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Incorporating Supra-Local Social Structure into Social Impact Assessment using Causal Network Analysis

ABSTRACT

This paper discusses the incorporation of supra-local social structure (SLSS) analysis into social impact assessment (SIA) practice in order to afford a deeper and more complex understanding of the social production of the impacts of planned interventions. We define SLSS as the total set of political, economic, socio-cultural and ideological driving forces and external structural phenomena shaping the social vulnerability of affected communities. We advocate causal network analysis for effectively incorporating SLSS into SIA and we take the conflict over the HydroAysén project in Chilean Patagonia as an empirical case study. While previous applications have interpreted planned interventions as the root cause of impacts, this paper analyses the dialectical interaction of four elements: the SLSS, the local community, the planned intervention and its impacts. This application revealed two fundamental issues. First, on a theoretical-conceptual level, it showed the capacity of SLSS to mould the causal pathways of a project's impacts on the affected community. Second, on an applied level, it enabled identification of the elements that should be addressed to facilitate social management of the project.

Keywords: Dams, hydropower, HydroAysén, causal maps, network analysis, Gephi

1. INTRODUCTION

The primary objective of social impact assessment (SIA)[1] is to manage the risks and social impacts caused by planned interventions. These projects do not occur in a vacuum. Planned interventions are embedded in a supra-local social structure (hereafter, SLSS) which significantly influences the production and shaping of impacts and the design and execution of the intervention (Domínguez-Gómez, 2016). Since SIA was first developed, many analysts have discussed this influence from a political perspective (Craig, 1990; Freudenburg, 1986; Howitt, 1989; Meidinger & Schnaiberg, 1980). Mainstream SIA practice, however, which has been dominated by a technocratic approach (Lockie, 2001; Vanclay, 2006), has excluded the influence of SLSS, defining an impact as a one-way relationship between the planned intervention (force of change) and the affected population (passive subject of change). In this paper, SLSS is interpreted as the total set of political, economic, socio-cultural and ideological driving forces and structuring phenomena that mould the social vulnerability of the community, the technological and organisational morphology of the planned intervention and the production of social risks associated with it. SLSS is not restricted to the community or territory directly affected by the project, but also refers to the sociological macro and meso driving forces acting on a higher scale (regional, national or global) of the socio-political structure (Blaikie, 2005; Howitt, 1989).

If we take the case of large hydroelectric projects in well-established democratic states with powerful legislation and high levels of institutional stability, the final morphology of a dam and the strategies for managing the impacts caused by its construction and operation will be very different to those in failed states with weak or non-existent governance (Eynard et al., 2018). In the first type of states, the local affected population may use institutional mechanisms to influence decision-making processes in order to assert their interests in the technical design of the project, impact management or compensation procedures. Furthermore, the capacity of action of the business consortia that develop hydroelectric projects is subject to political, social and legislative controls (Burki, 2012). In failed states, on the other hand, the specialised bibliography (Mazrui, 1995) provides many examples of projects in which the developers' ability to substitute state provision of basic services confers them excessive control over the community (Taarup-Esbensen, 2019). This influence enables them to impose the technological and organisational morphology of the project, maximising profits while incurring impacts that can affect the most vulnerable groups (Fearnside 2016). Resettlement of displaced populations, moreover, can be highly contentious and create conflict, sometimes leading to human rights violations (Jing, 2000). Also, the corruption prevailing in these failed states (McDonald et al., 2009) increases the strength of the negative impacts affecting the most vulnerable groups (Zárate-Toledo, 2019). These examples show how the social production of impacts is related to the SLSS in which the planned intervention is embedded. Thus, both the technical characteristics of the hydropower project and the causal pathways created by the impacts experienced by the local community are highly influenced by this supralocal socio-political environment.

The idea underpinning this paper is that the impacts caused by the planned intervention are inextricably linked to the way in which these two elements (planned intervention and impacts) are inserted in and shaped by the SLSS, thus articulating a complex causal network. If the ultimate objective of SIA is to obtain quality information that improves the management of the social impacts generated by a planned intervention, it should also include the analysis of the different social, political and ideological spheres where risk is generated so as to ensure that mitigation and compensation measures are comprehensive and efficient. SIA, then, should address the complexity of the impact network and the influence of factors external to the planned intervention.

Consequently, the overall purpose of this paper is to analyse the role that SLSS plays in the complex causal interactions between SLSS, the community, the planned intervention and its impacts. The objective of the study is twofold. First, it investigates difficulties in acknowledging and including the influence of SLSS in the practice of SIA and the role played by SLSS in shaping impacts. Second, and based on the analysis stemming from the first objective, it proposes causal

[1] Abbreviation list: social impact assessment (SIA); supra-local social structure (SLSS).

network analysis as a methodological tool for facilitating management of the complexity derived from the SLSS-community-planned intervention-impact interactions using a holistic and systemic approach.

The paper is organised into two parts, corresponding to the above two objectives. The first part is, in turn, divided into three sections: (1) a review of the difficulties found when attempting to fit SLSS analysis to mainstream SIA methodologies; (2) an exploration of the concept of SLSS, referring to two contributions that are external yet concomitant to the discipline of SIA, namely, social vulnerability studies and the institutional theory approach; 3) a description of the role of SLSS in the causal impact pathways through its influence on the community and the planned intervention. We take the conflict arising over the HidroAysén project in Chilean Patagonia as an empirical test case for our proposal. Through this case study, we argue that causal network analysis is suitable for the systematic incorporation of SLSS into impact identification and assessment and justify the data collection and categorisation methods used. Subsequently, we perform a causal network analysis and explore its potential as a tool for assisting the management of the multicausal complexity derived from the SLSS–community–planned intervention–impact inter-relationships.

2. CONCEPTUAL PROPOSAL: INCORPORATION OF SLSS INTO SIA

Although giant steps have been made in the theory and methodology of SIA in addressing its constructed, political nature, in practice, the discipline continues to be dominated by a technical approach based on positivist ontology and quantitative methodology (Craig, 1990; Karami et al., 2017; Lockie, 2001; Suopajärvi, 2013). This technocratic approach has three problematic features that are directly related to the research problem addressed in this article. First, it does not encompass the influence of SLSS on the construction of the impact and the social production of the project. Second, it establishes simple and direct relationships between the impacts of the planned intervention and the affected community (Asselin & Parkins, 2009). Third, it uses expert-driven rather than participatory procedures to identify and assess impacts (Arce-Gomez et al., 2015), rendering SIA a neutral exercise and isolating it from the socio-political process of which it forms a part (Howitt, 1989; Lockie, 2001). Below, we address these three difficulties.

In mainstream SIA practice, discussion of the socio-political setting (Vanclay, 2015), usually addressed in the scoping and baseline phases, is limited to the local level affected by the project (Rowan, 2009; Ziller, 2012). These preliminary stages of SIA are concerned with describing the community and other stakeholders directly related to the planned intervention, the technical characteristics of the planned intervention and the affected environment. It is symptomatic that SIA guidelines for SLSS analyses limit their scope to the social vulnerability of the communities involved in the project and to the local institutional environment (see Burdge et al, 2003; Fenton, 2005; IAIA, 1994; Queensland Government 2018). In these manuals, the baseline phase describes the community in state 0 (the pre-project phase), which then serves as a comparison and measure of change with respect to the community in state 1 (post-project; Franks, 2012), but the role of SLSS in shaping the project and its impacts is not investigated.

Second, most SIA models or frameworks see impacts as a direct product of the planned intervention with no influence from external forces (see UNPAN, 2006; Slootweg et al., 2001). Soderstrom (1981, in Lockie, 2001: 280) remarks that the task of SIA is to establish, under a known set of conditions, the causal relationships between variables (that is, if X then Y), where X is the project and Y the impact. The conditions, therefore, are limited to the technological morphology of the planned intervention and the social characteristics of the community. According to the technocratic paradigm, SIA is based on a linear causal logic which begins with the intervention and ends with its impacts on the environment (Aledo & Domínguez-Gómez, 2017). This approach de-contextualises the project, isolating it from the surrounding social reality and preventing an understanding of the role played by social change and the influence of structural phenomena in the production of social impacts (Serje, 2017). The omission of SLSS is even more marked in the central phase of SIA, concerned with impact identification and assessment (Becker

& Vanclay, 2003; Esteves et. al, 2012). The use of prescribed checklists of impacts in these phases establishes an analytical process that excludes the socio-political context from the assessment process. Asselin and Parkins (2009) study the weaknesses of this procedure, which usually takes the form of a Leopold matrix (Leopold, 1971; Sondheim, 1978): the construction of checklists is based on ideal models of non-contextualised projects that also generate series of impacts unrelated to one another. Using these matrices, the researcher checks whether an impact appears in the case study and assesses it based on a series of standardised analytical variables. Employed in this way, this tool excludes SLSS from the generative forces of the impacts (Vanclay, 2002) and does not acknowledge the filtering and modelling effect that SLSS has on the community-planned intervention-impact relationships. Impacts, however, are not caused by a single force (the planned intervention) but are the product of the interaction of multiple factors (internal and external to the planned intervention), which combine to generate a complex, contextualised, multicausal impact network. This second approach sees impacts as nodal elements in the complex network of multiple cause-effect interactions. This complexity of the causal networks cannot be integrated into checklist tools (Taylor et al., 2004).

Third, in technocratic SIA application, specialists are responsible for impact identification, measurement and assessment based on scientific-technical authority and the neutrality and objectivity of positivist principles. This technocratic approach does not acknowledge the constructed, political nature of impacts. Technical managers frequently assume that judging risks is solely a matter of biophysical science, probably because of their lack of training in social theory and methods (Kasperson & Ram, 2013; Ortiz & Climent-Gil, 2020). As defined by Vanclay (2003a), an impact is the way in which individuals physically and cognitively experience the consequences of a planned intervention. This definition extends the assessment community (Funtowicz & Ravetz, 1992) and includes the local community as part of the research group (Ortiz & Climent-Gil, 2020). The technocratic approach, on the other hand, depoliticises SIA practice, turning it into a mechanical process that excludes the local socio-political context. Impact assessment specialists' lack of training in social theory and methods conditions the way SIA is conceived. The isolation of the community–planned intervention–impact relationship restricts discussion on the unequal distribution of impacts, which is influenced not only by the affected local population's conditions of vulnerability but by deep causes rooted in dominant ideologies and supralocal power structures (Wisner et al., 2004). Project developers tend to disregard the fact that planned interventions can be influenced by extreme external events that affect them negatively (Taleb, 2007), and treat interventions as if they existed in an isolated, deterministic, easily-controlled world (Flyvbjerg, 2014). In this respect, it is important to acknowledge that decision making, planning and management are processes that involve many stakeholders with conflicting interests (Aaltonen & Kujala, 2010). As delineated by Burdge and Vanclay (1996), the political approach to SIA has a critical orientation (Howitt, 1989), contrasting with the objective of mainstream SIA, which consists in identifying and predicting project impacts and subjecting policies to technical analysis (Dietz, 1987; Khan, 2014). The incorporation of the contextual approach into SIA involves acknowledging that the socio-environmental systems in which planned interventions are implemented are complex, interactive and uncertain and recognising our limited capacity to quantify them and predict their behaviour (Lord, 2011).

2.1. Defining the concept of SLSS

After this analysis of the common shortcomings in the incorporation of SLSS into mainstream SIA practice, we will now focus on the concept of SLSS, examining its theoretical foundations and delimiting its conceptual scope.

The concept of SLSS in this paper is based on social vulnerability studies (Moser, 1998) and the institutional theory approach (Meyer & Rowan, 1992). Social vulnerability studies stress the role of economic, socio-cultural and political conditions in predisposing and/or increasing the susceptibility of a community to suffering the negative impacts of a natural (Cutter et al., 2003) or anthropogenic threat (Ortiz et al., 2018). Blaikie et al. (1994) describe how (1) the production

of vulnerability begins in macrosociological root causes, such as ideology, the unequal distribution of power, a particular economic model or the orientation of national economic policies; (2) the root causes materialise in a specific territory through dynamic pressures; and (3) these dynamic pressures are experienced by the local populations in the form of unsafe conditions originating in the socio-structural process of vulnerability production.

Although, as already mentioned, mainstream SIA methodologies fail to include SLSS, over the last decade SIA studies have been showing greater interest in the macrostructural contexts of planned interventions by embracing the social vulnerability dimension. Thus for example, Esteves et al. (2017) have emphasised that the social context is dynamic and influences the adaptive capacities and priorities of affected populations. Along the same lines, Smyth and Vanclay (2017) have developed the *Social Framework for Projects* to determine whether the various factors influencing the well-being of a community have been adequately described in a community profile aimed at improving the management of social problems derived from planned interventions.

While the social vulnerability approach focuses on how the supralocal context influences the characteristics of the affected community, the institutional theory (DiMaggio & Powell, 1991) enables us to bring to the fore the influence that the supralocal context has on a planned intervention. This approach argues that companies tend to adapt their form to the pressures brought to bear by the institutional environment in which they operate (Taarup-Esbensen, 2019). In weak or non-existent institutional environments, extractive companies do not attempt to mitigate their harmful effects as they would in well-established democratic contexts, thereby increasing local communities' risks of experiencing the undesired impacts of planned interventions (Giannarakis et al., 2016).

Both approaches give substance to the concept of SLSS, defined in this paper as the set of driving forces and political, economic, socio-cultural and ideological structuring phenomena on the supralocal level. Addressing SLSS in project impact analysis enables us to discern its influence on (1) the distribution of *local assets*, (2) the design and execution of the planned intervention and (3) the way in which these factors interact in the affected territory, conditioning the morphology of impacts. SLSS should be broken down into two operational levels:

- The macro level includes the role played by the state, the market and society (Kaztman, 1999), in addition to the principal generating forces of the structuring processes that intervene in the allocation and distribution of local assets. The ideologies, beliefs, narratives and discourses that articulate and legitimise the unequal distribution of assets also belong to this category. For example, the hegemonic persistence of the modern nature-dominating project embodied in dam-building (Schnitter, 1994) facilitates the social acceptance of the flooding of land as an inevitable consequence of development, and therefore favours the expulsion of affected communities (Merino & Bello, 2014).

- The meso level places the structuring macro processes within a specific space-time framework (Ashley & Carney, 1999); that is, the area of influence of the project on a regional level. The meso elements are classified according to demographic, geographical, economic, socio-cultural and institutional factors. For instance, the characteristic centralism of Chilean public policy is reflected in a highly deficient road network in Patagonia, which, in turn, makes the commercialisation of the region's agricultural and livestock production difficult. Likewise, the deficiencies of Patagonian state schools are a consequence of the privatisation policies of the state education system imposed by the Pinochet dictatorship; and this drives the emigration of young people to universities in the area of the country's capital, thus in turn resulting in the low qualification of the Patagonian workforce.

These macro and meso levels are then deployed on the micro level, influencing (a) the community, defined as the pre-existing local socio-political structure in the immediate area of influence of the planned intervention; (b) the planned intervention, defined as the project's characteristics, morphology and possibilities for implementation, and the actions directly derived from it; and (c) the impacts generated by their interactions, understood as the "intended and

unintended social consequences, both positive and negative, of planned interventions (policies, programs, plans, projects) and any social change processes invoked by those interventions" (Vanclay, 2003b: 6). The capacity of SLSS to influence the local community social structure is manifested through the unequal allocation of local assets characterising the different social groups before the planned intervention (Chambers & Conway, 1992; Middlemiss et al., 2019). These specific conditions enable or hinder the development of community strategies to successfully confront the consequences of the planned intervention (Ross & McGee, 2006; Vogel & O´Brien, 2004).

As an example, we may again take the case of large hydropower plants. With respect to the influence of SLSS on plant morphology it is essential to understand that the construction of such projects does not solely serve an instrumental purpose; i.e., to address an existing or foreseen energy deficit, but is driven by deep motivations and political, social, economic, technological and symbolic factors (De Rijke, 2012; Menga, 2015). The technological morphology of a hydraulic infrastructure project is underpinned by an ideology that moulds the way in which the dam relates to the natural and social environment of the affected territories (Kaika, 2006; Steingberg, 1987). Thus, hydraulic infrastructure becomes an actor conveying the largest-scale supra-structural factors to the territory (Stephenson et al, 2010). An example of this is the construction of the Aswan dam, used by Egyptian President Nasser to show the world that a "non-aligned country" had the capacity to modernise (Mitchell, 2002). The influence of SLSS on the planned intervention conditions: (1) the morphology and design of the project, (2) the space-time framework planned for its development, (3) the processes of change that it induces, (4) the unequal distribution of its effects and (5) the mechanisms for negotiating with the affected populations.

The interaction between these three elements, SLSS–community–planned intervention, shapes the ultimate form of the impacts. This view positions SLSS as an articulating element of the dialectical interactions of the community and the planned intervention and, therefore, directly intervenes in giving form to the impacts.

Having justified the need to incorporate SLSS into SIA through its conceptualisation and after highlighting its importance in causal impact pathways, the following sections address our methodological proposal for analysing, through a holistic and systemic approach, the causal network formed by the SLSS, the community, the planned intervention and the impacts. In order to fulfil this objective, we first offer a brief description of the HydroAysén case study. Subsequently, we present our methodological proposal and describe how the fieldwork was organised, particularly focusing on delineating (a) the space-time scope of the planned intervention and (b) the identification of the stakeholders involved in the conflict. Also, we describe the use of the causal network approach for gathering information. We follow this with the data analysis and categorisation of the information obtained in the interviews. Finally, we perform a causal network analysis and present its main results.

3. INTRODUCING THE CASE STUDY

This article takes the conflict arising over the HidroAysén project as an empirical test case for our methodological proposal. HidroAysén comprised the construction of five large dams in the Baker and Pascua rivers in the Aysén Region (Chile) and their connection to the national electrical grid through a 3,000 km-long electric transmission line. The territory in which HidroAysén was to be developed had an area of 9,000 hectares, the estimated investment was 3.2 billion US$, with an estimated timeframe of 11 years and a labour requirement of approximately 2,260 workers (HidroAysén, 2008).

The HidroAysén project was planned by Colbún SA and Endesa Chile (an affiliate of the Spanish company Endesa), the country's two largest energy companies, and presented to the Chilean government in 2007. It was accepted by the Environmental Assessment Commission (CEA) and received the support of Sebastián Piñera's centre-right government. During its planning phase, a series of conflicts arose, including: (1) an intense debate within Chilean society

consisting of conflicting views regarding the Chilean development model (Romero, Romero & Toledo, 2009); (2) the purchase of lands in the region by the project developers and (3) the creation of great expectations on a local scale regarding the positive impacts of such a large project (Climent-Gil et al., 2018).

In 2012, a strong environmental protest movement, financially supported by US activist Douglas Tompkins, appealed to the Chilean Supreme Court against the CEA's decision. The movement sent numerous activists to the Aysén region to attempt to influence local communities and shift their perceptions of the benefits and risks that the project would bring (Fessenden-Raden et al., 1987). The project confronted two very different development models and energy cultures (Hernando-Arrese & Tironi, 2019; Stephenson et al., 2015). While the exogenous development model envisaged export of the energy produced in the region to the North of the country, the heterogeneous anti-HidroAysén group advocated an endogenous development model for which the project was unnecessary.

There was a change of government in March 2014 when ex-president Michelle Bachelet returned to power. The environmental groups and several political parties against the project had supported her candidacy and, fulfilling her campaign commitment, the HidroAysén project was suspended by the Chilean Cabinet in June 2014 (Borgias & Braun, 2017).

4. METHODOLOGICAL PROPOSAL

4.1 Fieldwork design

The timeframe of this study spans from the beginning of the design stage of the planned intervention in 2007 to the end of the fieldwork in December 2016. The study used a qualitative methodology and was divided into two parts. First, an exploratory analysis was conducted to study the historical, economic, social and political contexts of the potentially affected area and the characteristics of the project. This stage also included a documentary analysis (encompassing official statistics, opinion polls, grey literature, project technical reports, the specialised bibliography and newspaper archives), the organisation of three focus groups in the Aysén region (two groups of 5 participants involving local leaders, representatives of environmentalist groups and university professors from the Coyhaique Commune, and one group of 6 participants involving local and regional leaders from the Cochrane Commune) and seven semi-structured interviews with key stakeholders (4 political representatives at regional and local levels, 2 civil society representatives and 1 representative of the HydroAysén project). The information gathered enabled (a) identification and characterisation of the stakeholders involved in the conflict and (b) elaboration of a checklist of processes of social change induced by the planned intervention. These outputs then served as a starting point for the next stage (the construction of causal impact maps). This exploratory phase allowed for the identification of two concentric areas in delineating the spatial scope of the research (see Figure 2): (1) the Primary Influence Zone, made up of the three municipalities directly affected by the construction of the dams (Cochrane, Tortel and O'Higgins) and (2) the Secondary Influence Zone, made up of the municipalities on the periphery of the affected area (Puerto Guadal, Puerto Ingeniero Ibáñez, Coyhaique, Puerto Aysén and Chile Chico).

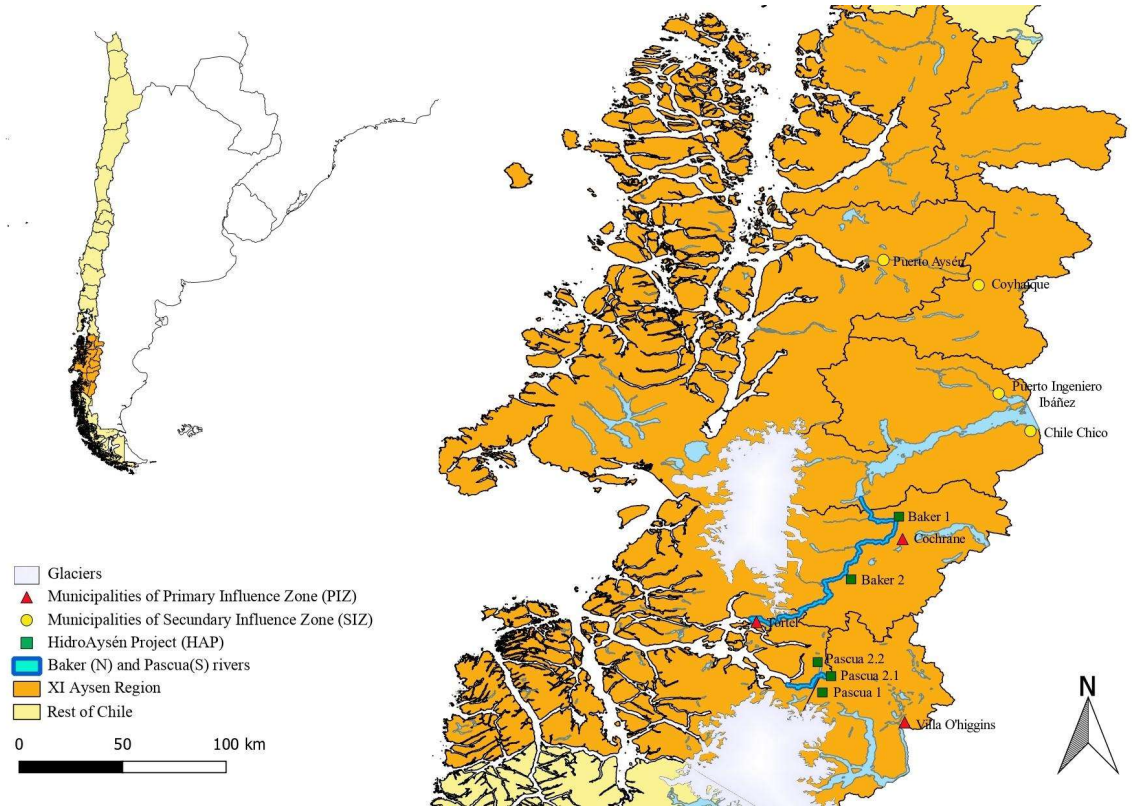

Figure 1. Areas of influence of the Planned Intervention

The second phase of research consisted in carrying out 50 semi-structured interviews with stakeholders in both areas. The total number of interviews was not determined beforehand. Interviews were conducted until information saturation had been reached. In line with the stakeholder analysis made in the first phase, the following groups of stakeholders were selected for interview: environmentalist groups (7), academics with specialised knowledge of the HidroAysén project (4), representatives of local and regional governments (6), representatives of the project developers (4), tourism entrepreneurs (4), large landowners (3) and representatives of local communities (18) selected from local associations, residents of the main towns affected in both urban and rural areas and families living in the area exposed to flooding as a result of the project (4). The protocol used in the interviews is explained in the subsection below.

4.2. The causal network approach for SLSS analysis in SIA

This methodological proposal is based on the causal network analysis approach, which is particularly useful for analysing complex problems. This approach enables identification of complete chains of relationships and provides a holistic, systemic perspective on the phenomenon studied (Ackermann & Alexander, 2016). According to Perdicoúlis and Glasson (2006), the role of causal networks in impact assessment has been predominantly concerned with identifying and predicting impacts. Causal networks enable representation of impact pathways, facilitating identification and understanding of the relevant cause and effect mechanisms of complex systems (Brismar, 2004), exploration of where and how impacts arise (Glasson, 2006), and detection and integration of finite communities as nodes in the graph (Cavallari et al., 2019). A further strength of causal networks is their capacity to track impacts on several levels through sequences of interactions and to detect indirect and accumulated impacts (Franks et al., 2010).

While there is an abundant literature on social network analysis using big data (Block et al., 2020; Camacho et al., 2020; Groshek et al., 2020; Li et al., 2018), this methodology has also been applied to cases with a limited number of stakeholders, nodes and interactions among nodes,

as occurs in the social impact assessment of dam projects (Aledo et al. 2015; Brismar 2004; Voegeli et al., 2019). These studies use causal maps to examine the effects generated by a project and to identify the interventions in the physical environment as the root cause of the impacts. This application of causal network analysis efficiently predicts and detects impacts in the natural environment, but is more limited when its objective is an in-depth, holistic understanding of the morphology of impacts in the social environment (Serje, 2017). Social impacts are not simple relationships between a single root cause (the planned intervention) and its effects. On the contrary, the causal pathway between the actions of a project and the social experience of its impacts is a complex network of interactions (Esteves et al., 2017) in which factors originating in the SLSS and transcending the scope of the project come into play. As we shall see in the analysis section, understanding these causal pathways requires in-depth study of the way in which the SLSS interacts with the pre-existing social dynamics in the local community and with the planned intervention.

The procedure adopted to carry out the interviews incorporated both the causal network analysis approach and the role of the SLSS. The interview dynamic was based on a checklist, previously developed by the research team using the information gathered in the exploratory phase, and composed of: (a) the main impacts generated by large dams; (b) the main impacts caused by the HidroAysén project during its design and planning phase; and (c) the impacts most likely to occur during the construction and operation phases. The interviewer requested informants to select the three impacts from the checklist that they considered to be the most important. Respondents could also add new impacts to the list or modify the existing ones. Subsequently each of the three selected items was placed in the centre of a cardboard sheet. The researcher requested each interviewee to draw three causal maps to encourage a process of reflection on: (a) the root causes that generated the impacts; (b) the impacts derived from the selected one; and (c) their interactions.

This procedure is consistent with the contextual approach of SIA presented in this paper, as it assumes that the ultimate impact-generating causes do not exclusively depend on the planned intervention, but originate in the interaction of the SLSS, the distribution of assets among the local community and the processes of change induced by the planned intervention. Thus the information generated enables us to ascertain, through a process of reflection, the stakeholders' interpretations of: (1) the pre-existing problematic socio-structural factors moulding the characteristics of the planned intervention; (2) the deficiencies in local asset distribution; and (3) the reshaping of the local community's characteristics after experiencing the impacts.

5. DATA ANALYSIS AND RESULTS: THE CAUSAL NETWORK ANALYSIS

The first phase consisted in combining the causal maps drawn by participants into a single causal network. To this end, the nodes were defined as the elements in the causal chains identified by participants. Atlas.ti software was used to homogenise all nodes with similar semantic content, and subsequently the causal maps were merged into a single causal network. This process was performed manually by one member of the research team and later revised by the whole group. Also, the nodes were classified into four categories: SLSS, Community, Planned Intervention and Impacts. This phase yielded a causal network made up of 62 nodes and 128 causal connections (edges), once information saturation had been reached.

Once the nodes had been unified and categorised, the next step was to rank and organise the 62 nodes and 128 edges making up the causal network. As we explain in this section, Gephi network analysis software was used to manage the volume and complexity of the information and to afford a more in-depth interpretation of the interactions among the nodes.

The use of Gephi enabled us to visualise three aspects of the network's internal structure from a systemic perspective: (1) the rank of each node according to its relational position in the network, (2) the spatial organisation of the nodes in the network, and (3) the interactions between the categories of nodes (Camacho et al., 2020; Hanneman & Riddle, 2005). Due to the qualitative

nature of our methodological proposal, Gephi was used only to enhance our interpretation and understanding of the information collected through the articulation of a categorised, organised, hierarchical causal network, in order to highlight the role of SLSS within the causal network, and eventually to facilitate the identification of areas for strategic intervention.

To perform the analysis, the information was introduced into Gephi by constructing an adjacency matrix composed of: (1) the nodes identified by participants; (2) the cause-effect relationships between nodes (edges), also identified by participants; and (3) the distribution of the nodes into the four pre-assigned categories (SLSS, Community, Planned Intervention and Impacts). Secondly, the nodes were ranked according to betweenness centrality and distributed by means of ForceAtlas2, an algorithm that spatially organises the causal network according to attraction and repulsion factors between nodes, applying the LinLog mode and avoiding overlaps (Brandes, 2001, Jacomy et al., 2014). Betweenness is a centrality measure that quantifies the frequency with which a node acts as a bridge across the shortest path between another two nodes (Aggarwal, 2011) and shows its capacity to integrate other network components (Sun & Tang, 2011).

The choice of betweenness centrality as opposed to other centrality parameters (closeness or degree), made it possible to focus on the elements mediating between the root causes and the ultimate impacts. On the one hand, direct intervention in the root causes can be complicated by their high level of abstraction. On the other hand, direct intervention in the final impacts, which can show a high degree of dispersion and have little capacity to influence the rest of the network, limits actions to the surface effects of the problem. It is at this intermediate point that we usually find the nodes with the best balance between their capacity to influence the whole network and their real potential for decision-makers to influence and act on them. Therefore, intervention in these nodes is essential for efficient social management of the planned intervention, either directly, or by influencing the nodes that contribute to their configuration.

Subsequently, we oriented the analysis towards three fundamental objectives, namely: first, to study the explanatory and integrating capacity of the SLSS nodes for the whole network; second, to study the influence that the SLSS nodes had on the other central nodes in the network; and third, with the ultimate objective of facilitating impact management, to track the SLSS elements in the causal impact chain. To achieve these objectives, our analysis focused on: (1) comparing the causal networks resulting from either incorporating or ignoring the SLSS nodes; (2) tracing the causal chains of the elements with the highest betweenness centrality; and (3) tracing, as an example, the causal chain of node 19 (the impact node with the highest betweenness centrality index).

Figure 2 represents the causal network resulting from the Gephi network analysis. The network shows: (a) the circles or nodes that articulate the network; (b) the directed edges, representing the direct cause-effect relationships between pairs of nodes drawn by the participants; (c) the spatial distribution of the nodes, as established by the ForceAtlas2 algorithm; (d) the size of the nodes, according to the betweenness centrality index; (e) the colour of the nodes, according to the category pre-assigned to each node: SLSS (blue), Community (pink), Planned Intervention (yellow) and Impacts (green); and (f) the numbering of the nodes according to their ID (Table 1). Figure 3 shows the causal network without the nodes from the SLSS category, with the aim of probing the structural and interpretative weaknesses of the network in the absence of this category.

CATEGORY	BETWEENNESS CENTRALITY	LABEL	ID
Community	195	Low level of community social capital: in the stage prior to the arrival of the planned intervention the community lacked local organisations defending their interests.	12
Community	172	Lack of local training to benefit from the project's employment opportunities.	34

Community	129	Lack of local control over the development of extractive projects in community territory.	30
Community	123	Little local influence in the decision-making process.	29
Community	118	Brain drain of the youth population in the period prior to the project's arrival.	39
Community	90	Dependence on state benefits to supplement incomes of households with above-average national poverty rate.	24
Community	41,5	High education dropout rate compared to other regions.	0
Community	26	Insufficient development of agriculture hinders economic diversification and causes dependence on other regions for fresh fruit and vegetables.	31
Community	14,5	Lack of local secondary schools and higher education centres.	42
Community	4	Cultural identity sensitive to external factors.	40
Community	0	Low fertility of agricultural soil. Nutrient-poor soil hinders the development of agriculture.	11
Community	0	Shortage of fresh food imports, especially fruit and vegetables	14
Community	0	Deficiencies in municipal health care service, both in human and material resources, in the period prior to the arrival of the planned intervention.	22
Community	0	State employment as the main source of income.	28
Community	0	Strong community perception of state abandonment.	38
Impact	139	Community conflict between groups in favour of and against the project.	19
Impact	82	Instrumentalization of community needs by the project developers.	50
Impact	67	Transformation and diversification of productive activities	61
Impact	66	Perception of the instrumentalization of community needs by external environmental groups.	49
Impact	60	Loss of cultural traditions.	52
Impact	57,65	Alteration of social relations: the settlement of a mega-project in the area would have generated important changes in social relations among members of the local community.	1
Impact	18	Increased awareness of the community's socio-environmental richness: the expectations triggered by the planned intervention and the protest movement against the project led to greater community awareness of its socio-environmental assets.	5
Impact	18	Development of mechanisms (knowledge of legislation, capacity for mobilisation, use of social networks, etc.) increasing the power of communities to oppose the extractive industry.	25
Impact	17,35	Loss of community influence on local development decision-making due to concentration of power in the hands of the project developer.	51
Impact	16	New business opportunities stemming from demographic increase.	47
Impact	16	Improvement in community communication as a result of arrival of the project	48
Impact	13,75	Increased anxiety and stress: The lack of information about the consequences of the planned intervention was experienced with anxiety and distrust by the local community.	4
Impact	13,5	Feeling of dispossession due to the loss of community land.	60
Impact	12	Increased pressure on scarce public resources: the deficit of public resources suffered by the community in the pre-project period would have been aggravated by the arrival of new population.	7
Impact	9,75	Fragmentation of community social cohesion as a result of the arrival of the mega-project.	37
Impact	5,5	Local community feeling of uprooting due to the massive arrival of foreign population.	59
Impact	3,5	Problems in resource management and pollution due to increased population pressure.	55

Impact	0	Increase in community social capital: the communities affected by the project established new connections with environmental groups and external social movements.	2
Impact	0	Increase of intergenerational conflicts due to opposing development models supported by older and younger generations.	3
Impact	0	Increased perception of insecurity: the community's knowledge of the events occurring in similar mining mega-projects in other regions led to a feeling of insecurity in the face of the arrival of foreign populations.	6
Impact	0	Collapse of municipal health care services due to the increase in population and deficiencies prior to the arrival of the planned intervention.	16
Impact	0	Collapse of the municipal education system due to demographic increase and deficiencies prior to the arrival of the planned intervention.	17
Impact	0	Decrease in the quality of life due to the changes that the planned intervention would have generated.	27
Impact	0	Improvement of living conditions as a result of the economic opportunities arising from the planned intervention.	45
Planned Intervention	460	Purchase of large extensions of land by the company.	18
Planned Intervention	94	Low contracting of local population: exclusion of the local population from the jobs generated by the planned intervention.	32
Planned Intervention	53	Privatisation of natural commons.	54
Planned Intervention	51	Massive recruitment of foreign workers.	44
Planned Intervention	28	Asymmetrical relationships between the community and the developers and bad corporate practices towards the local community	57
SLSS	392	Fragility of the economy on the regional level.	36
SLSS	180	Low diversification of the regional economy characterised by subsistence agriculture, extensive cattle industry and fishing	10
SLSS	147,2	Enduring historical, geographical, economic and socio-cultural isolation from the rest of the country.	56
SLSS	72	The absence of paved roads makes it difficult to connect the dispersed rural population to the population centres.	8
SLSS	47,6	Lack of access to internet and telephone in rural areas.	33
SLSS	47	Trend towards the privatisation of public services.	21
SLSS	45	Low educational level in rural areas.	13
SLSS	39	Lack of legislation providing for collective bargaining means that each eviction or resettlement is managed individually.	41
SLSS	29	Absence of state mediation between the community and the company: the non-existent role of the Chilean state as a mediator in the conflict leads to inequalities in the distribution of power between the two interested parties.	9
SLSS	27	Difficulty of access to rural areas by vehicle.	26
SLSS	15	The Chilean state's disregard of regional cultural particularities.	35
SLSS	0	Characteristic Chilean state centralism creates a disconnection between central government policy and the needs of the Patagonian population.	15
SLSS	0	Ideological-discursive controversy: disputes over the meaning of key concepts such as nature, the Patagonian territory or the best development model, with the aim of legitimising or delegitimising the project	20
SLSS	0	Insufficient state investment in basic community public services for these to achieve adequate health and education levels.	23
SLSS	0	Weak environmental institutions allow for the privatisation of natural resources such as river water.	43
SLSS	0	Neo-extractivist character of the state's national development policies.	46
SLSS	0	The Chilean state’s neoliberal policies diminish protection of the local population.	53
SLSS	0	Progressively deteriorating cattle sector.	58

Table 1. Description and categorisation of the causal network nodes of the HydroAysén project

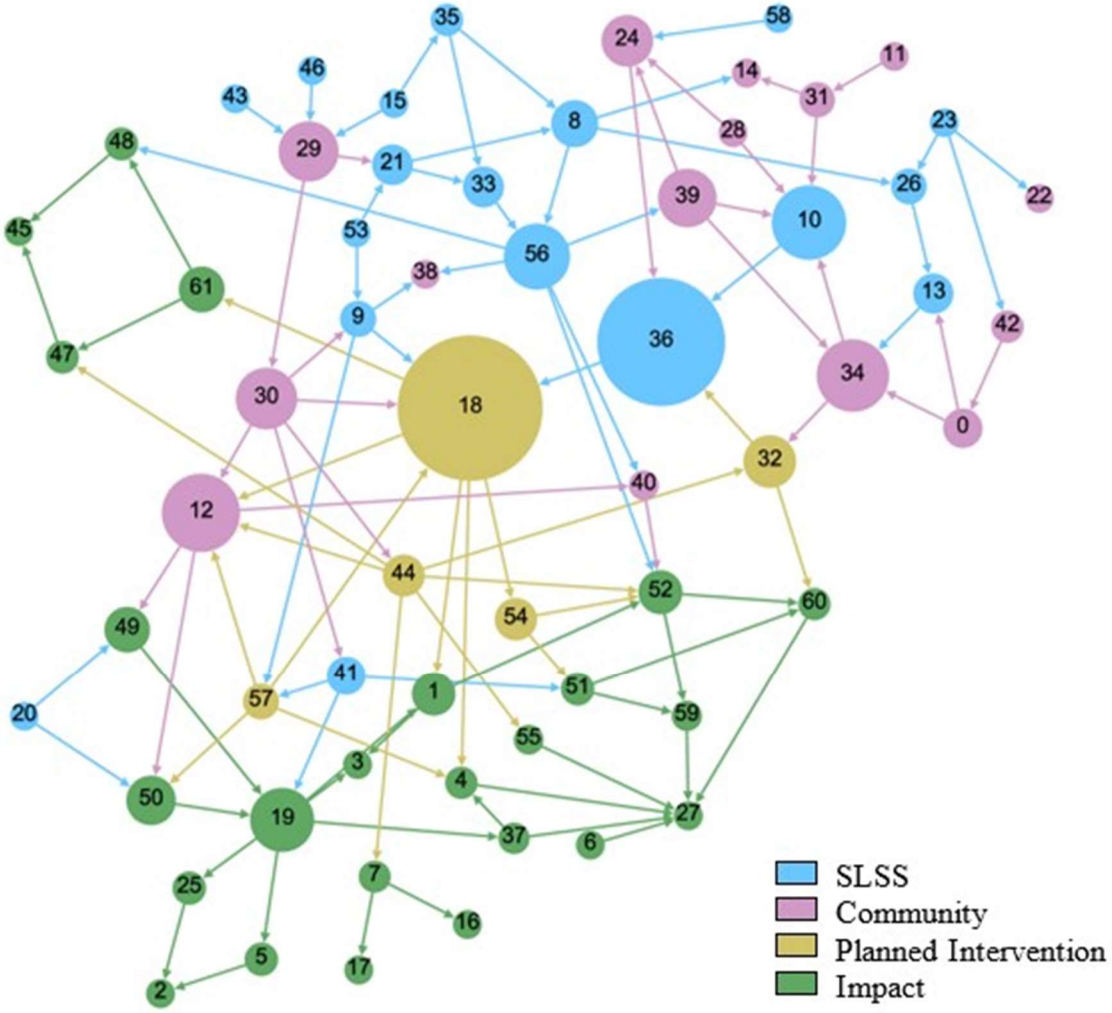

Figure 2. Causal network of the HydroAysén project

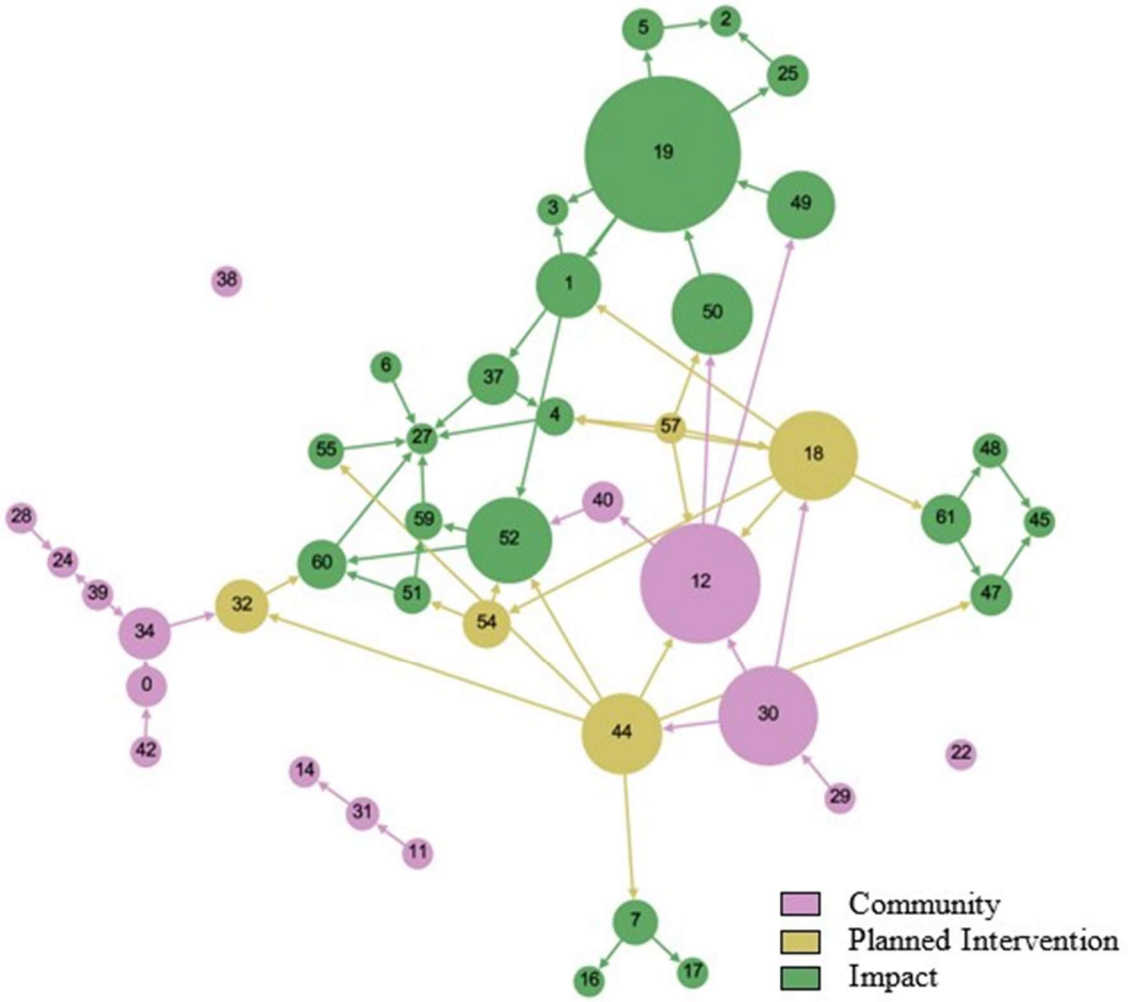

Figure 3. Causal network of the HidroAysén project without the SLSS nodes

Figure 2 allows us to identify the nodes with the highest betweenness centrality measures (illustrated by their size) when all the nodes of the SLSS category were included. The node with the highest betweenness centrality index was *Purchase of large areas of land by the company* (node 18), belonging to the Planned Intervention category. This node was directly caused by two nodes in the SLSS category: *Fragility of the economy at a regional level* (node 36) and *Absence of State mediation between community and company* (node 9); also by *Asymmetric relations and bad corporate practices* (node 57) in the Planned Intervention category and *Lack of local control over the development of extractive projects* (node 30) in the Community category. In a second causal line, *Purchase of large areas of land by the company* (node 18) was also influenced by three other nodes in the SLSS category: *Low diversification of the regional economy* (node 10), *Absence of State mediation between community and company* (node 9) and *Lack of legislation providing for collective bargaining* (node 41). Following its causal chain, node 18 was indirectly influenced by all the nodes in the SLSS category except for *Ideological-discursive controversy* (node 20). In turn, examining the intermediary capacity (betweenness) of node 18, it directly influenced *Low level of community social capital* (node 12), in the Community category, *Privatisation of natural commons* (node 54) in the Planned Intervention category, and *Transformation and diversification of productive activities* (node 61) and *Increased anxiety and stress* (node 4), both in the Impact category. Indirectly, node 18 influenced most of the impacts in the network.

The node with the second highest betweenness centrality measure was *Fragility of the economy at a regional level* (node 36), belonging to the SLSS category. This node was directly

caused by another node in the SLSS category, *Low diversification of the regional economy* (node 10), and also by *Dependence on state benefits* (node 24) in the Community category, and *Low contracting of local population* (node 32) in the Planned Intervention category. Again, Node 36 was indirectly influenced by almost all the SLSS nodes in the network. Likewise, Node 36 directly influenced *Purchase of large extensions of land by the company* (Node 18) in the Planned Intervention category, and indirectly influenced multiple impacts, as was the case with Node 18.

As for the node with the third highest betweenness centrality index, *Low level of community social capital* (node 12), in the Community category, it is worth highlighting the causal relevance of two nodes in the SLSS category, *Lack of legislation providing for collective bargaining* (node 41) and *Absence of state mediation between the community and the company* (node 9), through *Asymmetric relations and bad corporate practices* (node 57), in the Planned Intervention category, and *Lack of local control over the development of extractive projects* (node 30) in the Community category. These causal elements had their deepest roots in an SLSS characterised by a clear neo-extractivist bias (node 46), the centralist nature of the Chilean State (node 15), its weak environmental legislation (node 43) and neoliberal policies (node 53).

In this first analysis of the network, we observe the importance of the SLSS category in shaping and understanding the whole network, through both its dialogue with the Community category and the configuration of the nodes with the greatest betweenness centrality. The causal relations connecting the network in Figure 2 show how the impacts physically and cognitively experienced by the local population, related to their perceived loss of influence on local decision-making, were not exclusively conditioned by the intervention but rather by socio-structural factors preceding and influencing the planned intervention. Observation of the network shows that the purchase of land (node 18) acquired a political interpretation that revealed the power inequality between the affected parties. In a traditional impact assessment matrix analysis these connections would not be revealed and would instead be interpreted as a mere economic transaction essential to the implementation of the hydropower project. This political interpretation of the project and its impacts is reinforced by the importance of the node *Low level of community social capital* (node 12), which connects with the centralist, neoliberal and export-oriented political model inherited from the Pinochet dictatorship.

Likewise, the purchase of land explained the social construction of such important impacts for the community as the dispossession of their communal goods and the anxiety and stress caused by the project, which in turn reflected the importance of the sense of place and its alteration by this type of mega-project (Devine-Wright, 2011). The fragility of the local economy had the second highest index of betweenness centrality. Its connecting power shows why it was one of the main arguments deployed by the Piñera government to justify its intervention in Patagonia.

As can be seen in Figure 3, if the nodes in the SLSS category are eliminated, a large part of the explanatory capacity of both the local structure (community) and the planned intervention and its impacts is lost. Consequently, due to the strong interrelationships between the pre-existing elements at the micro level and those at the meso and macro levels, the majority of the nodes in the Community category are disconnected from the rest of the network. This happens in the case of node 22 (*Deficiencies in the municipal health care services*), node 38 *(Strong community perception of state abandonment*), and nodes 11, 31 and 14 (nodes on the deficits in the agricultural sector). Overall, the absence of supra-local factors and the disconnection of community elements lead to the alteration of the betweenness centrality index, changing the focus of attention to *Community conflict between groups in favour of and against the project* (node 19) in the Impact category and *Low level of community social capital* (node 12) and *Lack of local control over the development of extractive projects* (node 30) in the Community category. The absence of explanatory structural causes for the weakness of community social capital thus makes the community itself responsible for the impacts of the planned intervention and creates a false dichotomous conflict between the company and the community which is difficult to act upon.

Finally, to explore the possibilities for strategic management offered by the attention to SLSS in the causal network, we take as an example the case of node 19, *Community conflict between groups in favour of and against the project*, as it was the impact with the highest betweenness centrality index (see Figure 2). On the one hand, *Lack of legislation providing for collective bargaining* (node 41 in the SLSS category) was among its direct causes. This relationship reveals, then, that impact assessment legislation requiring collective bargaining can be an important instrument for avoiding conflict within communities in the case of mega-projects such as HidroAysén. On the other hand, along a second causal line, we reach the SLSS node of *Ideological-discursive controversy* (node 20) through nodes 50 and 49 (perceptions of the instrumentalization of community needs by project developers and environmental groups), both in the Impact category. Setting up participatory processes of deliberation enabling the local population to deconstruct the exogenous discourses imposed by the different interests in the dispute would thus be a first step towards decision-making models oriented towards the general interest and social acceptance of the project (Wüstenhagen et al., 2007).

These examples illustrate the capacity of structural elements to integrate the multiple nodes involved in the production of impacts, in addition to the importance of these elements for impact explanation. The need to analyse impacts in their generative context, either for a correct understanding of the impact or for the identification of direct or indirect strategies that may facilitate their management, is therefore justified.

6. CONCLUSIONS

This article argues that the capacity of influence of SLSS should constitute one of the focuses of SIA. This would allow us to gain a full understanding of the social production of the impacts caused by planned interventions. SLSS has been defined as the series of driving forces and political, economic, socio-cultural and ideological structural macro and meso phenomena that influence the social vulnerability of affected communities (Blaikie, 1994) and mould the technological (Flyvbjerg, 2014), organisational (Taarup-Esbensen, 2019) and symbolic (De Rijke, 2012) characteristics of planned interventions. With the objective of incorporating SLSS analysis into SIA, here we have proposed a causal network analysis method. This proposal questions traditional impact assessment methodology, which assumes that intervention in the physical environment is the root cause of the impacts. While traditional assessment tools, such as Leopold Matrixes, disaggregate the qualities of the impacts and only take into account the effects of the planned intervention actions on the different impacted areas, our proposal complements such methods by adopting a relational approach that goes well beyond the local consequences of the intervention. We incorporate analysis of the dialectical interactions between SLSS–community–planned intervention–impacts. To effectively manage the volume and complexity of the information and make a more in-depth interpretation we conducted the Causal Network Analysis using Gephi.

Application of this methodological tool proved its ability to reveal the influence of the socio-structural environment on the morphology of the causal pathways of the planned intervention's impacts on the affected community. Respondents' endeavours to trace the root causes made it possible to identify the influence of supra-local elements of a political and ideological nature on the morphology of the project and its impacts.

The analytical scope of this tool affords a systemic approach focused on the interactions between the SLSS, the community, the planned intervention and the impacts, highlighting those nodes that have a greater capacity to mediate in, support and influence the causal network. Thus, causal network analysis enables us to detect which elements should be acted on to facilitate the social management of planned interventions. In the HidroAysén case study, in order to efficiently address the problem created by the project, reviewing company strategies for purchasing large areas of land, intervening with respect to the fragility of the local economy, and setting up mechanisms to stimulate the prior growth of community social capital (elements with the highest

betweenness centrality) would have constituted the main priorities for facilitating social management of the project's impacts. The approach that we propose here, then, can (a) strengthen company decision-making processes when selecting social responsibility and social risk management actions, and (b) guide the development of public policies for addressing existing deficits in the potentially affected community.

Furthermore, the process of reflection required for constructing causal maps - with respondents' iterative identification of the complex ramifications and deep causes of the most important impacts - can increase the empowerment of local communities by providing them with robust information for decision-making processes regarding the best lines of community development. This approach also represents a useful tool for identifying fundamental factors that are controversial or consensual among stakeholders and the reasons for the emergence of such conflicts.

Finally, it should be highlighted that these advantages could be strengthened; first, in their practical application, through the inclusion of stakeholders in reading and interpreting the causal network, which would favour social learning processes and increase the capacity to reach consensus when formulating proposals; and second, in their analytical and technical procedures, by enhancing the causal network analysis; for example, by assigning weights to the edges in order to clarify interpretation of the strength of cause-effect relationships, by integrating and identifying finite communities to improve the efficiency of the graph and reduce its complexity (Cavallari et al., 2019), or by developing assessment dimensions (Camacho et al., 2020) adapted to micro-local data analysis.

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