between academics of the same discipline or between actors of the same category, such as the public sector or civil society. These relationships are relevant because quality transdisciplinary research is anchored in the disciplinary roots of each researcher involved in the process. Bonding ties allow each group to develop their own knowledge. However, a very high density of ties can also homogenize views and isolate and place groups in rigid positions.
8 Average number of bridging ties per individual	Bridging ties are links between individuals of different groups (defined according to certain attributes). These relationships are generally associated with new opportunities, facilitating access to innovative ideas, favoring dialogue between different perspectives, and increasing the mobilization of resources not available in the group. The average number of bridging relationships per individual is estimated relative to each of the other groups separately.	Indicator positively associated with transdisciplinarity. Bridging relationships correspond to collaborative relationships between researchers from different disciplines and non-academic actors, such as members of civil society, the community, or the public sector. These relationships favor mutual learning and the integration of knowledge around multidimensional problems. They favor the generation of research results which are relevant to society and more easily translated into concrete actions.

Case study: the EcoSaludETV project

To illustrate the application of SNA to the study of collaborations between actors involved in Ecohealth projects, we chose the *Iniciativa Para el Liderazgo y Desarrollo del Campo de Ecosalud y Enfermedades Transmitidas por Vectores en América Latina y el Caribe*, or EcoSaludETV project (Ecohealth Field Building Leadership Initiative For Vector-Borne Diseases in Latin America and the Caribbean). This initiative, developed from 2010 to 2015, aimed to form a strategic alliance between actors and institutions in Latin America and the Caribbean to develop the Ecohealth approach for prevention and control of vector-borne diseases. The project sought the integrated management of

ecosystems and developed activities around four axes of action: education, training, research, and social participation.

A longitudinal study was carried out to characterize the evolution of collaborative relationships between project participants and to understand how the observed collaborative patterns could explain the barriers and opportunities of the project. Attributes and relational data were collected by questionnaires sent by email to all project participants in 2011, 2012, 2013, and 2014. The questionnaires included questions about: (1) individual characteristics of the participants, such as gender, age, language spoken in the work environment, academic background, sector and level of professional activity, among others;

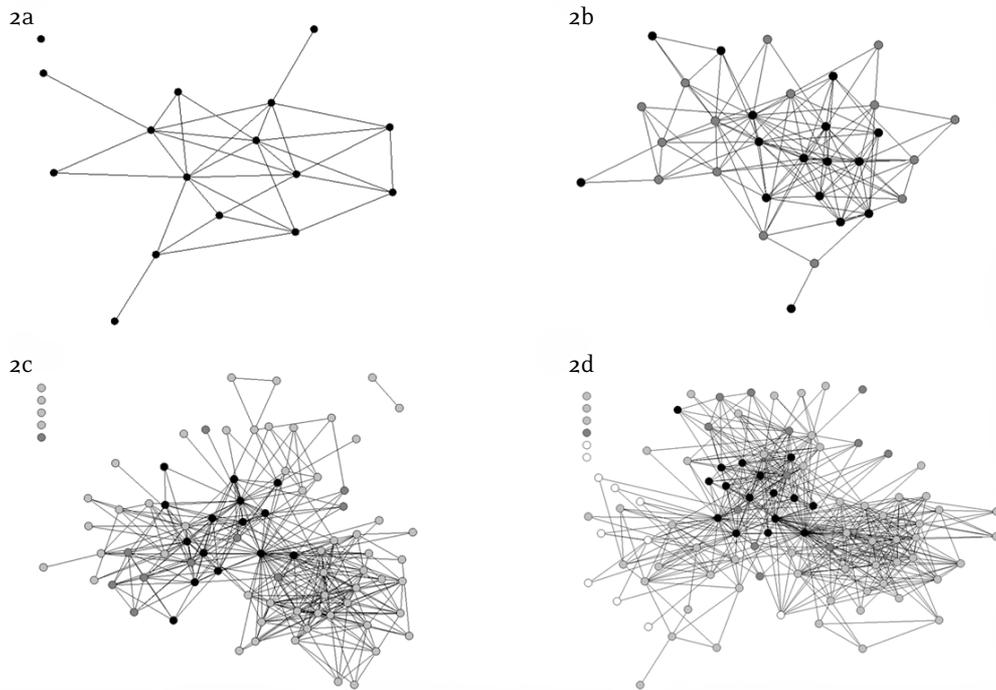
(2) the collaborative relationships they established during the development of the project activities. Collaboration among the members of the initiative was defined as: the joint development of professional and/or work activities, such as collaboration in research projects; health intervention and promotion activities; organization of events or courses; co-guidance of students; or co-authorship of academic publications. The analyses considered only

reciprocal collaboration relationships, that is, when both participants indicated that they collaborate with each other.

The evolution of participation

Figure 2 presents the evolution of the collaboration network among the members of the EcoSaludETV project in 2011, 2012, 2013, and 2014.

Figure 2 – Evolution of the collaboration network among the members of the EcoSaludETV Initiative



Legend: Collaboration network in 2011 (a), 2012 (b), 2013 (c), and 2014 (d). Participants are identified with shades of gray according to the year in which they became involved in the project, i.e. in 2011 (black), 2012 (dark gray), 2013 (light gray), or 2014 (white).

Table 1 shows the evolution of the values of indicators 1-4 over the same period. Regarding the diversity of groups of actors (indicator 2), several attributes can be used to map the diversity of the research participants. The example chosen here is the professional practice sector of the actors. The set of indicators used shows the collaborative

process in which an increasing number of actors participate (indicator 1) and which has a progressive diversification of the sectors involved (indicator 2) and increased intensity of collaboration over time (indicator 3). Indicator 4 shows that despite increasing, the network keeps most actors connected to each other.

Table 1 – Characterization of the evolution of participation among the actors of the EcoSaludETV project

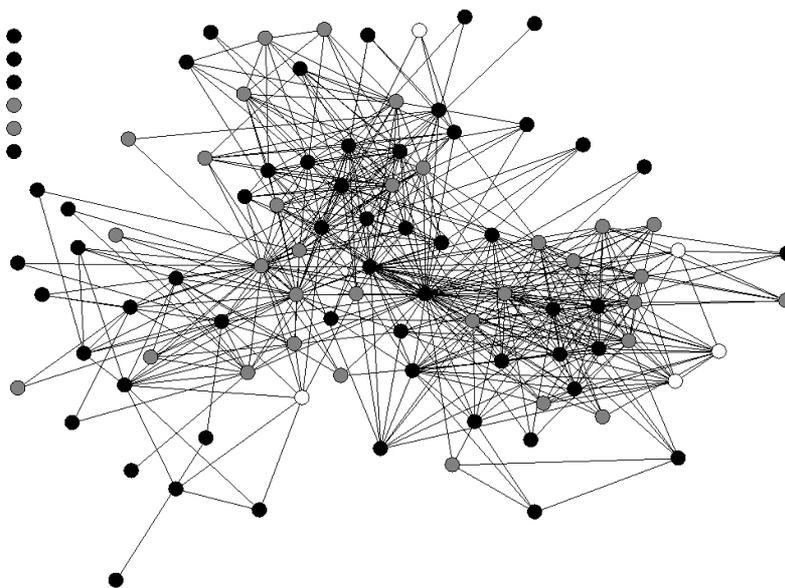
Characteristics of the collaboration network	Data collection year			
	2011	2012	2013	2014
Network size (indicator 1)	16	31	84	98
Diversity of groups of actors* (indicator 2)	3	4	5	5
Average number of relationships per individual (indicator 3)	4.1	8.3	9.1	10.9
Number of components (indicator 4)	1	1	2	1
Number of isolated individuals (indicator 4)	1	0	5	6

* The diversity of the groups of actors was assessed regarding participants' professional sector: academic, public, private, civil society, community.

Equity of participation

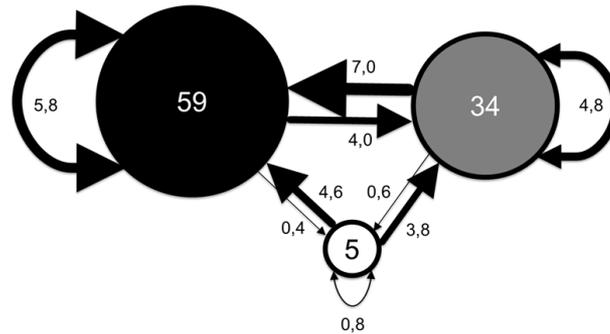
Figure 3a presents the collaboration mapped in 2014 among the actors of the EcoSaludETV project, identified according to their academic

area: health, social, and environmental sciences. In Figure 3b, actors from the same academic area were grouped together to estimate the average number of relationships within and between groups.

Figure 3a – Collaboration network between the members of the EcoSaludETV Initiative in 2014

Legend: Participants are identified with colors according to each academic area: health sciences (black), social sciences (dark gray), and natural sciences (white).

Figure 3b – Map of the aggregated collaborations between participants in health, social, and natural sciences



Legend: The figure uses the same color code as Figure 3a. Groups are represented by circles whose surface area is proportional to the number of individuals in each group. The reflexive arrows indicate bonding ties, between actors from the same group, or disciplinary ties. The width of the reflexive arrows is proportional to the average number of collaborative relationships between the actors in the group. The arrows between groups represent the bridging or interdisciplinary ties. The width of a directional arrow from one group to another is proportional to the average number of collaborative relationships the first group has with the second. The number beside each arrow represents the average number of collaborative ties individuals have with individuals from the other group.

The analysis of the collaboration patterns between actors of the three major academic areas shows an unequal collaborative process (Figure 3 and Table 2). Health sector actors are much more present than actors of other groups (indicator 5). Actors of health and social sciences dominate the collaborative process whereas natural sciences researchers are less involved (indicator 3). These results were considered to develop actions to promote participation equity within the EcoSaludETV project. That is, initiatives have been developed to increase the involvement of environmental science actors in the project and balance the areas of knowledge.

The generation of transdisciplinary knowledge

The collaboration network of the 2014 EcoSaludETV project (Figure 3 and Table 2) also shows how SNA allows characterizing interdisciplinarity in Ecohealth projects. Health scientists collaborate mostly among them through bonding ties, i.e., disciplinary collaborations (indicator 7 and proportion of bonding and bridging ties). The social sciences group mostly has interdisciplinary relationships, mainly directed to health scientists. Under 10% of the collaboration

relationships of the environmental sciences group are disciplinary (indicator 7 and proportion of bonding and bridging ties). Most are interdisciplinary, directed similarly toward social and health scientists (indicator 8 and proportion of bonding and bridging ties). These results show that, despite their smaller number in the collaboration network, environmental scientists are actively involved in interdisciplinary collaborations, helping integrate the environmental dimension with social and health issues in the prevention and control of diseases transmitted by vectors.

Despite the lack of reference values that could be associated with an effective interdisciplinary process, we expect to find a balance between disciplinary relationships that guarantees a solid basis for the research mode and interdisciplinary collaborations that allow addressing complex problems in an integrated way. These indicators can be used as explanatory variables to understand the results of collaborative processes in Ecohealth projects, such as the improvement of human health indicators, the resilience and sustainability of ecosystems, or the adaptive capacity of populations affected by the health problem.

Table 2 – Characterization of participation equity and interdisciplinarity among the actors of the EcoSaludETV project

Characteristics of the collaboration network	Health Sciences	Social Sciences	Environmental Sciences	Total
Average number of relationships per individual (indicator 3)	10.2	12.3	9.2	10.9
Relative size of groups of actors in % (indicator 5)	60	35	5	100
Average number of bonding ties per individual (indicator 7)	5.8	4.8	0.8	5.2
Average number of bridging ties per individual (indicator 8)	4.4	7.5	8.4	5.7
Proportion of bonding ties	56.7	38.8	8.7	47.6
Proportion of bridging ties	43.3	61.2	91.3	52.4

Final considerations

Ecohealth values the role of social relations in generating innovative knowledge and using this knowledge to improve the health conditions of populations. SNA provides a theoretical framework and methodological proposals to study the collaborative relationships between the actors involved in research and intervention processes on complex topics that link social, environmental, and health aspects. We examined the contributions of SNA to study the evolution and equity of participation and the generation of interdisciplinary knowledge, which are key themes for the development of Ecohealth projects. We hope that the conceptual and analytical proposals presented can introduce applications in various social and geographical contexts to better understand the role of social relations in projects about the links between the dynamics of socioecological systems and human health, seeking to promote quality of life and environmental sustainability.

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Authors' contribution

Mertens, Távora, Santandreu, Luján, Arroyo and Saint-Charles worked on the project design, on theoretical development, and on result interpretation. Mertens and Távora worked on data collection and analysis. Mertens wrote the article. Távora, Santandreu, Luján, Arroyo, Saint-Charles participated in the critical review of the article and approved final the version of the manuscript.

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