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Article

Social-Ecological Knowledge Integration in Co-Design Processes: Lessons From Two Resilient Urban Parks in Chile

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Abstract
Cities worldwide face multiple social and ecological challenges, such as climate change and its impacts. Adapting and transforming our urban environments is urgent to improve their resilience to uncertain scenarios. These challenges require renewed urban solutions and force us to rethink their design processes. Multiple actors are involved in such processes, coming from different sectors, and sometimes having conflicting agendas and knowledge backgrounds. Many of these processes can be considered co-design processes, with actors interacting to improve the design quality, legitimacy, and feasibility. Many conceptualise cities as social-ecological systems and public spaces are their subsystems. A collaborative approach to designing public spaces contributes to integrating the social-ecological knowledge from the public, private, and citizen actors. The question remains: How is sometimes conflicting social-ecological knowledge integrated into public space co-design processes? We study two large-scale urban parks in Chile. We framed them as social-ecological systems and analysed their co-design processes. This study aims to provide insights into the difficult-to-grasp phenomena of knowledge integration in co-design processes. We analysed these cases in previous studies. Now we provide insights into social-ecological knowledge integration in co-design processes. Although framed in Latin America, the findings may be helpful elsewhere.

Keywords
Chile; co-creation; co-design; knowledge integration; public space; resilience; social-ecological systems

Issue
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1. Introduction

Cities worldwide face multiple social and ecological challenges, such as climate change and its impacts. Impacts, floods and land erosions, displaced refugees, housing shortages, wildfires, wealth disparities, and pandemics are some of the problems cities face. They should be addressed with urban transformations in integrated ways (Webb et al., 2018). They require new solutions, so we should rethink the processes to design them (Colloff et al., 2017; Saad-Sulonen et al., 2018). Some suggest a resilient evolutionary approach (Davoudi et al., 2012) and climate-sensitive planning (Haasnoot et al., 2013; Peker & Ataöv, 2021) to adapting cities through nature-based solutions (Ersoy & Yeoman, 2020).

Resilience emerged in the 1970s in ecological research to define the ability of a system to change when under stress (Holling, 1973). This definition includes the capacity to withstand, re-organise, and recover (Berkes et al., 2008; Brown et al., 2021). Three resilience interpretations are often recognised: the engineering, the ecological, and the evolutionary. While the engineering approach focuses on returning to its previous state, the ecological approach accepts change as adaptation (Fingleton et al., 2012; Rose, 2004). The evolutionary resilience approach emerged to define the capacity of a system to change as a dynamic, relational, and transformable process (Carpenter et al., 2001; Davoudi et al., 2012; Folke et al., 2010; Gunderson & Holling, 2001; Walker et al., 2004). The latter is often suggested for urban planning (Davoudi, 2021). Urban resilience has been defined as the capacity of urban systems and their social, ecological, and technical networks across temporal and spatial scales to adapt or transform (Meerow & Stults, 2016). An evolutionary approach defines that cities should be prepared for change (Davoudi et al., 2012) through participatory approaches (Peker & Ataöv, 2021). In this study, we adhere to the evolutionary resilience approach and understand cities as social-ecological systems that can persist, adapt, and transform.

Cities are often conceptualised as complex and evolving social-ecological systems (Berkes, 2017; Biggs et al., 2021; Folke, 2006; Ostrom, 2009). An adaptive resilience approach to cities as social-ecological systems challenges expert-driven processes and call for new understandings of space and time (Davoudi, 2021; Gaete Cruz et al., 2021). This study addresses the dichotomy between social and ecological systems (Berkes & Folke, 1994), where diverse actors collaborate to respond to crises creating social networks and shared visions (Folke et al., 2005). This study conceptualises public spaces as social-ecological systems and analyses their co-design processes.

Designing public spaces requires social and ecological parties (Webb et al., 2018). Designers, experts, stakeholders, and citizens are involved in such processes, coming from different sectors with sometimes conflicting agendas, values, and knowledge backgrounds (Agid & Chin, 2019; Gaete Cruz et al., 2021, 2022a, 2022b). This diversification brings together different forms of knowledge from and beyond disciplines. Multiple formal and informal knowledge, empirical knowledge (Gibbs et al., 2018), local knowledge (d'Hont & Slinger, 2022), implicit or tacit knowledge (Sanders, 2002), and perceptions (Ducci et al., 2023) from practices and experiences, capabilities (Janssen & Basta, 2022), and even values, and aims converge (Gaete Cruz et al., 2022b). Indigenous, local, and citizen expertise knowledge forms can complement traditional academic disciplines (Biggs et al., 2021). Collaboration in design challenges conventional procedures within multi-stakeholder settings to improve context-suitability (Gaete Cruz et al., 2022b; Mattelmäki & Visser, 2011; Sanders & Stappers, 2008).

Public space processes involve actors with diverging aims and knowledge fields (Webb et al., 2018). They may come from different sectors and backgrounds. Public spaces are contested, and interventions often raise conflicts. In designing them, multiple aspects should be discussed, negotiated, and deliberated (Brysch & Czischke, 2022; Castro, 2021). The wider the diversity of knowledge, aims, and values integrated into the process, the more the awareness of the diversity and uncertainty in addressing social and ecological challenges. When intervening within cities, knowledge integration is critical for systemic change (Berkes, 2009; Folke, 2006).

The co-design concept defines design processes in which actors interact to improve the design quality, legitimacy, and feasibility (Gaete Cruz et al., 2022b; Sanders & Stappers, 2008). Such interactions may result in the integration of diverse knowledge forms. We found that in co-design processes, multiple actors interacted and played a role within three co-design arenas: strategic, transdisciplinary, and socio-cultural (Gaete Cruz et al., 2022b). Then we analysed the knowledge integration design mechanisms throughout the processes (Gaete Cruz et al., 2023). However, the types of knowledge integrated still need to be determined.

In designing within social-ecological systems, knowledge integration is crucial, especially when the knowledge is conflicting, diverse, and specific. This study aims to provide insights into the difficult-to-grasp phenomena of knowledge integration throughout co-design processes. It follows previous studies analysing the same co-design processes and advances in answering how is sometimes conflicting social-ecological knowledge integrated into public space co-design processes.

The question remains: How is sometimes conflicting social-ecological knowledge integrated into public space co-design processes? To answer this question, we conceptualise public spaces as social-ecological systems and analyse the integration of knowledge throughout the co-design processes. We study two large-scale urban parks in Chile. We aim to understand how social, ecological, and social-ecological knowledge is integrated throughout the design processes. We start by analysing the actors involved in the processes and the disciplinary or non-disciplinary knowledge from consultancies and organisations. Then, we analyse the integration of knowledge reported throughout the processes based on the interviews. We were able to map the trajectories of the cases throughout the design.

This study contributes to the difficult-to-grasp phenomena of knowledge integration in blurry co-design processes. This study provides new insights into social-ecological knowledge integration in public space co-design processes. This study follows previous studies on the same cases (Gaete Cruz et al., 2021, 2022b, 2023) and elaborates further on the complex phenomena of public space co-design for resilience.

2. Social-Ecological Co-Design for Resilience

Due to the interdisciplinary nature of the resilience approach, frameworks are essential as overarching guides for collaboration (Biggs et al., 2021). Frameworks identify and organise factors to understand a phenomenon (McGinnis, 2011). In social-ecological systems research, frameworks define concepts, elements, processes, and relationships to explain or predict outcomes (Biggs et al., 2021). This study combines co-design processes and the social-ecological systems approach. We build on literature to define the analytical approach to studying social-ecological knowledge integration.

2.1. Public Space Co-Design Processes

Design is both a practice and a discipline that uses and produces new knowledge to solve ill-defined problems

(Cross, 1982, 2001; Krogh & Koskinen, 2020). Urban design and planning have dealt with uncertainties and change for a long time (Healey, 1992; Innes & Booher, 1999). Many collaborative and communicative turns have been suggested to overcome the distance between designers, planners, their users, and other stakeholders. Collaborative and participative approaches to design have emerged in the last decades to address complex problems (Manzini, 2015; Mattelmäki & Visser, 2011).

Co-design approaches refer to the collaboration of multiple actors in design processes to improve the projects (Sanders & Stappers, 2008). This study defines co-design as the collaborative approach to the design process in which multiple actors from diverse sectors and backgrounds interact, collaborate, and integrate knowledge (De Blust et al., 2019; Gaete Cruz et al., 2022b). Co-design processes are iterative and evolving, and most focus on the early phases and the fuzzy front end (Sanders & Stappers, 2014). We adhere to the iterative, cyclical, and somewhat chaotic nature of collaboration and its changes through time (Botero & Hyysalo, 2013; Di Siena, 2020; Gaete Cruz et al., 2022a).

In previous studies, we contributed two analytical co-design frameworks (Gaete Cruz et al., 2022a, 2022b). We adhered to the cyclical design conceptualisations defining the steps and phases of the projects (Hansen et al., 2019; Jonas, 2007; Roozenburg & Eekels, 1995). We then linked them to Arnstein's (1969) participatory ladder (see also Collins & Ison, 2006) to analyse processes and overcome the academic bias of focusing on co-design activities (McDonnell, 2018; Saad-Sulonen et al., 2018).

The design cycles occur throughout the phases and define how the project develops in the four steps of collection, analysis, ideation, and evaluation. This approach is conceptualised as the "trial-and-error process that consists of a sequence of empirical cycles in which the knowledge of the process, as well as the solution, increases empirically" (Roozenburg & Eekels, 1995, p. 90). As shown in Figure 1, the cycle is repeated in each phase as a frame for the analysis. The design process has a conceptual, a preliminary, and a final design phase before the implementation (Van de Ven et al., 2016). In the conceptual phase, the problem, objectives, and foremost criteria are defined to produce outline proposals (Cross & Roozenburg, 1992; Roozenburg & Eekels, 1995). In the preliminary phase, a scheme is developed from possible spatial layouts, functional displays, and material propositions (Cross & Roozenburg, 1992; Roozenburg & Eekels, 1995). During the detailing phase, the technical definitions are developed and defined (Cross & Roozenburg, 1992).

Despite the linear timeline shown in Figure 1, our understanding of co-design processes is fuzzy (Sanders & Stappers, 2008), messy, and cyclical (Botero & Hyysalo, 2013). The timeline is a simplified conceptual representation used to analyse different aspects of iterative co-design processes. This background section combines this timeline with a social-ecological system approach to further analyse knowledge integration processes.

2.2. Social-Ecological Knowledge

Urban and ecological approaches have been integrated for decades to produce socio-technical and ecological spaces and processes. For decades urban functional approaches have been contested (Geddes, 1968; Lynch, 1964; Olmsted et al., 1997; Rossi, 1966) and many have urged for the integration of urban infrastructures and the environments that support them (Carson, 1962/2009; McHarg, 1969; Spirn, 1984). Urban and ecological approaches have been brought together to broaden the limits of urbanism (Bélanger, 2016; Brown & Stigge, 2017; Mostafavi & Doherty, 2016; Waldheim, 2016). In this integrative turn, the social-ecological systems approach is helpful to conceptualise the two interlinked and interdependent systems. A collaborative approach to their design processes may improve such urban designs.

Cities have been conceptualised as complex and evolving social-ecological systems (Berkes, 2017; Biggs et al., 2021; Folke, 2016; Ostrom, 2009). The social-ecological system approach integrates humans into nature, stressing their interdependence, interconnectedness, and reciprocal feedback (Folke et al., 2016). Human and ecological systems are understood as interdependent, inseparable, and intertwined. The term emerged in the early 1990s amongst scholars in ecological economics and common-pool resource systems (Berkes et al., 1989; Ostrom, 2009). It combines social and ecological systems and an integrated adaptive system with feedback and dynamics (Biggs et al., 2015; Folke et al., 2010) that constantly change in response to internal or external pressures (Davoudi et al., 2012).

In urban design, new projects should account for the interconnectedness and interplay between the social and ecological systems and their emergent features and processes (Biggs et al., 2021; Preiser et al., 2018). To do so, they use the available knowledge within their systems, combined into a whole through human creativity in design processes (Devisch et al., 2018; Roozenburg & Eekels, 1995).

Academic disciplinary knowledge is often conceptualised as mental frames and models, technical and

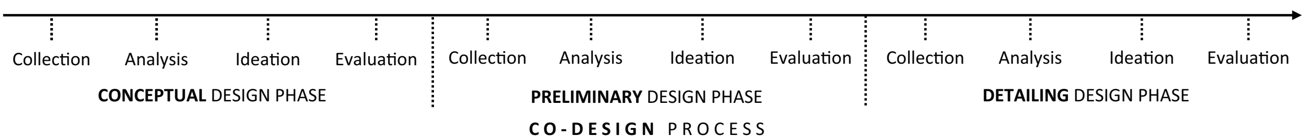

Figure 1. Generic timeline for co-design processes: Cyclical steps and phases.

design knowledge (Christiaans, 1992). Non-disciplinary knowledge is often informal and refers to the practice, technical, experiential, and value-oriented knowledge. However, such classifications refer to the sources of such knowledge and their type. This study conceptualises knowledge as the information, methods, and solutions needed to design spaces, functions, flows, and institutions. It focuses on the systems that frame such knowledge types, particularly their co-design processes.

Social-ecological knowledge is needed to make cities for people and nature. Social, ecological, and social-ecological knowledge are defined in Table 1. For the scope of this study, such knowledge systems are focused on public space design. Our definition follows previous ones in understanding spatial, temporal, and organisational scales (Biggs et al., 2021). Also, the action-oriented perspectives define actors, areas, and flows (Tjallingii, 2015). We recognise that social, ecological, and social-ecological forms of knowledge are contributed to and integrated into co-design processes, as shown in Figure 2.

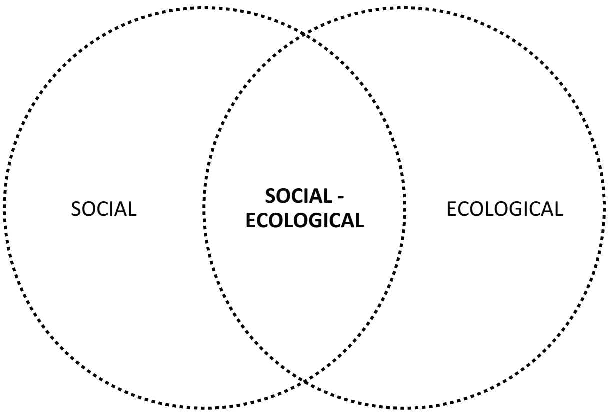

Figure 2. Diagram of the social-ecological knowledge within the system.

We recognise social, ecological, and social-ecological knowledge systems, as shown in Table 1. We acknowledge that drawing boundaries to the components of systems is challenging but valuable for analysis (Biggs et al., 2021). For this study, these categories were defined to study them interconnectedly. The social knowledge system is broadly understood and comprises socio-cultural aspects, values, and physical infrastructure details to support human settlements. The ecological knowledge system is the information about biotic and abiotic elements that allow us to comprehend, protect, and intervene towards sustaining biodiversity, forestry, flows, and supporting structures. The social-ecological knowledge system is the combined approach to the information that links and connects social and ecological spaces, functions, and institutions. We acknowledge the importance of social-ecological integrated knowledge when designing integrated and resilient public space projects.

2.3. Social-Ecological Co-Design Processes Framework

Due to the interdisciplinary nature of resilience and the social-ecological systems approach, there is a conceptual and methodological pluralism (Colding & Barthel, 2019). Analytical and conceptual frameworks have been said to be important in social-ecological systems research as overarching guides to facilitate collaboration (Biggs et al., 2021). They contribute to defining concepts, elements, and processes. In this study, we develop an analytical framework that allows different forms of knowledge to be mapped in a timeline (Figure 3).

This study's analytical framework links social, ecological, and social-ecological forms of knowledge with a generic timeline. The framework focuses on the types of knowledge present in co-design processes. In doing so, a social-ecological knowledge landscape is defined. Although schematic, the framework allows different co-design processes to be mapped, and different process trajectories can be compared for further analysis.

The framework is an evolution of the co-design process framework previously developed by the author (Gaete Cruz et al., 2022a) and contributes to further conceptualising co-design processes (Bossen et al., 2016;

Table 1. Definitions of knowledge systems.

	Definition	References
Social	Social, economic, political, cultural, technological, physical, dynamic, and institutional elements regarding communities and institutions, activities and flows, physical infrastructure, and geomorphologies	Biggs et al. (2021); Folke et al. (2016); Landman (2021); Ostrom (2007); Tyler and Moench (2012); Webb et al. (2018)
Social-ecological	Interconnected, interdependent, and interactive social and ecological systems are equally important; elements, relations, and processes	Berkes (2017); Berkes et al. (2000); Biggs et al. (2021); Colding and Barthel (2019); Ostrom (2007)
Ecological	Biotic (population dynamics, food interactions, biodiversity) and abiotic (nutrient flows, climate patterns, forestry, water, soil, and air) physical, dynamic, and institutional elements	Biggs et al. (2021); Ostrom (2007)

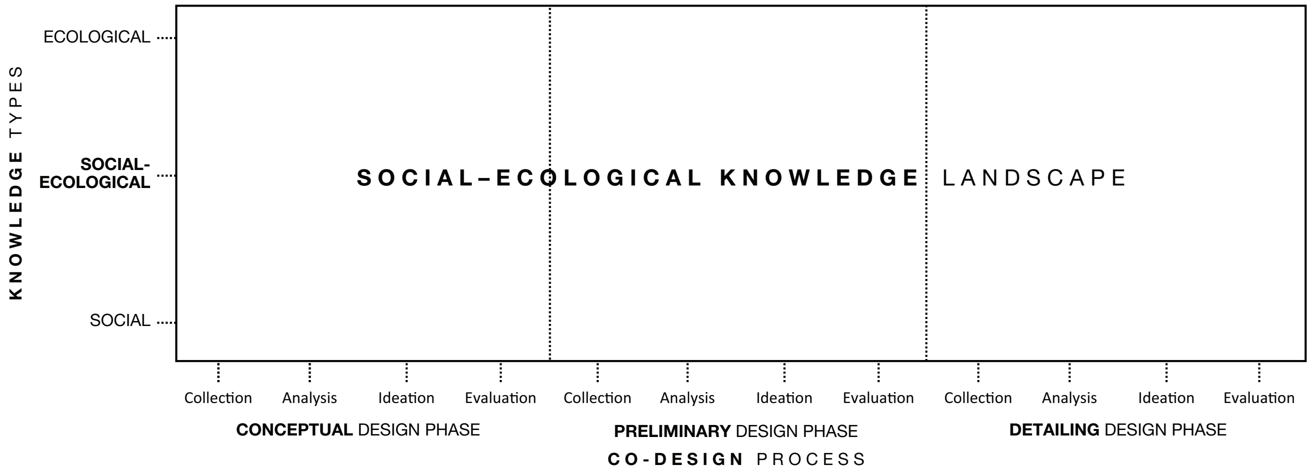

Figure 3. The social-ecological co-design processes framework.

Drain & Sanders, 2019; Nguyen, 2022; Szebeko & Tan, 2010). It contributes to studies on the resilience of social-ecological systems.

3. Method and Cases

A case study approach was used to compare two urban park co-design processes in the Atacama Desert in Chile. This section briefly introduces the cases and methodological approach.

This study analyses two co-design processes of public space projects that the author had previously analysed (Gaete Cruz et al., 2021, 2022b). The two cases were selected due to their resilience approach and collaborative design processes. Both cases are big-sized urban parks. In their design, multiple actors contributed knowledge and collaborated. The designers, experts, stakeholders, and citizens involved belonged to the public, the private, the third sector, and academia. These cases are some of the few examples of this in the country.

3.1. Kaukari Urban Park

Kaukari Urban Park is a naturalisation of the riverbank of the Copiapó River in Copiapó City (Figure 4). The urban park is 60 ha wide and develops along the river for 3.5 km in the middle of the city. In the design processes, multiple actors were involved. The process studied consists of a conceptual phase (2009–2010), where the municipal regulation plan was developed; the preliminary design phase (2011–2012), where the urban park was further designed; and the detailing phase

Figure 4. Picture of Kaukari Urban Park. Source: Courtesy of Tomás Gómez.

(2013–2014), where the construction documents and plans were developed. Many participatory sessions were undertaken with citizens throughout the process. Two public ministries had a strategic role; one (Ministry of Housing and Urbanism) focused on the urban park, while the other (Ministry of Public Infrastructure) focused on the riverbank restoration.

All interviewees considered Kaukari Urban Park an integrated social and ecological park. As defined early in the process, the riverbed urban park provides social and ecological urban solutions. This was done by integrating social and ecological knowledge provided by relevant actors such as the landscape architect and hydraulic engineering design teams and was driven and supported by the public entities involved in the process (Ministry of Housing and Urbanism and the Ministry of Public Infrastructure). However, as reported, such a solid and integrated stakeholder cohesion was complemented by a rather conventional and informative citizen participation process within a non-participative and top-down social scenario (Gaete Cruz et al., 2021).

Even though there was a general sense of urgency to restore the riverbed due to the drought (dry from 2005 until 2012), an initial lack of agreement on how the vast area had to be addressed was reported. Some initiatives that reveal such a lack of compatibility are the Rock Without River music festival on-site, the Active River water mirror, and playground structures to be installed in the river. The Kaukari Urban Park riverbed restoration can host festivals, playground areas, and other functions.

The project was designed based on community participation, which was reportedly shallow and conventional, achieving informative and consultive collaboration levels (Gaete Cruz et al., 2022b). This can be observed in the designed project with generic recreational functions and areas: multifunction squares, football fields, multi-sport fields, public toilets, extended planters, tree-lined boulevards, and promenades. This was reported to have changed in recent years as citizen participation evolved, and a wider diversity of cultural, sports, and economic functions were incorporated into the original project. One interviewee reported: “We now involve citizens in the decision-making processes of the park.’’

Climate change awareness was said to have evolved in the community. There was a lack of trust in such a different approach to river flooding defences. The project support started to change after implementing one park section, and two catastrophic flooding events occurred in the city (2015 and 2017). This happened towards the end of the process, requiring the project to be adjusted. As one of the interviewees commented: “We had to improve the river’s capacity dramatically…after the floodings.’’

Ecological restoration and naturalisation of the river were central aims of the project, so river inflow knowledge was a central research concern and project outcome. During the design process, the caring capacity of the project was defined considering the available knowledge. However, the water volume had to be updated after the design process due to the improved climate change awareness acknowledging uncertainty. Even though the riverbed restoration played a central role in the design, it may have shadowed other ecological restoration opportunities identified in the early research phase, such as the existing greenery and trees in the desertic valley, the tailing dumps, and the possible nearby rainwater drainage, amongst others.

3.2. Antofagasta Seaside Park

Antofagasta Seaside Park is a public space throughout the 35-km-long city (Figure 5). CREO Antofagasta, a public-private citizen partnership with a living lab approach, led the project. First, many actors were summoned during the partnership’s initial years in a relationship-building process (2012–2014). Then, a public contest for ideas defined the design consortium based on a proposal. Finally, the consultancy occurred (2017–2021).

The interviewees valued Antofagasta Seaside Park due to the initial collaborative approach. Stakeholders from diverse backgrounds and sectors (public, private, third sector, community, academia) were involved in an open process where the problem was defined and analysed. From this early set of participative activities promoted by the CREO Antofagasta NGO, a partnership was built for developing this and other urban development projects for the city. Interviewees valued the shared understandings as outcomes of the process. Some interviewees reported trust issues due to the lack of communication in the following phases (Gaete Cruz et al., 2022b). However, most interviewees valued that the leading designers were recognised as high quality, so there was a sense of expectation about the resulting project.

The general community supported the project due to the collaborative collection that had taken place over a couple of years. Industry associations, academics, and community and sports organisations reported this. A general sense of awareness had been built regarding the seaside’s socio-cultural value and urban functions and the need to integrate the existing interventions (restaurants, sports fields, fishing areas, seaside sports structures, greenhouses, commercial areas, artificial beaches, amongst others). With a conflict matrix method, conflicting areas and activities were collectively recognised.

Neither interviewee did not report climate change awareness, and there was no mention of the sea level rise in the design process. However, interviewees reported that many natural and ecological hotspots were recognised and spatially protected early in the process with the built structures and didactic signages. This was the case with water springs, birds nesting, fishing, and rocky seashell areas.

The design team reported some iterations regarding diminishing the breakwater defence structures in the beach areas. This demonstrated a will to use fewer

Figure 5. Picture of Antofagasta Seaside Park. Source: Courtesy of Nicolás Sepúlveda.

materials and intervene at the seaside less. They reported having opted for an overall discreet intervention of the coastal areas focalising major structures only on the two artificial beaches to be built.

3.3. Case Study

This study uses a case study approach to analyse a contemporary, complex, and context-sensitive phenomenon of co-design for resilience (Yin, 1994). We chose two cases and analysed their co-design processes retrospectively. This approach allows the analysis of processes from practice and develops new knowledge (Ridder, 2017). We aim to produce both specific and generalisable knowledge for science and practice. We took an instrumental approach and developed a framework that structured the analysis and interpreted the results (Stake, 1995).

The study builds on primary and secondary data that the author obtained in fieldwork conducted in Chile in 2019 and 2020. Primary data consisted of 27 semi-structured in-depth interviews with key actors of the cases studied. To make the sampling extensive, the interviewees were selected from diverse sectors such as the public, private, third sector, academia, and society (Ridder, 2017). Secondary data were written reports, social media, press, project plans, and images.

The interviews aimed to collect the participants' perceptions regarding the processes they were involved in. They were asked to define the processes and their involvement. Explicit questions regarding the social and ecological knowledge and aspects of public spaces are designed to capture perceptions of the social-ecological systems. The interviews and data underwent a content analysis with the Atlas Ti software. A coding system was developed to classify data based on the framework of this study (Table A1 in the Supplementary File).

The author has previously studied both cases. The enablers and barriers to collaboration and design were analysed from an evolutionary resilience approach (Gaete Cruz et al., 2021). Then, the levels of collaboration of the diverse actors in the different design steps were assessed by analysing the co-design activities (Gaete Cruz et al., 2022b). The acknowledgement of the relevance of knowledge integration and co-production in co-design processes was made evident. From there, another study analyses how interdisciplinary and transdisciplinary knowledge integration occurs in co-design processes, especially if framed as multi-stakeholder design processes (Gaete Cruz et al., 2023). This study analyses the types of knowledge integrated throughout the process and validates the co-design phenomenon's results and overall complexity.

The author of this study was partially involved in the two co-design processes. In the first case, she was the project leader within the leading architecture design firm Teodoro Fernández Associated Architects. In the second case, she was the design leader of the CREO Antofagasta NGO during some time of the co-design process. The key roles in both processes allowed access to data and interviewees that would have been impossible otherwise. Additionally, valuable insights were gained due to her previous involvement in the cases and connections to relevant practitioners and organisations. We acknowledge that such involvement might bring legitimacy issues, so we addressed it through verification and triangulation. The study of these co-design processes has been iterative and from diverse conceptual approaches, as reported in previous academic publications (Gaete Cruz et al., 2021, 2022b). The analysis and results of this study were shared and verified with some interviewees for clarification and validation purposes.

4. Results: Social-Ecological Knowledge Integration

4.1. Social-Ecological Knowledge in the Cases

We classified the main stakeholders, design teams, and experts involved in the two processes according to their main knowledge contribution. The interviewees were asked to report on the knowledge or information that may have played a role in the co-design processes. The questions were kept open for them to reflect on the main aspects discussed and how they evolved when collectively prioritised. Sometimes interviewees referred to the design outcome and how the designed project considered, disregarded, or neglected certain aspects.

The interviews were complemented and verified with secondary data. This was done in two steps. First, a classification of the stakeholders, and then the design teams and experts. Table A2 in the Supplementary File shows the main stakeholders involved in the cases studied, and Table A3 the main disciplines and experts involved in the design consultancies.

In Figure 6, the stakeholders are classified according to their main knowledge focus (Table A2 in the Supplementary File). Different actors took an integrated social-ecological approach in the two cases. In Case 1, the leading stakeholders were reported to be interested in the urban park's social and ecological functions. In Case 2, not all leading stakeholders aimed for a social-ecological approach. However, this was a primary concern for the leading NGO CREO Antofagasta, the architectural firm, and some community organisations. Interestingly, no stakeholder was reported to pursue predominately ecological aims.

Figure 7 shows the design disciplines and expert studies for each design consultancy (Table A3 in the Supplementary File). This data was collected from reports and other secondary data and verified with the interviews. In Case 1, the leading design teams were urban landscape designers and hydraulic engineering design. They have played one of the most critical roles in the design process, combining river tide and urban park requirements in integrated spaces. It is worth noticing that social aspects

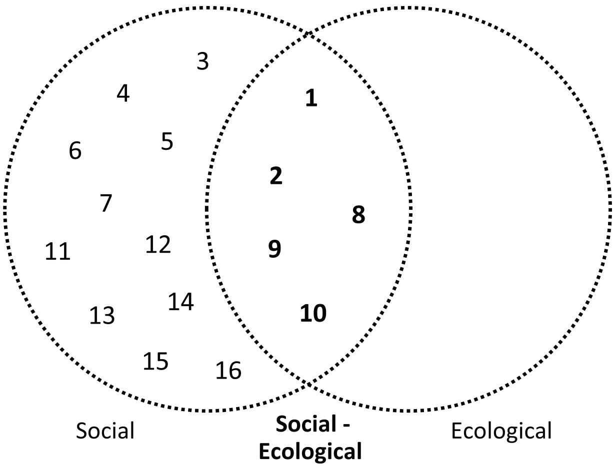

Figure 6. Classification of the stakeholders involved in the co-design processes according to their main knowledge focus.

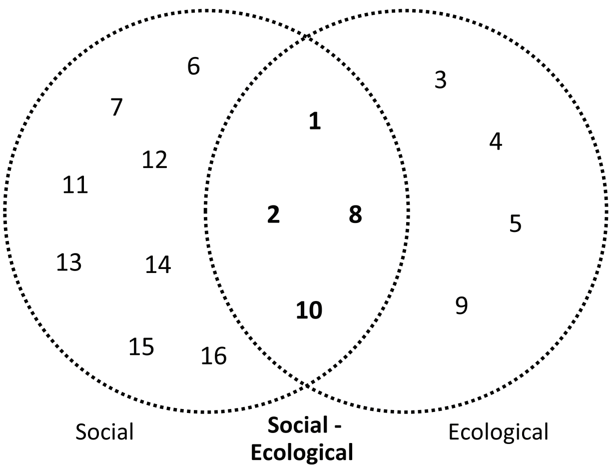

Figure 7. The design teams and experts involved in the co-design processes are classified according to their main knowledge focus.

were mainly reduced to public consultancies about the possible recreation functions of the park. Also, technical engineering projects were classified under the social category because they aim to address human needs. For Case 1, the leading design teams, and public organisations (Ministry of Housing and Urbanism and the Ministry of Public Infrastructure) aimed for a social-ecological integrated approach. This was confirmed by some interviewees that the design teams of architects and hydraulic engineers "had a common idea on the naturalisation and restoration of the riverbed" and that they "developed a way of working together throughout the design process." This was also confirmed by the public servants that commented: "They had to convince the higher authorities to work together with the Ministry of Housing and Urbanism." In Case 2, only the urban designers aimed for social-ecological knowledge integration. This may explain why they reported difficulties getting the engineers on board with such an approach. The public servants interviewed commented that they "tried to convince the neighbour public entities to commit to the project." This is further explained in the following sections.

The interviewees were asked for the informal knowledge gathered to complement the analysis of the design teams and experts involved. According to the interviewees, both cases initially aimed to collect information from citizens and citizen organisations. For both cases, this social-ecological knowledge was reported to have been collected in the conceptual phase. It influenced the following phases in which more conventional design disciplines played a more relevant role.

For Case 1, only a low amount of informal knowledge from citizen participatory studies was reported. Much of what was reported consisted of public space requirements such as football fields, traditional dance squares, market areas, open-air auditoriums, kiosks, and skate squares. Although these requirements are very relevant, they are rather conventional and generic.

Case 2 had much more informal social and ecological knowledge brought to the process. The informal social knowledge reported to have been gathered consisted of requirements for recreation and commercial functions (fishing market areas, delimitation of car parking areas, distributed cafeterias, and snack bars, amongst others), the experiential usage knowledge from citizens, sports organisations (bodyboard, surf, swimming, water polo), and local fishermen, and the existing commercial uses and activation hotspots. This was complemented by social-ecological knowledge from the historical evolution of the seaside, the experiences of the annual Sea Festival to test and promote water sports, and the value of several sports waves for surf and bodyboarding. This is in addition to the ecological knowledge of bird nesting zones, the biodiversity in the rocky seaside areas, the water spring as ecological hubs in the desert, and the natural rock pools throughout the seaside.

Social, ecological, and social-ecological knowledge was recognised to have been relevant in the co-design processes. Both cases dealt with social awareness building, social activities, and social spaces. The processes considered ecological site-specific values spatially, and conservation and restoration areas were combined with urban functions. Some sense of awareness of the climatic crisis was observed in both cases. The following section explains how knowledge integration evolved throughout the processes.

4.2. Social-Ecological Knowledge Integration Throughout the Co-Design Processes

Co-design processes can be understood throughout the three phases in which the project is developed. Figure 3 shows how social, ecological, and social-ecological knowledge was (or was not) integrated into the two cases throughout the different phases.

The design processes started with the conceptual phase, and collaboration was fostered to integrate social and ecological knowledge from multiple actors. According to Figure 8, in Case 1, social and ecological knowledge was integrated. As reported by interviewees, this mainly occurred amongst the design teams and the two public entities involved. On the other hand, in Case 2, social and ecological knowledge was integrated, but the design teams lost the social-ecological integrated approach in the following phases.

In the preliminary phase, one first design is developed, which is further technically detailed in the final phase. In Case 1, this phase sustained the social-ecological knowledge integration achieved in the previous phase. The leader of the architectural firm reported to "have worked in the same office with the hydraulic engineering team." The engineering design leader commented: "We worked together, and both disciplines developed the plans and proposals together."

On the contrary, in Case 2, the preliminary phase was challenging and failed to maintain social and ecological knowledge integration. Interviewees within the architectural design teams reported having problems "working with the engineers because of their conventional ways" and no "flexibly or willingness to make any extra coordination work." This aligns with the miscommunications and mistrust reported by industrial and society interviewees.

Towards the end, the project's technical aspects are defined in the detailing phase. Expert designers conventionally do this, so collaboration with other actors may only occur if fostered by them. How social-ecological knowledge integration happens in the previous phases determines how the technical design decisions respond to them. However, in co-design processes, knowledge influences the technical details of the projects implemented and the space's future use, management, and cooperation. Other actors may play relevant roles in preparing the future implementation of the projects.

In Case 1, the Ministry of Housing and Urbanism started with the "governance of the park" meetings to open the operation decision-making to interested

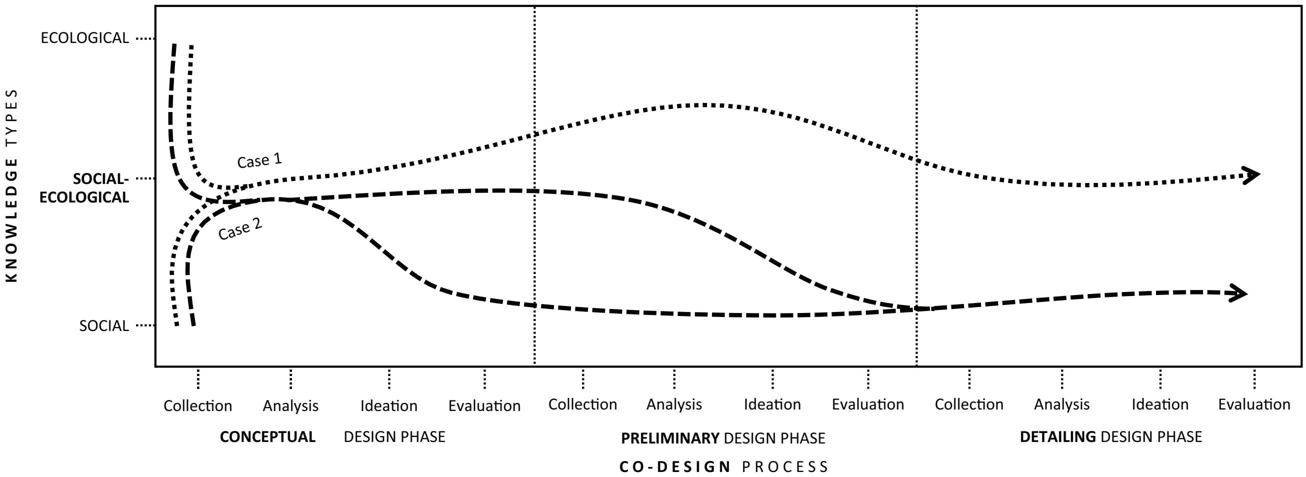

Figure 8. Social, ecological, and social-ecological knowledge in the co-design processes of Kaukari Urban Park (Case 1) and Antofagasta Seaside Park (Case 2).

people. They "invited public servants, cultural organisations, NGOs, academics and citizens" and reported that this measure improved the project's legitimacy and social knowledge towards the end of the process. This allowed them to verify some functions and sports that could be changed in the project to suit the current needs better. Similarly, the floodings that occurred towards the end of the design process also prompted changes in the final project. An additional design change had to be done to the hydraulic design for the river to contain more significant amounts of water to safeguard the city in extreme weather events.

Moreover, in Case 2, the leading NGO organisation changed its executive director, and the project leader assumed its leading role. This was said to improve the communication and involvement of the relevant actors in the first phase and to improve the process and the project definitions in this final stage.

5. Discussions and the Three Dimensions of Public Spaces as Social-Ecological Systems

In this study, we adhere to the conceptualisations of cities and their public spaces as social-ecological systems under uncertainty. Urban design practices should be collaborative to address such complexities. In doing so, social, ecological, and social-ecological knowledge are integrated. We have taken a co-design approach to analyse two co-design processes from practice.

According to the results, all three types of knowledge play a role in public space design. In the processes studied, there were different trajectories due to how the integration evolved from the initial collection of knowledge to the development of the projects where the leading design teams had a predominant role in knowledge integration. In Case 1, the leading design teams worked integrated, which was reported from the processes, the practices, and the project. In Case 2, the design teams did not maintain the initial integration. Even though the project did not address many ecological aspects, they were reported to have protected most of the ecological values mentioned.

Knowledge integration is crucial when co-designing social-ecological systems. Conflicting knowledge and polarisation were observed in the cases studied. First, there were conflicting agendas and aims amongst the diversity of stakeholders involved in the projects. Then, the projects to be implemented generated conflict among the different actors. In Case 1, the citizen and social media were sceptical of the project and its implementation. In Case 2, the inclusiveness of the conceptual phase was challenging to maintain in the following phases, so the project was mistrusted and had to change over time. The idea of knowledge integration speaks of selection. Conflicting knowledge needs to be addressed and therefore prioritised. This is especially relevant when integrating social, ecological, and social-ecological knowledge. From the knowledge collected, some aspects were disregarded or not addressed in the final designs.

Four design steps were used to conceptualise the design cycles. The first three steps are crucial to knowledge integration. The first step contributes to collecting data, information, and knowledge. The analysis and synthesis are crucial in prioritising different forms of knowledge. In this step, selection occurs with conflicting knowledge, which leads to knowledge integration. This was the case of some stakeholder or citizen knowledge and requirements that could have been considered in the projects. The ideation step is where new knowledge is produced. In some cases, social-ecological knowledge was produced as design strategies or designed projects.

Social and ecological knowledge was reportedly integrated into both processes studied. We found that knowledge is attached to its institutions. A collaborative approach to urban landscape design facilitates knowledge integration. A social-ecological approach to knowledge may contribute to opening design not only to spaces, functions, and flows but also to less conventional forms of knowledge. In these cases, many involved actors and stakeholders pursued urban and social aims rather than ecological ones. The fact that the Natural Environment Ministry of Chile, currently in charge of promoting climate adaptation projects throughout the country, was not involved in the cases may suggest why the projects privileged urban requirements over ecological ones. This may be why ecologically focused projects are still exceptional in the country. In this study, we found that there is no perfect process and no perfect social-ecological project.

In the conceptual phase, the problem is defined and agreed upon, which allows for defining the main criteria and objectives to which the project should respond. The fact that social-ecological knowledge was present and increasing in this phase influenced the following phases. In the embodiment phase, the first design proposals are ideated, so if relevant knowledge was integrated before, it is used. The detailing phase is often technically oriented, but it is also when the implementation, use, management, and further operation can be fostered.

Findings suggest that the social-ecological systems approach to public space design may widen urban design's focus on spatial layouts and essential functions. As suggested by the interviewees, the physical and spatial dimensions were combined with dynamic and institutional ones. We found that an urban landscape project should consider physical and temporal (dynamics, flows, and activities that can be unexpected) and that they depend on their institutional systems. We confirmed that public spaces could be conceptualised as social-ecological systems. The physical dimension of public spaces considers their spaces with urban and ecological elements. The dynamic dimension involves flows, activities, mobility, and ecological biodiversity. The institutional dimension refers to the actors, their rules, and their interactions. Urban social-ecological systems should be conceptualised, analysed, and designed as interdependent spaces, dynamics, and institutions. Doing so may contribute to the awareness of social and ecological conflicts and uncertainties and open possibilities for urban resilience and adaptation.

Social-ecological systems should be studied across space and time, considering the actors at stake. This should happen not only during the design process but also throughout the whole span of the lifecycle of public space, including the previous and the implementation and operation phases. The more the awareness of unpredictable functions flows, and dynamics, the more flexible and transformable spaces will be incorporated into the design. Designers should define the crucial elements of their social-ecological systems while keeping them open for future change.

6. Conclusions

We analysed knowledge integration throughout the co-design processes of two big-sized public spaces. We wanted to answer how is sometimes conflicting social-ecological knowledge integrated into public space co-design processes. We wanted to know who contributed and integrated, what kinds of knowledge, and when this happened.

To answer the research question, we developed an analytical framework to analyse social-ecological knowledge in co-design processes. The two cases had been previously studied (Gaete Cruz et al., 2021, 2022b). This study conceptualises social-ecological systems and knowledge in co-design processes and focuses on the contents of the projects.

This study connects various bodies of academic literature. It builds on co-design literature following the author's previous studies (Gaete Cruz et al., 2022a, 2022b, 2023). This study is a step towards uncovering the roles of knowledge in co-design processes, which is especially relevant in social-ecological systems literature. According to the main findings, more stakeholders and design teams should hold a social-ecological integrated approach. Ecological expertise and design approaches should be fostered to improve urban resilience in contexts where innovation is rare.

The findings of this study should be contrasted by analysing other cases. The difficulty in grasping and communicating knowledge made it difficult for interviewees to relate to the object of study. There may be limitations to the framework's applicability and findings in other contexts. The trajectories express knowledge integration but must differentiate between interdisciplinary and transdisciplinary approaches. Further studies could focus on the roles of knowledge within and beyond disciplines. Also, the roles of tacit and explicit knowledge could be studied. This would be especially interesting if analysed in the different design steps.

Analysing social-ecological knowledge in co-design processes allowed us to discuss generalisable and context-specific findings and contribute knowledge for practice. This study contributes an analytical framework to study co-design as a social-ecological knowledge integration process. We found that multiple forms of knowledge were integrated (social, ecological, and social-ecological) throughout the three design phases (conceptual, preliminary, and detailing). This knowledge integration occurs in the collection, analysis, and ideation design steps. Stakeholders, design teams, experts, and citizens contribute and integrate knowledge in these steps. This study advances the conceptualisation of knowledge integration in co-design.

Further research should aim to understand how integrating sometimes conflicting social-ecological knowledge may improve resilience. Approaching social-ecological systems as unfolding in space, dynamics, and institutions may allow the assessment of urban resilience. This study is the baseline for analysing public space projects and the embodied resilience of their design strategies. The author is currently assessing the resilience of public space design strategies.

Although the cases are framed in the Latin American context, findings may be useful elsewhere. The framework may be used for social-ecological systems research, and findings may provide guidelines for co-design practice.

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Conflict of Interests

The author declares no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the author (unedited).

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