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CONTEXTS

SYSTEMIC DESIGN ASSOCIATION

Methodological Pluralism in Practice: A systemic design approach for place-based sustainability transformations

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Abstract

To leverage the fullest potential of systemic design research in real-world contexts, more diverse and reflexive approaches are necessary. Especially for addressing the place-based and unpredictable nature of sustainability transformations, scholars across disciplines caution that standard research strategies and methods often fall short. While systemic design promotes concepts such as holism, plurality, and emergence, more insight is necessary for translating these ideas into practices for engaging in complex, real-world applications. Reflexivity is crucial to understanding these implications, and systemic design practice will benefit from a deeper discourse on the relationships between researchers, contexts, and methods. In this study, we offer an illustrated example of applying a diverse and reflexive systems oriented design approach that engaged three mountain communities undergoing sustainability transformations. Based on a longitudinal, comparative research project, a combination of methods from systemic design, social science, education, and embodied practices was developed and prototyped across three mountain regions: Ostana, Italy; Hemsedal, Norway; and Mammoth Lakes, California. The selection of these regions was influenced by the researchers' varying levels of previous engagement. Reflexivity was used to explore how place-based relationships influenced the researchers' interactions with each community. Different modes of reflexivity were used to analyze the contextual, relational, and boundary-related factors that shaped how the framing, format, and communication of each method and practice adapted over time. We discuss these findings through visualizations and narrative examples to translate abstract concepts like emergence and plurality into actionable insights. This study contributes to systemic design research by showing how a reflexive approach of weaving across different places, methods, and worldviews supports the critical facilitation processes needed to apply and advance methodological plurality in practice.

Keywords: reflexivity, regeneration, action research, mountains, community engagement, real-world laboratories, embodied practices

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1. Introduction

"We are constantly navigating real-world systems that exceed our capacity to fully understand them" (Midgley & Lindhult, 2021, p. 647). This concept is reflected in the latest developments in sustainability science and transitions research. Instead of standardized, "one size fits all" solutions, there is growing awareness of the need to interweave different cultural and disciplinary perspectives to address today's socioecological crises (Caniglia et al., 2020). However, current approaches lack the know-how to navigate the epistemological and practical challenges of pluralizing different cultures of reasoning and their respective methods (Knickel et al., 2019; Schlüter et al., 2022). For example, there is increasing support for integrating participatory design practices, systems thinking, and sustainability transition theories to address complex "wicked" problems more effectively (Coops et al., 2022; Irwin, 2015), with systemic design emerging as a promising approach for intervening in regenerative systems change (Jones & Van Ael, 2022; Sevaldson, 2022). Yet to leverage the fullest potential of systemic design, expanding knowledge systems, methods, and practices, from scientific knowledge to lived experiences, is critical to engage with plural, value-laden challenges such as sustainability (Luthe, Fitzpatrick, et al., 2021; Vink, 2023). To pluralize systemic design approaches, methods, and researchers' roles, greater reflexivity is needed to avoid inadvertently reproducing systemic injustices (Soriano et al., 2022; Vink & Koskela-Huotari, 2022). Furthermore, practical examples are needed to test and apply reflexive and plural approaches in complex, real-world contexts (Bergmann et al., 2021; Luthe, 2017).

Toward the aim of developing more plural and reflexive systemic design methodologies, we provide an illustrated example of applying a multimodal approach to engage across "real-world" communities undergoing sustainability transformations. We prototyped a systemic application of plural methods and practices across three international mountain communities: Ostana, Italy, Hemsedal, Norway, and Mammoth Lakes, California to explore ways of understanding and engaging in complex systems. Rural mountain communities, significantly impacted by climate change and characterized by complex socioecological relationships with urban areas, are key areas for studying sustainability transformations (Wyss et al., 2022). The researchers' embodied knowledge and ongoing ties with these three mountain communities informed their understanding of each one's unique cultural, geographical, and scale-based responses to shared challenges. A systems oriented design approach (SOD) (Sevaldson, 2022) was used to investigate how the evolving relationships between context, stakeholder dynamics, and researchers' roles influenced how and when methods were used. Through concrete examples, we expand on Olmos-Vega et al.'s reflexivity framework (2022) to illustrate how diverse modes of reflexivity can expand plural approaches in systemic design.

In the following sections, we provide a brief framing of the relationships between reflexivity and methodological plurality and how these relate to systemic design research (Section 2). Second, we explain the methodology, including descriptions of the different methods and practices and communities (Section 3). Third, we describe the process of systemically applying plural methods and practices within and across each of the communities and synthesize key themes through different reflexivity modes (Section 4). Finally, we discuss the learnings gained, the limitations of the research, and possible future research avenues to increase plurality in systemic design (Section 5).

2. Theoretical Framing

Recently, research on sustainability transitions and transformations has emphasized more diverse, context-specific, and participatory approaches to better intervene in complex systems change (Caniglia et al., 2020). Transdisciplinary and mixed-method strategies are gaining considerably more attention, yet more research is needed on how to maintain the integrity of individual knowledge systems in combined approaches (Goodchild, 2021; Schlüter et al., 2022). This challenge relates to a concept known as methodological pluralism, which seeks to engage with epistemically different and sometimes conflicting methods to support plural ways of understanding complex challenges (Midgley et al., 2017). Systemic design offers the potential to advance methodologically plural approaches for place-based sustainability transformations yet requires greater inclusion of methods and practices outside of design (Luthe et al., 2021) through practice-based examples (Blomkamp, 2022). Building from Vink (2023), we argue that reflexivity is central to advancing understandings of methodological pluralism in systemic design through prototyping interactions with diverse actors and contexts and evaluating insights gained. In the following sections, we discuss how reflexivity has been used within design fields and, more recently, in sustainability science. We continue this discussion on how this relates to the challenges and opportunities in expanding systemic design methodologies and where further attention is needed.

2.1 Reflexivity: A precursor for methodological plurality

Reflexivity is increasingly viewed as an essential skill to better engage with and understand complex "wicked problems" (Moore et al., 2018; Nastar, 2023). Reflexivity[1] is "a problematic [and] paradoxical concept"(Babcock, 1980, p. 2) that involves the process of actively questioning our thoughts, values, and actions to better understand our roles in relationship to others (Bolton & Delderfield, 2018). Critical systems theory has argued that reflexivity is necessary for boundary critique as it is an interdependence of observations, evaluations, and

[1] Diverse modes of reflexivity can be used to analyze complex issues, such as corporeal and cultural reflexivity (Vink & Koskela-Huotari, 2022), epistemological reflexivity (Palaganas et al., 2017) and methodological and contextual reflexivity (Olmos-Vega et al., 2022). Different *types* of reflexivity (self-reflexivity, indexical reflexivity, symbolic reflexivity, etc.) along with *distinctions* (internal or external, implicit or explicit, etc.) offer diverse ways to understand complex meaning-making processes and cultural phenomena (Babcock, 1980).

boundary judgments (Midgley, 2000; Ulrich, 2003). Reflexivity is crucial for sustainability transformations to challenge the separations between humans and nature, as well as the disciplinary boundaries that shape research agendas (De Verlaine, 2022; Knaggård et al., 2018). This relates to Beck, Giddens, and Lash's theory of reflexive modernization, which suggests that in today's era of "risk societies" of managing complex crises, traditional institutions and norms are re-evaluated and rearranged in response to an unprecedented growth of knowledge, technology, and other forces (Beck et al., 1994).

In design research, understanding the role of *reflection* has been influenced by Schön's seminal work on the concept of the reflective practitioner and the distinction between reflecting-in-action versus reflection-on-action (Schon, 1983). Yet *reflexivity*, often prompted by unexpected or uncomfortable experiences, is not necessarily guaranteed in design processes (Bleakley, 1999). Instead, reflexivity must be cultivated through intentional actions (Vink, 2022) and self-questioning to critically assess the ethical impacts of one's actions on society (Ulrich, 2000). Despite increasing scholarship on the relationship between reflexivity and design methods (Vink & Koskela-Huotari, 2022), designers and design researchers need to be more reflexive of method choice and use when working in diverse cultural contexts (Öz & Timur, 2023). Within systemic design, scholars argue for greater reflexivity in how researchers identify and design interventions for systems change (Van der Bijl-Brouwer & Malcolm, 2020).

This relates to the shifting researcher roles in both systemic design and sustainability science. There is an increasing emphasis on de-centering the role of a designer/design researcher and, instead, focusing on facilitating collective co-design (Öz & Timur, 2023). Similarly, sustainability science researchers are becoming more active within their systems of study, expanding their roles from traditional observers to "process facilitators" and "change agents" (Wittmayer & Schäpke, 2014). For example, researchers in both design and sustainability science tend to adopt more facilitator and coordinator roles when working with practitioners and real-world challenges (Bulten et al., 2021; Zielhuis et al., 2022). The skills developed in these positions can be described as "orchestrating capacities," or the ability to mediate knowledge and ideas across multiple types of actors, sectors, and scales (Horlings et al., 2020). However, there is a substantial need for greater reflexivity to understand how researcher roles across disciplines shift according to different contexts, project stages, and method choices. This points to a broader need to promote capacities for researchers and practitioners alike to "intentionally cultivate … a deepening of system reflexivity over time" (Moore et al., 2018, p. 3).

2.2 Methodological plurality: process-oriented and adaptive

Reflexive research approaches are entangled with methodology. Methodological reflexivity is essential for recognizing the link between methods, theoretical assumptions, and sense-making processes (Dervin, 1999). Design researchers suggest that reflexive approaches are process-oriented and use a wide range of methods (Buchert, 2021; Dorst, 2019). Scholars working across design and sustainability science highlight the need for transitions research to focus more on processes, like those found in design research, rather than outputs (Gaziulusoy & Öztekin, 2019). Yet, when working in real-world, complex systems, there are substantial methodological gaps in grappling with constantly changing contexts

(Vandenbussche et al., 2020). A deeper investigation is needed into how methods can adapt without compromising integrity (Knickel et al., 2019; Law, 2004), as well as expanding methods to include more plural ways of knowing and being (Akama et al., 2019).

Gerald Midgley has framed this concept as "methodological plurality," or the act of incorporating methods from different disciplines and knowledge domains to expand ways of engaging in complex systems (Midgley, 2000; Midgley & Lindhult, 2021). Midgley et al. (2017) continue to describe the conundrum of methodological plurality as the intersection of a *philosophical challenge* (irreconcilability of paradigms attached to certain methods), a cultural challenge (separation of knowledge based on different systems), and a *psychological challenge* (resistance to learning new methodologies). Within systemic design, more clarity is sought to learn how diverse approaches can enhance, not replace, designerly ways of knowing (Sevaldson, 2022). Systemic design advocates for plurality and contextual specificity of methodologies and practices to activate systems change (Sevaldson & Jones, 2019). However, scholars highlight the need to expand beyond the field's established mapping methods, as their two-dimensionality can restrict plural ways of knowing and being (Vink, 2023). For example, some are investigating the use of gamification to enhance understanding of Indigenous perspectives and the impact of Western treaties (Singh & Calahoo-Stonehouse, 2022). Other scholars advocate for more embodied practices and lived experiences of complex systems (Lake et al., 2022; Vink, 2023) as well as scientific, quantitative methods, like social network analysis (Luthe et al., 2021; Murphy & Jones, 2020) and those found in sustainability transitions research (Gaziulusoy & Öztekin, 2019).

2.3 The need for situated, place-based examples

While theoretical discussions on reflexivity, methodological adaptability, and plurality are gaining attention, there is a shortage of concrete cases where these concepts are applied in practice (Blomkamp, 2022). There is a substantial need for more responsible scaling of place-based sustainability strategies across different contexts (Lam et al., 2020). More knowledge is needed on how to transfer insights gained from a particular place to other contexts and scales without reproducing systemic harm (Balvanera et al., 2017). Systemic design researchers are increasingly acknowledging the situated realities and lasting effects of design initiatives on diverse communities, yet community engagement efforts could be further expanded across the field (Lake et al., 2022).

Therefore, we aim to help address these gaps by offering a prototype for an expanded understanding of systemic design through comparative, illustrative real-world examples of engaging in three mountain communities—Ostana, Italy, Hemsedal, Norway and Mammoth Lakes, California. The in-depth place-based knowledge and ongoing relationships with each of these communities substantially influenced methodological decision-making. Reflexivity was a central aspect throughout the research project, from designing the methodology to navigating complex and unpredictable conditions in different cultures and places, interpreting data, and understanding the researchers' changing roles.

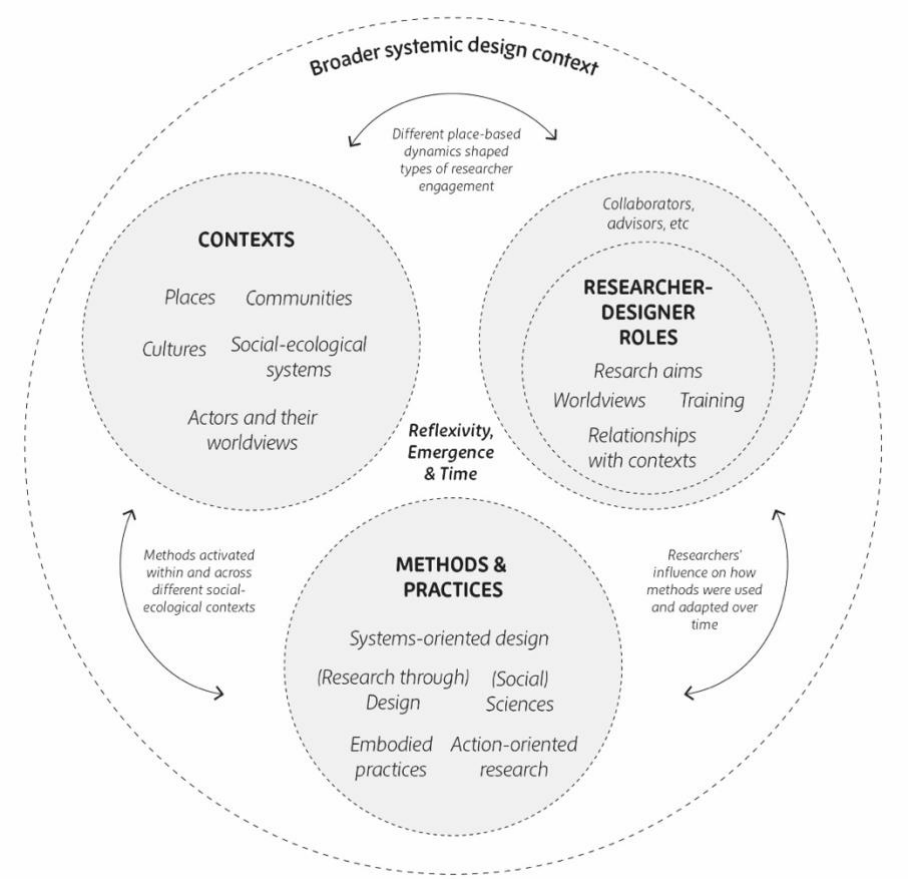


Figure 1. Diagram of overall methodology describing the relationships between methods and practices, contexts, and researcher roles.

We build on the reflexivity framework of Olmos-Vega et al. (2022) to analyze the findings, which are further explained in Section 4. We use "engage" as an overarching term to describe the first author's active participation in working with, learning from, and adapting to each of the mountain communities' dynamic contexts. We see the concept of engaging in complex systems distinct from *intervening*—which is often used in systemic design discourse to describe the deliberate actions of a designer/researcher to influence or improve the system. Rather, we focus on how the systemic application of plural methods and practices can encourage shared reflexivity and lay the groundwork for future community-led interventions. This distinction is further discussed throughout the findings and discussion sections.

3. Methodology

3.1 Weaving together methods, contexts, and researcher roles through systems oriented design

Systemic design was the overarching approach to guide this Research through Design (RtD) and community-based participatory action research (CBPAR) project (Figure 1). While systemic design broadly encompasses design methodologies and systems thinking, we expand on this general definition and include quantitative and qualitative science-based methodologies and embodied practices[2] (Figure 3).

Systems oriented design (SOD), considered a praxis-based "dialect" of systemic design (Sevaldson, 2022), was used to examine the relationships between researcher roles, methods and practices, and contexts (Figure 1). Research through (or by) design is integral to SOD and was used to navigate the complexities of working with practice-based, real-world contexts[3]. Likewise, CBPAR was used to guide how the first author engaged across each of the three mountain communities. A branch of participatory action research (Cornish et al., 2023), CBPAR[4] is a collaborative approach that aims to empower community members, address local needs, and build capacity through participatory methods that can lead to positive change (Checkland, 1999; Mosavel et al., 2019; Wilson, 2019).

Within these broader research and design research approaches, a selection of established systemic design methods, methods from social sciences, and practices from embodied research was prototyped across three different mountain communities (Figure 3). Likewise, the research drew from the first author's professional expertise in visual communication, incorporating visual methods like diagramming, sketching, and photographic documentation (Mitchell et al., 2018) as both process and communication tools. Overall, the first author's background, institutional relationships, including the second and third authors, research

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2 Here, we frame embodied practices as part of a wide range of transdisciplinary scholarship around embodied research which emphasizes the bodily experiences of researchers and/or participants (Spatz, 2017). Practices such as physical observations, movement traditions, role-playing, ceremony, etc. can range from artistic, spiritual, and sports-based (Lundvall & Maivorsdotter, 2021). Embodied experiences are increasingly acknowledged in sustainability transformations research (Bentz et al., 2022). Likewise, embodied practices are significantly lacking in systemic design research, yet are helpful in studies to cultivate situated and action-oriented change (Vink, 2023).

3 RtD has largely focused on generating knowledge through designing artifacts and prototypes to better understand complex, future-oriented problems (Jonas, 2007). For example, gigamapping, a core practice in SOD, is also an RtD artifact that supports processes of building relational insight (Sevaldson, 2022).

4 CBPAR/PAR and broader ethnographic research share commonalities, such as prioritizing participants' perspectives and employing a range of qualitative methods such as fieldwork, interviews, and participant observation. Yet while ethnography emphasizes understanding participants' lives through theoretical interests with researchers as external figures, PAR centers on addressing community-defined problems collaboratively, involving participants extensively in all stages of the research process (Eisenhart, 2019).

aims, and different place-based relationships significantly influenced the systemic application[5] of plural methods and practices[6] within and across each community.

3.2 Comparative contexts—Mountain communities as rich spaces for reflexivity

The first author prototyped a systemic application of plural methods and practices concurrently across the three mountain communities over two years (i.e., Ostana, Hemsedal, and Mammoth Lakes). Rural mountain communities are seen as barometers of climate change effects and, thus, critical contexts for investigating complex sustainability transformations (Steiger et al., 2022). Mountain communities offer valuable opportunities for reflexivity due to their connection with wider urban and regional socioecological systems while offering feasible spatial boundaries for study (Wyss et al., 2022). Each of these communities was selected based on several factors: comparability, diversity, and the researchers' existing relationships. Each community is based on a single-sector tourism industry with clear economic exchange to nearby urban areas and increased strain on local infrastructure. However, each community has different scales (population size and municipal boundaries), cultures (both at a national and regional level), historical relationships to place, and stage within their sustainability transformations (Luthe & Wyss, 2015) (see Table 1). This offered the possibility to compare how shared sustainability challenges manifested uniquely across each distinct context. Figure 2[7] illustrates key perceived challenges that local and regional participants identified during workshops, interviews, and embodied practices that the researchers facilitated. Furthermore, the researchers' in-depth place-based knowledge and varying degrees of relationships with these communities provided the opportunity to understand how our roles influenced the engagement processes, which is further explained in Section 3.3.

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[5] We consider a *systemic* application of plural methods and practices to be based on core systems-thinking principles, such as embracing adaptability, emergence, complexity, and uncertainty in the methodological process.

[6] We use the term *practice* to describe the situated, community-based activities performed in place with stakeholders (see Section 3.4 "Embodied practices"). Sevaldson explains practice through the lens of praxeology, which is a set of "practices, experiences, and tacit knowledge that are externalized and systematized in a tool chest or library … compared to a methodology, it does not describe procedures that are repeatable. Instead, [praxeology] describes heuristics, experiences, and problematiques." (2022; p. 324).

[7] This diagram is not a comprehensive picture of all identified community challenges but rather illustrates that certain challenges are perceived by participants to be more significant than others (i.e., "loss of historical identities" is perceived as a greater challenge in Ostana than in Hemsedal). See Supplemental Material (Table 4) for further information.

Ostana

Ostana, the smallest of the three communities, is in the Piedmont region in the Cottian range of the Italian Alps. Ostana is characterized by five small settlement clusters spread along steep slopes and connected by trail networks. The town suffered a depopulation crisis due to the industrial automobile growth of the 1950s and 60s. In the early 2000s, when only five full-time residents remained in the village, the mayor initiated a re-inhabitation project for Ostana through a new tourism economy by promoting the restoration of local Occitan culture and architecture. This growth-oriented approach is currently of central interest to the community. As indicated in Figure 2, participants perceived and identified a "loss of historical identities" as a key challenge the community faces.

Hemsedal

Hemsedal is in the Viken region along historical trade routes between Bergen and Oslo, at the eastern edge of Norway's western mountains. Hemsedal is one of the few communities with an increasing population rate in the rural Hallingdal Valley. Hemsedal's built environment comprises three main settlements along the Hemsila River: Trøym (where the municipal center is located), Ulsåk, and Tuv, and dispersed agricultural settlements. Hemsedal is home to Norway's second-largest ski resort and can attract up to 50,000 tourists per winter season.[8] As indicated in Figure 2, participants perceived and identified "centralized power in single sector economy" as a key challenge the community faces.

Mammoth Lakes

Mammoth Lakes is in the Eastern Sierra region of northern California, United States. Before Western colonialization in the 1800s, this area was and continues to be stewarded by many Indigenous peoples who call the region Payahuunadü, or "land of the flowing water." The water wars of the early 1900s resulted in the diversion of the Owen's River to the Los Angeles aqueduct, causing systemic dewatering of the region, resulting in toxic dust pollution, loss of local food production, and disenfranchised tribal communities. Mammoth Lakes' major ski resort has contributed to significant seasonal and year-round population growth in the last 50 years, with unprecedented numbers during the COVID-19 pandemic. As indicated in Figure 2, participants perceived and identified "tension/siloing across social groups" as a critical challenge the community faces.

[8] Per interview with a manager at the local tourism office. Conducted by researchers in March 2022.

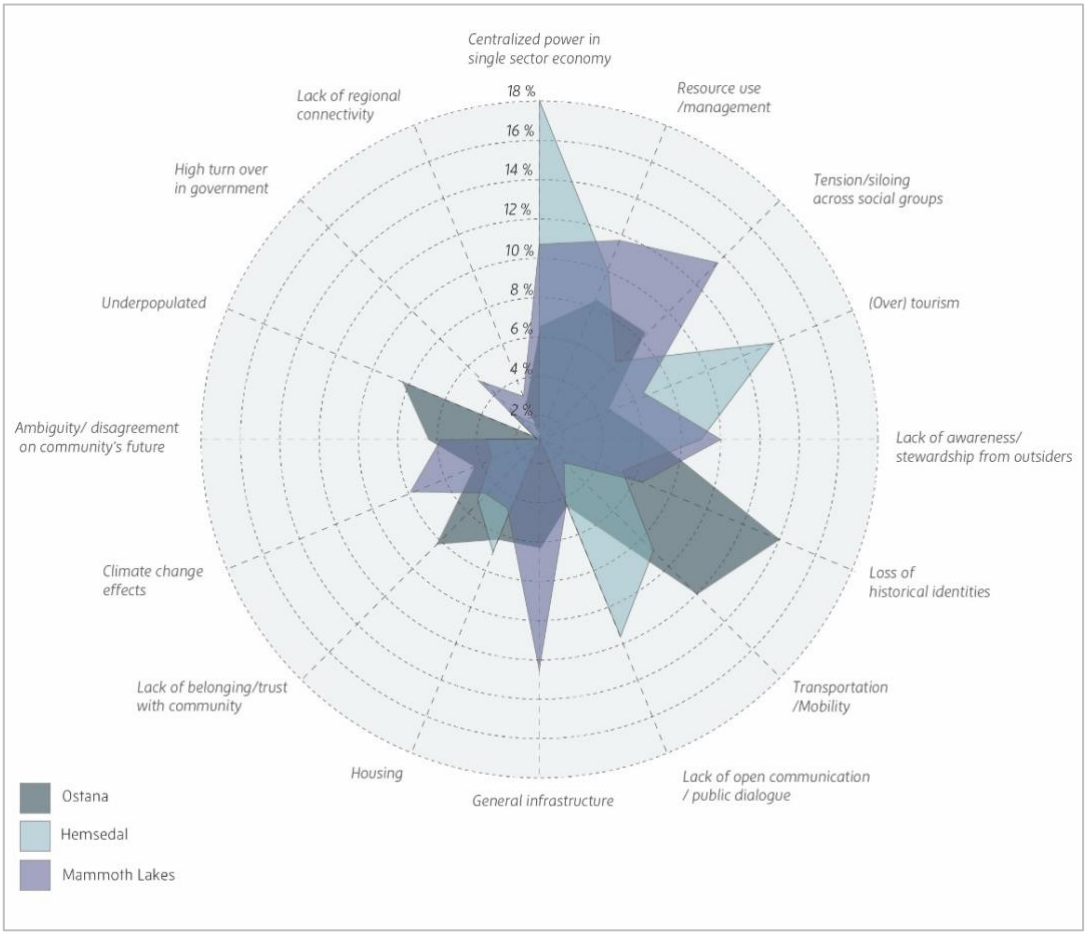


Figure 2. Key perceived challenges identified by participants during workshops, interviews, and community events. Percentages reflect the number of codes assigned to each challenge theme using qualitative content analysis through MAXQDA software.

Table 1. Comparison of Community Contexts

	Ostana Italy	**Hemsedal Norway**	**Mammoth Lakes, California, USA**
Climate characteristics	Temperate alpine; 1350m asl	Subarctic alpine; 650m asl	High alpine desert; 2500m asl
Major water system	Po River	Hemsila River	Payahuunadü, now known as the Owen's River (diverted to Los Angeles Aqueduct)
Predominant climate change effects	Drought, high-intensity storms, reduced snowpack	Flooding, reduced snowpack	High-intensity wildfires, flooding, reduced snowpack
Original peoples and associated culture, language	Ostanese, Occitan culture and language	Hallingmål dialect, Norse culture	Paiute and Kutzadika'a peoples, Numu language
Size of municipality	16.8 km2	753 km2	65.5 km2
Distance from the nearest city	Turin, 80 km	Oslo, 200 km	Los Angeles, 500 km
Population	84 (registered) 50 (full-time residents) (2020)	2,622 (2022)	7,271 (2021)
Historical economy (from 1800s)	Agriculture	Agriculture	Mining, ranching
Shift towards current tourism economy	early 2000s (municipality led re-inhabitation initiative)	1950s (private development of ski resort)	1960s (private development of ski resort)
Degree of community engagement with research project*	High (municipality and local/regional stakeholders consistently active in ongoing research activities with MonViso Institute)	Medium (municipality and local/regional stakeholders active throughout research activities)	Low (local/regional stakeholders active during targeted research activities)
Sources:	Istitutio Nazionale di Statistica (ISTAT)	Statistik sentralbyrå (SSB) Norway	United States Census Bureau

* See Supplemental Material (Table 4) for information on community engagement.

3.3 Researchers' Role: Entry points

All three co-authors had varying roles in the project. The third author significantly contributed to the institutional and SOD-based foundation of the research; the second author provided scientific and place-based framing. The second author also functioned as a "door opener" for the first author to engage in each community, with substantial expertise in community-based, transdisciplinary sustainability research in mountain areas. The first author executed the methodology, data collection, and analysis with guidance from the second and third authors. The first author's institutional relationships with these communities influenced engagement strategies. Table 2 highlights how the researchers were connected to each community, with an ongoing, long-term relationship with Ostana through the collocated research laboratory MonViso Institute, a growing relationship with Hemsedal through The Oslo School of Architecture and Design, and a nascent relationship with Mammoth Lakes with a few local contacts, but no institutional connection. These distinct "entry points" into each community shaped the degree of embeddedness the researchers had at the start of the project. As further discussed in the findings section, this allowed the first author to "step into the system [and] move with the system" (Ruijer et al., 2023, p. 131) to varying degrees, which led to different methodological outcomes.

3.4 Plural Methods and Practices

The following section describes a selection of different methods and practices, their origins, and why they were included in the research methodology (Figure 3). The interaction of these methods and practices was emergent and systemic, responding to broad research aims, researchers' backgrounds, contextual specificities, and unplanned circumstances that evolved during the project. The following ten methods and practices were selected to grapple with and communicate place-based challenges across each community and co-create possible pathways to address those challenges. Supplemental Material[9] further details the functions, disciplinary backgrounds, limitations, and formats of each method/practice. Most of the methods and practices—directly or indirectly—were used to stimulate reflexivity about the actors' roles within their communities to build awareness of broader complex systems (Vink & Koskela-Huotari, 2022).

[9] https://systemic-design.org/wp-content/uploads/2024/03/2024_VOL2_FITZPATRICK_Supplemental-Material.pdf

Table 2. Researchers' Entry Points in Each Community

Metric	**Ostana Italy**	**Hemsedal Norway**	**Mammoth Lakes USA**
Prior engagement before research project	Yes	No	No
Institutional relationship	1st author was a volunteer since 2019 at MonViso Institute (MVI); 2nd author is Director	Both researchers were instructors at AHO for courses in systems oriented design	No direct institutional relationship: The 2nd author had prior research activities in the region
Initial stakeholder relationships	Municipality members, mayor and vice-mayor, local business owners, and regional actors from MVI network	Second-home owner from 2nd author's network	Second-home owner and director of research lab from 2nd author's network
Frequency of first author's engagement	5-6x per year (20 visits total), 4-5 day stay average (2 hrs by train from Turin)	2x per year (6 visits total) with 1 week stay average (3 hrs by bus from Oslo)	3 visits with 1-week stay average (15 hrs flight from Oslo - LA, 5 hrs drive from LA to Mammoth Lakes)
Funding resources	Accommodation provided by MVI and transport covered by AHO research stipend	Accommodation and transport covered by AHO student course budgets	Accommodation and transport covered by AHO research stipend and external grants

As illustrated in Figures 2 and 3, these methods and practices range from design (gigamapping, synthesis maps, layered landscape mapping, interactive booklets), social sciences (semi-structured interviews, social network analysis, socio-economic census data collection), and embodied practices (curated outdoor experiences, which often included student groups and everyday participation in community practices). No recruitment occurred for any of the participatory methods and practices; instead, we advertised voluntary events through our initial stakeholder relationships (Table 2), local institutions' social media, and municipality outlets. While these diverse methods and practices were selected before the project started[10], the decision of when to apply each one in situ was an intentionally emergent process based on real-time learning and engaging with the dynamic factors of each community. Figure 3 visualizes the systemic interactions between each method or practice, i.e., used to generate knowledge, build stakeholder relationships, corroborate data, or enhance a different method or practice. The methods and practices are categorized into two broad typologies: continuous (ongoing, non-sequential) and punctual (sequential and planned). Most punctual methods depended substantially on group participation and extensive coordination, influenced by the researchers' degree of embeddedness with the community. Continuous methods, on the other hand, such as data collection for social network analysis, were not necessarily pre-planned but rather shaped by emergent conditions from each context.

The methods and practices identified in Figure 3 and explained below represent just one of many possible combinations of approaches to better understand and engage in complex systems. In Section 5, we discuss the limitations and suggest other types of methods and practices that would be useful to explore in future research.

Design Methods

Gigamapping workshops

Gigamapping, a core SOD method for system mapping, serves as both a device and a reflexive practice to generate relationships across complex systems (Davidová, 2020; Sevaldson, 2015). For this project, co-creative gigamapping workshops were conducted in each community to gather stakeholders' perspectives on interconnected challenges and future aspirations. These "visual dialogue" sessions stimulated critical reflection on the participants' roles within their communities and how they relate to different social and ecological systems. The format and number of participants varied according to various drivers, such as season, stakeholder relationships, and other events already happening in the community.

[10] Exceptions include layered landscape mapping, interactive booklets, and curated outdoor experiences. These three methods and practices were identified *during* the project, based on needs that emerged from engaging in the communities.

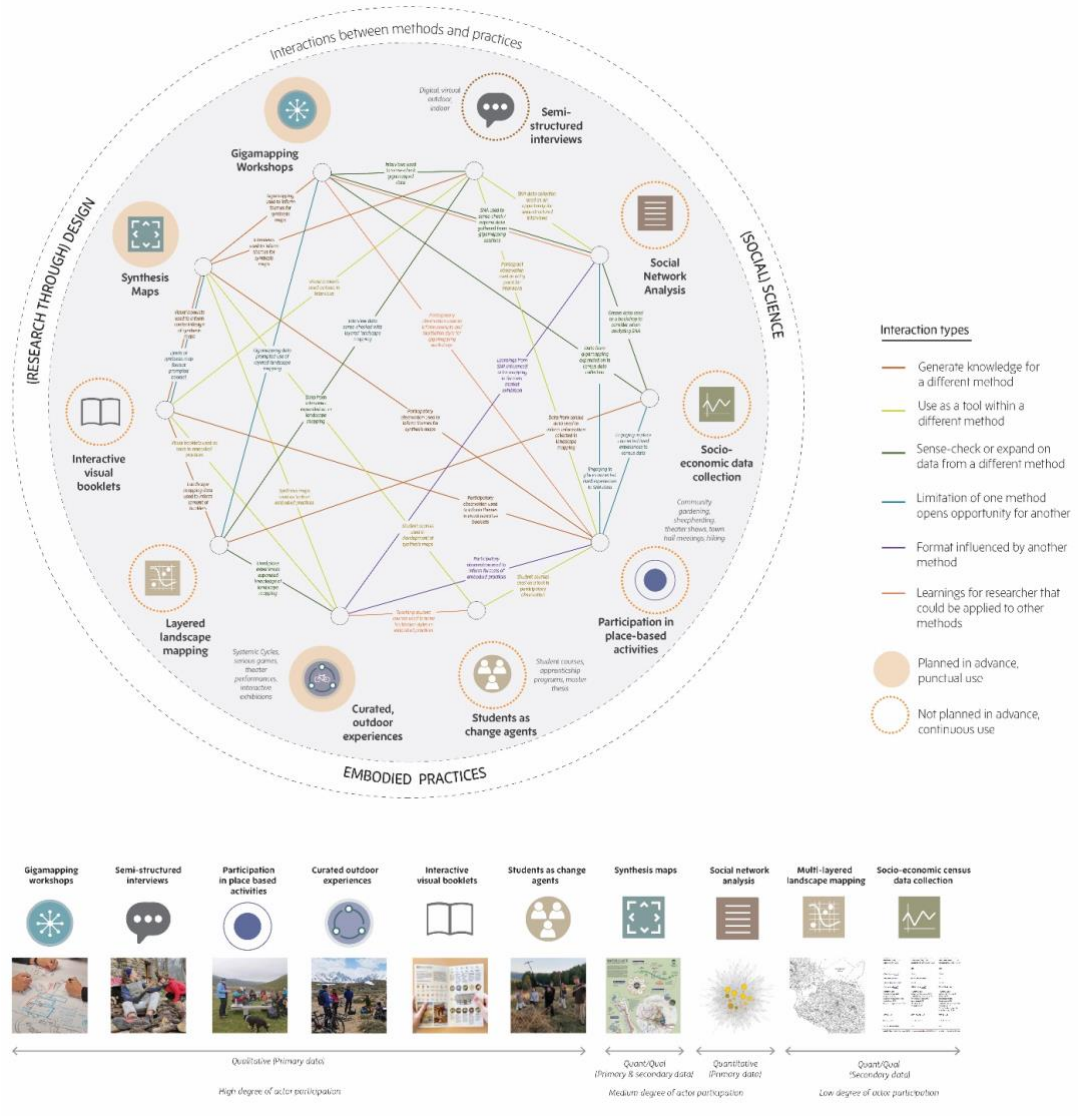


Figure 3. Ten plural methods and practices were tested across each of the three communities (circle diagram). This diagram illustrates the roles and systemic interactions of each method/practice during the research project. Photo examples of each method/practice are organized by degree of actor participation and data collection types. See Supplemental Material for full-sized images. Image sources: Haley Fitzpatrick and Tobias Luthe.

Synthesis Maps

Synthesis maps are an established systemic design method for visualizing complex systems and potential design interventions, particularly geared toward stakeholders (Jones & Bowes, 2017). Synthesis maps were used in this project to highlight themes from the gigamapping sessions and as "conversation starters" to stimulate critical thinking on current challenges and possible futures for each community. Likewise, the maps provided opportunities to sense-check with stakeholders the data collected in other methods, such as gigamapping workshops, interviews, and social network analyses. They were also used as a teaching device in Hemsedal and co-developed within student courses.

Interactive Visual Booklets

Visual booklets and interactive pamphlets were prototyped during the project due to the need for physical pocket-sized formats. Many interactions and interviews with stakeholders occurred outdoors or for shorter timeframes. Booklets were especially used in Mammoth Lakes to build stakeholder relationships due to the first author's low existing social network. In Hemsedal, a different pamphlet was prototyped with interactive drawing prompts for local business owners to share their perspectives on the future of Hemsedal. In Ostana, a digital booklet and interactive board space using Miro software were prototyped to maintain the continuity of discussions after the gigamapping workshops.

Multi-layered Landscape Mapping

In addition to the social dimension, multi-layered landscape mapping was conducted to understand how community challenges might be revealed spatially. This method, common in landscape architecture, involves separating and re-layering various maps or data sets to reveal and understand hidden connections between elements such as topography, vegetation, infrastructure, and land use. (Cohen, 2019). These aspects, as well as street connectivity and spatial accessibility to services and public spaces, are important criteria for assessing community resilience (Sharifi, 2016). For this project, the quantitative Geographical Information Systems (GIS) method was used to collect secondary data from each community's public records and transfer them into spatial maps. The series of maps was used to inform themes within the synthesis maps and provide a spatial understanding of the challenges participants raised during interviews and gigamapping sessions.

Embodied Practices

Curated Outdoor Experiences

Curated outdoor experiences were conducted to expand beyond two-dimensional representations of complex systems (i.e., mapping) and provide more embodied, textured understandings of such systems. Outdoor movement that connects mind, body, and place is gaining attention in sustainability transformations research (Blades, 2021). This relates to the increased awareness of the need for "embodied cognition," in which the most reflexive learning occurs when bodily movement is involved (Macrine & Fugate, 2022). For this project, three different formats of curated embodied practices were prototyped across each site based on themes identified from other methods. In Hemsedal, an interactive exhibition was conducted at the annual farmer's market with the municipality. In Ostana, an outdoor

theater performance was carried out with the MonViso Institute. Finally, a Systemic Cycles tour was conducted in Mammoth Lakes, where cycling was used to weave relationships between people and places to cultivate inner and outer resilience (Luthe, Schütz et al., 2021). This built upon previous Systemic Cycles tours in both Hemsedal and Ostana.

Students as Change Agents

As the authors were also teachers during this research project, student courses were used to supplement other methods and practices, which varied according to each community. When students actively participate in the complexity of real-world communities, it can be transformational for students, teachers, and stakeholders alike (Lehrman et al., 2013). The second author's experience involving student courses in community research has contributed to trust-building with stakeholders and sparked new ideas about rural-urban relationships (Luthe, 2020). In this project, the roles of the students varied from participating in community trail building, collecting social network questionnaires, and assisting in facilitating curated outdoor experiences. The researchers could not connect with student courses in Mammoth Lakes due to the lack of previous ties, which is further explained in the limitations section.

Participation in Place-Based Activities

The researchers participated in various place-based, everyday community activities as part of the broader CBPAR approach,[11] such as outdoor collective gardening, harvest parties, farmers' markets, trail restoration, etc. Indoor or virtual activities included municipality meetings, cultural center events, theater shows, etc. The purpose of this approach was for the first author to develop an embodied awareness of the intangible aspects of each community, such as place relationships, expressions of diverse traditions, etc. Accessibility to these events and activities depended on the researchers' entry relationships with each community as well as spontaneous engagement in unplanned situations.

Scientific Methods

Socio-economic Census Data Collection

Socio-economic data was collected from public census records to provide a quantitative understanding of comparable criteria that can contribute to assessing each community's resilience potential, such as demographic composition, average income, employment rates, economic sectors, homeownership, etc. (Sharifi, 2016). See Supplemental Material for details.

[11] The first author adopted the role of a "participant as an observer" or "moderate participation" during community activities (Schensul, 1999). The stakeholders being observed are aware of the researcher's presence and intent, but the researcher is not actively steering the outcome of the observed activity (Kawulich, 2005).

Semi-structured Interviews

Semi-structured interviews[12] served multiple purposes in this project. Firstly, they served as a means to include in-depth perspectives from social groups not present during the gigamapping sessions. Secondly, they acted as entry points to build relationships with stakeholders and explore possible future collaborative opportunities later in the project. Thirdly, they aimed to sense-check previously collected data from other methods, like gigamapping and participant observation. These open-ended discussions varied in length and format: outdoor or indoor, planned or spontaneous, and virtual or physical, depending on the actors' backgrounds.

Social Network Analysis

Social network analysis (SNA) is a quantitative method used within the social sciences to describe the structural relationships between different actors (Kelman et al., 2016). The purpose of using SNA was to generate a comparative scientific "snapshot" of the adaptive and innovative capacities of each community by measuring the collaboration potential of local businesses (Luthe & Wyss, 2016). A questionnaire was created and distributed to local businesses, and the findings were analyzed using different established network software. Collecting the SNA questionnaires also provided opportunities to conduct semi-structured interviews with local business owners.

3.5 Prototyping the Systemic Application of Plural Methods

The process of systemically applying the plural methods and practices across each of the communities is visualized in Figure 4. The SOD-based, iterative, and reflexive approach was intentionally used to provide substantial unstructured time to listen, react, and adapt to the "unknown unknowns" (Luft & Ingham, 1961) that emerged from each community. Each method or practice was applied in each community, yet the timing, format, and whether other methods were used in conjunction depended on the combination of the project phase, shifting researcher roles, community context, and the concurrent insights gained from the other communities. This recursive, prototypical process across all three communities is presented in Figure 4 as a visual timeline of the first author's three-year journey across each community. This diagram visualizes different types of processes that occurred across and between each community, such as building stakeholder relationships, cultivating place-based knowledge, iterating methods and practices, organizing participatory engagement events, and reflexive data analysis. These interactive processes flowed across and between different scales, modalities, and concepts. The first author intentionally guided these flows according to broad research aims while remaining flexible to adapt to divergent streams, navigate unexpected obstacles, and leverage emerging opportunities.

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[12] Semi-structured interviews are conducive to discussing complex issues because they allow for adaptive interview questions and encourage open-ended conversation (Longhurst, 2009). They also work well for different durations of time, which was critical for this project since many of the interviews were conducted in tandem with other methods.

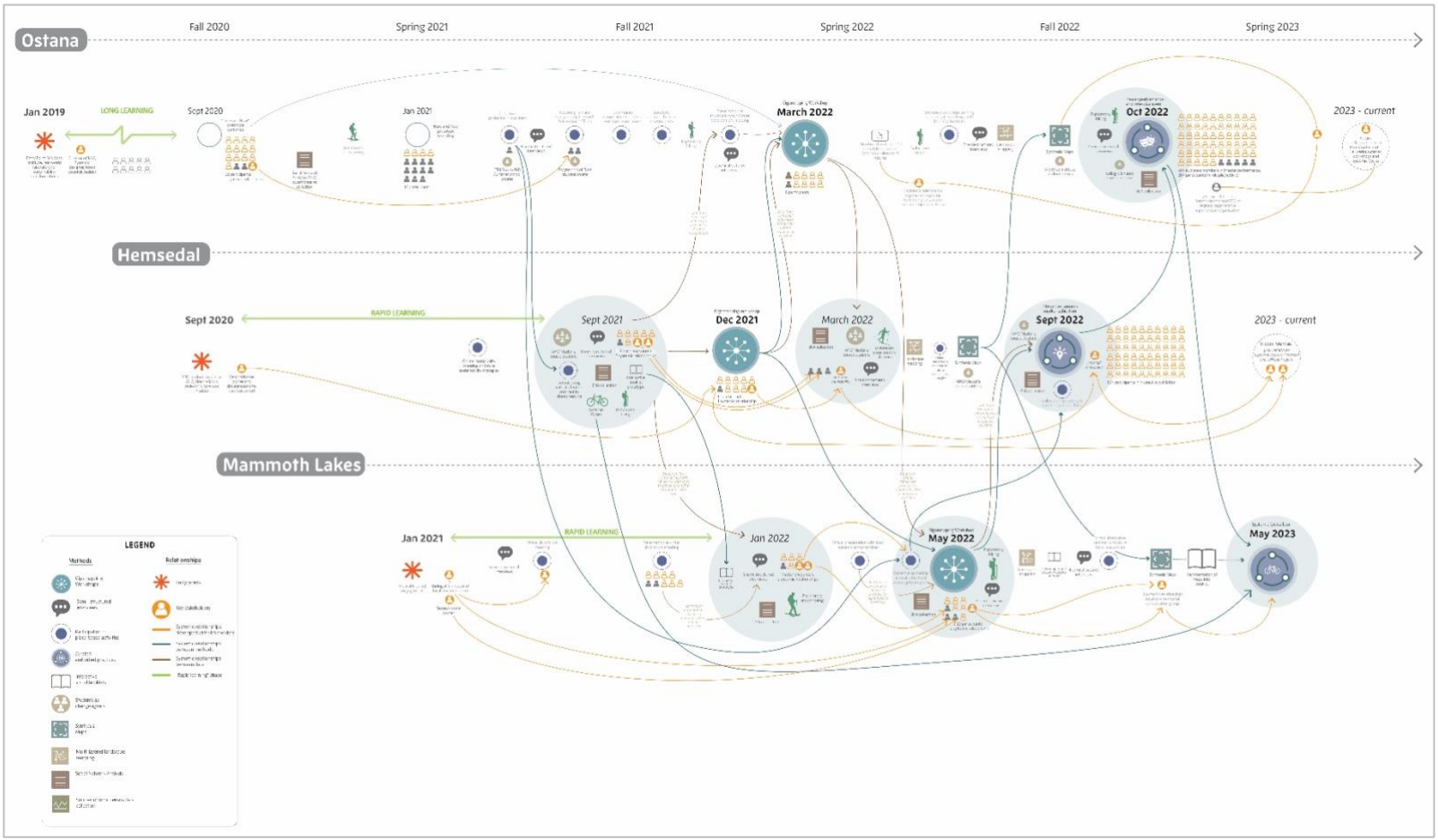


Figure 4. A visual timeline of the first author's journey of engaging in key processes across all communities. These processes include building stakeholder relationships, developing local knowledge, refining methods and practices, analyzing data, and organizing participatory events. See Supplemental Material for high-resolution image.

The researchers' previous involvement in each community was critical in deciding which methods and practices to prototype first. The long-term relationship with Ostana through the MonViso Institute ("long learning" as defined in Figure 4) enabled access to conduct virtual gigamapping workshops in September 2020. On the other hand, Hemsedal and Mammoth Lakes required substantial preliminary "rapid learning" (Sevaldson, 2015) to grasp community nuances and foster stakeholder relationships, much of it remote in Mammoth Lakes due to COVID-19 protocols at the time.

Subsequent field visits to Hemsedal and Mammoth Lakes (September 2021 and January 2022, respectively) were intentionally exploratory to gain a more embodied understanding of each place and allow specific research questions to emerge. While some interviews were planned, the visits mainly featured spontaneous and immersive activities like visiting farms and cultural sites, hiking, and participating in community events. For the first visit to Mammoth Lakes, a visual booklet of narratives and ideas collected from Hemsedal and Ostana was created as a conversation starter when meeting new stakeholders. Initial data collection of the social network analysis (SNA) questionnaires in Hemsedal and Mammoth Lakes commenced during these first field visits and continued during subsequent visits. SNA collection in Ostana occurred in October 2022 to correspond with related student courses.

The first participatory gigamapping workshop in Hemsedal in December 2021, coinciding with the AHO SOD master's course, utilized the students' final semester presentations as an opportunity to generate public interest. The aim was to both "sense-check" and expand upon the interconnected challenges and potential future ideas developed in the students' projects. The insights gained from the data collected and the workshop format influenced how the subsequent gigamapping sessions were designed for Ostana (March 2022) and Mammoth Lakes (May 2022). In March 2022, the Ostana gigamapping workshop was organized at the local cultural center in response to emerging contextual needs, notably younger stakeholders' calls for public forums to address community challenges. Like in Hemsedal, the findings from the Ostana gigamapping influenced the design of the Mammoth Lakes version (May 2022) several months later. This was decided for several reasons: more favorable weather decreased COVID-19 outbreaks and the possibility for the first author to present the project during a seminar series before the gigamapping workshop. This seminar provided a chance to engage a broad audience and offer a preview of the workshop's content, which assisted the first author in tailoring the content and facilitation style accordingly.

The gigamapping sessions were followed by an exploratory period to collect additional data through semi-structured interviews, community functions, and outdoor exploration. This period allowed the first author to synthesize findings thus far, refine research questions, and determine how methods and practices would be used for the next year. Following a Hemsedal municipality member's interest in further collaboration, virtual follow-up meetings and an additional field visit with students were conducted in March 2022.

Inspired by the visual booklet from Mammoth Lakes, an interactive pamphlet envisioning Hemsedal's future was designed and shared with local business owners during the SNA collection. During this period, we identified an opportunity to convey collected data through synthesis maps. While students contributed to early brainstorming iterations, the researchers predominantly shaped the content and final design. These maps were subsequently shared with the municipality member and showcased on the Facebook page and at the local cultural center.

However, the complex synthesis maps' limitations as communication tools became apparent when in-person discussions were needed to further explain them beyond mere display. Through additional follow-up meetings with the Hemsedal municipality, an opportunity emerged to host an interactive exhibition featuring the synthesis maps and other experimental activities at the annual farmer's market in September 2022. This initiated the first phase of "curated embodied practices," aimed at enriching the content of the synthesis maps - as two-dimensional representations of complex systems - through common activities in mountain communities such as a farmer's market. During the event, we observed participants' interaction with the synthesis maps. Despite facilitated explanations, the maps primarily served as conversation starters rather than prompting deeper engagement. This influenced the first author to investigate practices for fostering more embodied approaches in Ostana and Mammoth Lakes, focusing on practical, lived experiences. In Ostana, this led to co-designing a multi-day outdoor theater event with the MonViso Institute, prototyping more embodied understandings of human-nature relationships. Synthesis maps, based on themes from the Ostana gigamapping workshop and developed with an intern at the MonViso Institute, were used during the theater event to visually link concepts across local and regional scales.

The insights gathered from curated embodied practices in Hemsedal and Ostana led to planning a Systemic Cycles tour in Mammoth Lakes (Luthe, Schütz, et al., 2021). This was conducted in the nearby Long Valley, which encompasses the ancestral homelands of the Kutzadika'a People, a recreational tourism hotspot with a substantial ranching presence and an important wildlife conservation area. With local experts and individuals affiliated with local tribes, the researchers facilitated an interactive bicycle tour to encourage "mental movement"—expanding worldviews and understandings of place-based challenges by asking place-based questions.

While the Systemic Cycles tour in Mammoth Lakes marked the project's final empirical intervention, our relationships and research activities continued with Hemsedal and Ostana. For example, in Hemsedal, an opportunity has emerged to implement ideas gained from the research project through a new association and start-up innovation hub. In Ostana, the MonViso Institute continues to explore ways of co-designing regenerative futures through additional Systemic Cycles tours, serious games, and other interventions.

4. Findings

Following a SOD approach, several modes of reflexivity were used to analyze the findings. As noted in Section 2, we followed Walsh (2003) and Olmos-Vega et al. (2022), who defined four modes of reflexivity: Methodological, personal (researchers), contextual (culture, place, time, scale), and interpersonal (participants/researcher interactions). We expand upon this and include two additional categories, boundary and data reflexivity, building on the gaps highlighted in Section 2. From this analysis, we identify themes from each category and synthesize actions for cultivating each reflexivity mode (Table 3). We provide three detailed examples from each community that show how these different modes of reflexivity can be used to surface nuanced interactions and indirect effects between context, method/practice, participants, and researcher roles. These examples are derived from the larger process map (Figure 4) and are visualized in the accompanying "zoom in" Figures 5-7 which represent one method from science (Example 1), (research-through) design (Example 2), and embodied practices (Example 3).

4.1 Using reflexivity to understand the "betweenness" of methods, contexts, and researchers' roles

This project negotiated complex boundaries across worldviews, disciplines, methods, contexts, and scales. The researchers engaged in daily self-reflection and collective reflection on the interaction of these boundaries. Even though broad research aims and specific method choices provided a general framework, the project execution could not have been planned due to the complexity and uncertainty of many converging factors. Engaging in complex systems has no single "right" way, but real-time data reflexivity helped realign goals and appropriately adapt future methods and practices (Example 2). This was only possible due to highly flexible boundaries and time to engage in the "unknown unknowns:" pursuing exploratory detours, adjusting to stakeholders' schedules, iterating on method/practice format, and responding to changing seasons and community dynamics.

For example, when we first initially sought participation with Hemsedal stakeholders, the attempt to contact the municipality without prior relationships proved challenging. The activity of a Systemic Cycles bike tour led to an unplanned interaction with the mayor, which sparked the long-term relationship that AHO now has with the community. Likewise, redundancy in planting different "seeds" for future engagement options afforded greater flexibility when unexpected changes happened. In Mammoth Lakes, an opportunity to prototype one of the embodied practices (an outdoor, hands-on workshop on resilience) with a community wildfire initiative dissolved because of timing issues. However, due to other stakeholder relationships developing at the time, we could quickly develop an alternative, the Long Valley Systemic Cycles tour (Example 3), which better aligned with scheduling, location, and stakeholder needs. Examining system boundaries through different perspectives, times, scales, and knowledge types was crucial for understanding each community's complex data.

Toggling between each community led to a deeper analysis beyond exact data comparison, focusing instead on identifying common themes and insights. By honing in on the relationships *between* methods, data, contexts, and researcher roles, the project's scope of inquiry could expand and contract without adding an unrealistic number of topics to manage.

4.2 Illustrative Examples

The following three examples illustrate these reflexivity modes in detail (Table 3). Each example (Figure 5–7) captures one instance of a particular method/practice within the timeline shown in Figure 4. Each example visualizes how previous reflections shaped the current use of a method/practice and what reflections emerged for future application. There were varying degrees in which the first author and participants engaged with each method, its integration into the context, and how these factors influenced data interpretation and boundary framing. We use Wittmayer et al.'s (2014) different researcher roles[13] to describe the first author's function in each example.

The iterative process of diagramming these complex relationships in Figures 5–7 and the extended timeline in Figure 4 was a core aspect of reflexivity for the first author. Designing these diagrams led the first author to consider how their worldview and academic background influenced the analysis and interpretation of the research. Through three different examples, these diagrams aim to visualize how different reflexivity modes interact across multiple scales and hierarchies (Table 3). In the discussion section, we further discuss the implications and limitations of visualization approaches in systemic design.

13 Descriptions of each researcher's role based on Wittmayer et al. (2014).
Self-reflexive scientist: Part of the dynamic actions, reflexive about positionality and normativity
Knowledge broker: Mediates different perspectives and multiple ways of knowing, provides space for critical reflection
Process facilitator: Initiates and curates processes, prototypes, and learning journeys
Change agent: Expands stakeholder network, empowers participants to lead processes, participates in learning journeys

Table 3. Reflexivity Modes, Actions, and Potential Impact

Reflexivity mode	Action to cultivate reflexivity	Potential for expanding plurality in systemic design
Boundary	Zooming in and out (scales, systems, time, scope) starts as a worldview	Provides a mindset and language for understanding pluralities that already exist in a particular context
	Design for emergent opportunities: redundancy and diversity are key	Shifts perception of unpredictability from being a risk to an asset
Methodological	Adapt method/practice format, timing, and pairing with other methods	Shifts focus towards transferable insights and broader aims. Embraces situated and relational differences
	Weave together data visualization methods, narratives, and embodied practices	Increases awareness of how different methods and practices shape understanding of complex systems
	Identify indirect effects of methods and practices beyond the original purpose	Reframes and widens problematiques. Participants can become aware of their roles
Contextual	Engage in diverse contexts to expand points of comparison	Shifts comparability on underlying root issues and expands creativity in how insights can be scaled
	Build off existing contextual phenomena within method/practice framing	Connects place-based knowledge with broader perspectives to encourage community reflexivity on perceptions of localism
Data	Blur boundaries between data collection, analysis, and reflection	Design methodologies to allow for data analysis/reflection to occur throughout the project, rather than at completion
	Consider how the spaces where data is being collected influence the method/practice format	Being spatially embedded within a specific context increases the specificity of data in participatory methods and practices

Reflexivity mode	Action to cultivate reflexivity	Potential for expanding plurality in systemic design
Interpersonal	Meet actors where they are at—mentally and culturally - to build long-term collaboration	Breaks down assumption barriers and reduces unrealistic expectations for all involved
	Lift up the potential of students as change agents	Sparks mutual learning for students, participants, teachers/researchers. Opens new thinking around rural-urban relationships
	Diversify research collaboration and advisory network	Reflexive discussions with transdisciplinary research teams can help identify how and where disciplinary biases influence the project
Personal	Lean into your tacit knowledge while questioning its origins	Prompts reflection on the intersections between researchers' professional training, personality, and lived experiences
	Share with participants your personal experiences of navigating complexity and uncertainty	Normalizes emotions like anxiety and fear when working with complex, conflicting, and overwhelming issues
	Communicate your limitations, potential biases, and assumptions at the start, to all involved	Sets the stage to continuously address researchers' limitations/biases/assumptions as part of the research process

Example 1. Social network analysis in Hemsedal

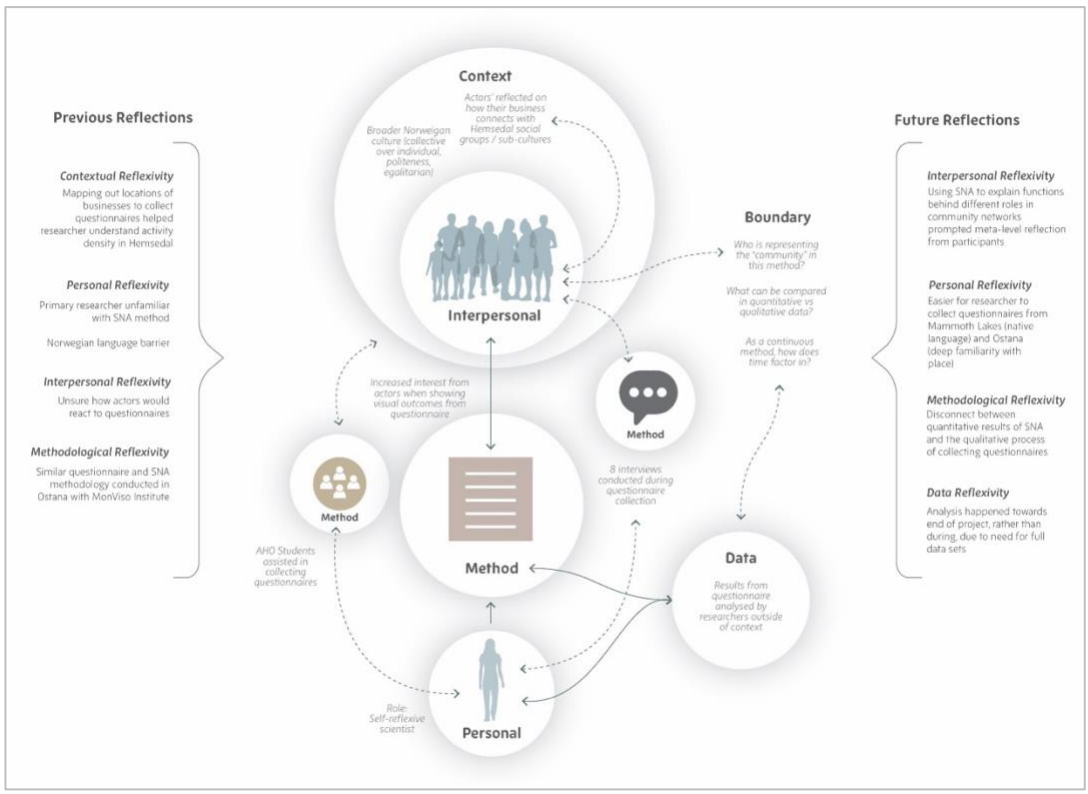


Figure 5a. Reflexivity diagram of social network analysis method.

September 2021–September 2022

In the initial Hemsedal field visits, collecting questionnaires for social network analysis was an entry point for engaging with the community as a place (Figure 5a). This process was integrated with other methods and practices, such as exploratory biking and skiing tours, semi-structured interviews, and in conjunction with student groups. These questionnaires aimed to provide a quantitative overview of business collaboration patterns to measure different community resilience metrics. Collecting questionnaires in person provided a valuable indirect effect: it prompted participants to reflect on their professional contexts and connections to other subgroups in Hemsedal (Figure 5a). While collecting the questionnaires, the researchers explained the aim of SNA and demonstrated how the data would be anonymized and represented in visual diagrams. This visual strategy helped overcome hesitancy among some participants since the researchers' lack of Norwegian language skills sometimes resulted in verbal communication difficulty (Figure 5b).

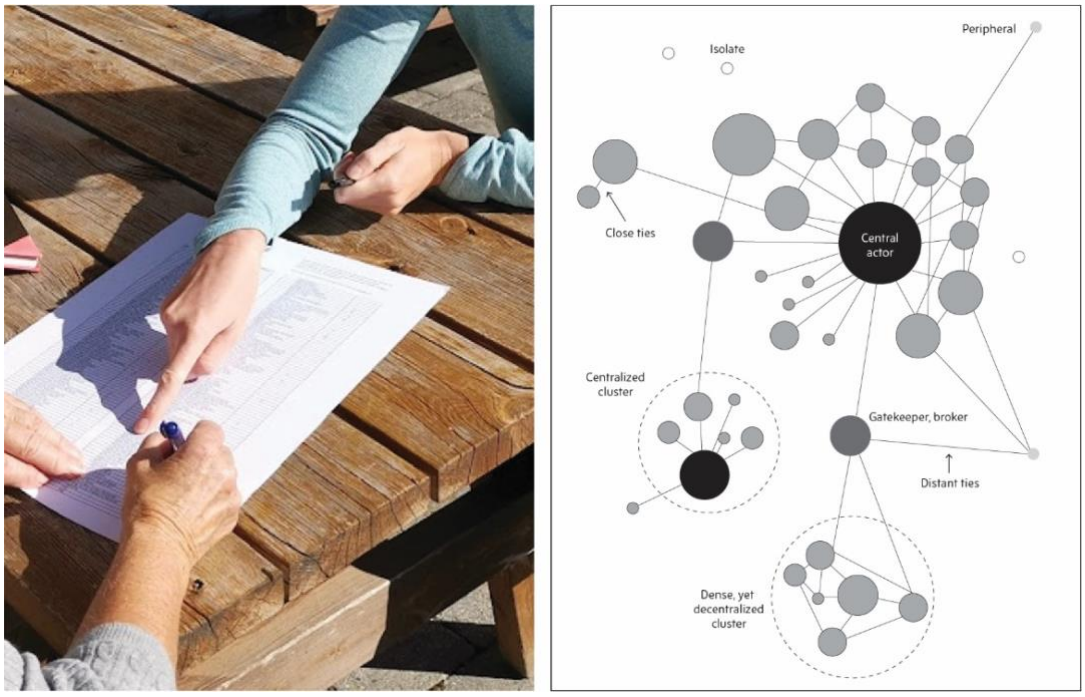


Figure 5b. Images of the questionnaire and representational diagram were used to describe SNA functionality to participants. Image: Tobias Luthe.

Additionally, motivated Norwegian students aided in gathering responses and fostering connections with key figures like the ski resort manager, who had been difficult for the researchers to reach. Many of our students came from urban areas, which sparked dialogue with participants on new rural-urban partnerships, leading to ideas like apprenticeships linking Hemsedal's businesses with university semester exchanges. These interactions frequently led to impromptu interviews and ongoing partnerships with local enterprises such as a regenerative farm and a coffee roastery.

For both the collection and analysis of SNA, the first author adopted a “self-reflective scientist” role, which contrasted the more engaged “change-maker” or “knowledge broker” roles assumed during the participatory methods and practices. Furthermore, the nature of social network analysis raises reflections about its methodological adaptability. The analysis of the questionnaires with network software required waiting until all data was collected, unlike immediate insights gained from gigamapping or interviews. Additionally, gathering and analyzing questionnaire data took longer than anticipated due to business owners' availability and the first author’s learning curve with SNA software. These different methodological, personal, and interpersonal factors pushed the network analysis process to the end of the project after completing most of the other methods and practices. While this approach limited real-time validation of visual network graphs with participants, using SNA gave the first author a deeper understanding of community collaborations and a quantitative perspective on social dynamics, complementing insights from qualitative methods like gigamapping.

Example 2. Ostana gigamapping workshop

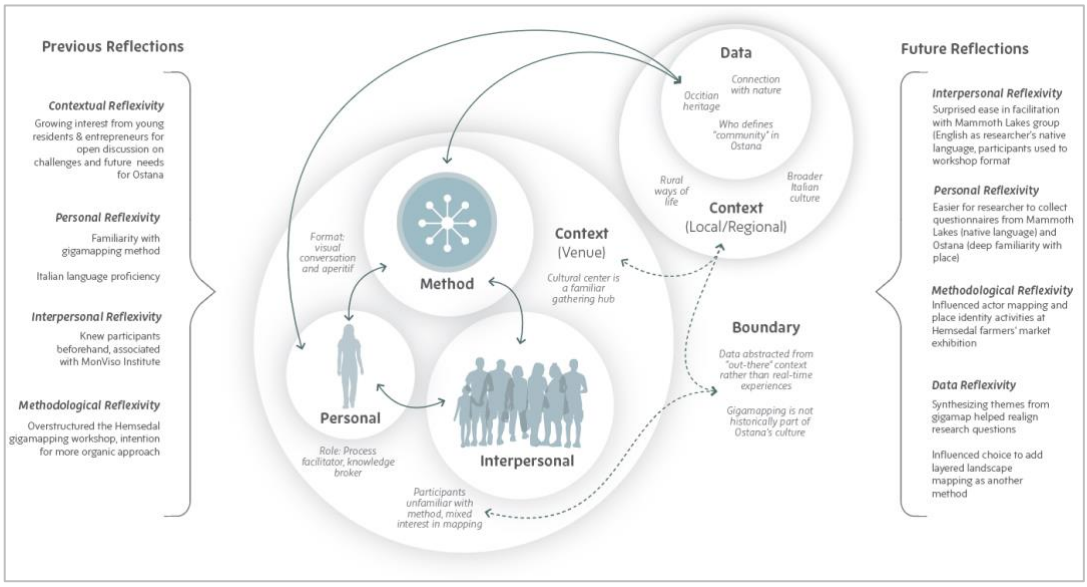


Figure 6a. Reflexivity diagram of Ostana gigamapping workshop.

March 2022

The researchers' deep relationship with the community of Ostana shaped the gigamapping process and outcomes (Figure 6a). The first author served as a "process facilitator" and "knowledge broker" to facilitate awareness of and negotiate diverging perspectives. Participants were highly familiar with the context, each other, and the researchers, yet had no experience with gigamapping. To encourage participation, the format was modeled around a casual evening "aperitivo" (a common Italian social practice), held in the cultural center's lobby, and was advertised as a response to the community's request for more open discussion forums (Figure 6b). Likewise, the first author reflected on the overstructured format of the previous Hemsedal gigamapping workshop and took a more relaxed facilitation approach in Ostana. Combining these design decisions aimed to make a new experience like gigamapping more fun and comfortable. However, some older participants found this method, like past activities from the MonViso Institute, "too sophisticated" for "urban intellectuals" rather than for "rural forest people." This feedback revealed a disconnect between participant expectations and researcher assumptions, prompting the researchers to adopt more hands-on approaches like outdoor theater performance for future engagements.

We reflect that the value of this gigamapping workshop was that it served as a needed forum for different actors to openly discuss their interpretations of "community" in Ostana and its challenges. This experience revealed participants' difficulties in thinking beyond a tourism-centric economic mindset to embrace diverse futures for Ostana. These insights later became central themes that the first author expanded on in the synthesis maps.



Figure 6b. Aperitivo-style format in Ostana gigamapping workshop and resulting map. Image: Tobias Luthe.

Additionally, the workshop emphasized the connection between the indoor setting of the session and the external environment of Ostana. Data derived from participants' implicit knowledge outside the room was represented abstractly with symbols and lines, not capturing the full context of their lived experiences. Overall, these indoor, two-dimensional gigamapping exercises across all three communities led to a shift towards experimenting with more embodied outdoor practices that allowed for real-time reflections within the actual socioecological contexts being experienced.

Example 3. Systemic Cycles tour in Mammoth Lakes

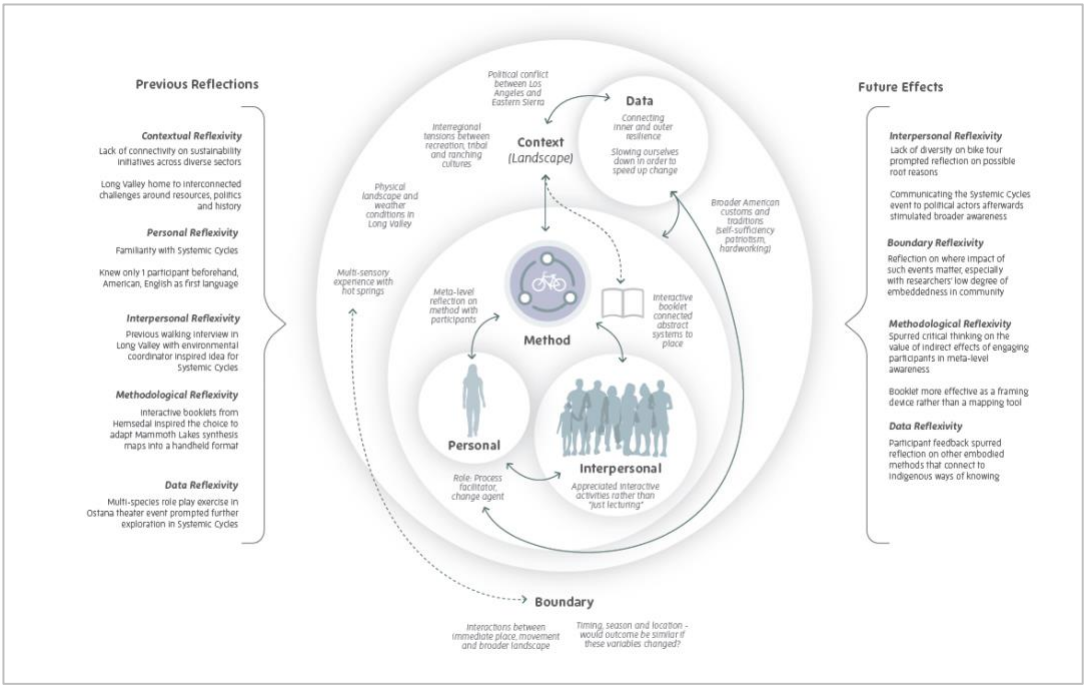


Figure 7a. Systemic Cycles tour in Mammoth Lakes.

May 2023

The Systemic Cycles bike tour in Mammoth Lakes was one of the final events in the project, representing a culmination of several years of method development and stakeholder engagement (Figure 7a). Like the previous examples, the format and timing of this embodied practice resulted from a combination of factors influenced by the researchers' deepening connection with the area, stakeholder dynamics, and weather conditions. In 2022, an unplanned walking interview with an environmental group coordinator in Long Valley planted the seed to design and organize the Systemic Cycles event with multiple local partners a year later. Although unforeseen at the time, this interaction shaped the event's promotion and participant composition, attracting individuals with biking experience, subject interest, or prior contact with the researchers.

From a methodological perspective, there was a clear feedback loop between content and physical experience. Drawing from reflections on using synthesis maps in Hemsedal and Ostana, the first author experimented with ways to improve interactivity while adapting the maps to accommodate bicycling. This resulted in a handheld, visual booklet where participants could reflect on key themes (rural-urban relationships, water and land rights, multispecies perspectives) as they traversed the actual landscapes in which such processes can be experienced (Figure 7b). The tour included both planned and impromptu stops for interactive reflection activities. For example, a planned stop at a popular desert hot spring site exemplified a local embodiment of global challenges, such as over-tourism, desecration of Indigenous lands, and resource extraction.



Figure 7b. Reflection activity during the Systemic Cycles tour in Mammoth Lakes; route itinerary as displayed in the booklet. Image: Tobias Luthe.

As we interacted with the hot springs and tourists using the area, we reflected on the participants' (who had mostly relocated from urban areas to the Eastern Sierra) own understandings of their roles in these complex relationships. Additionally, a spontaneous role-play exercise near the headwaters of the Owens River invited participants to reflect upon their worldviews by imagining those of other multi-species actors, such as trout, sage grouse, government agencies, and more.

Here, the first author acted as a "process facilitator" to stimulate meta-level reflection and a "change agent" to empower participants to lead change processes. We prompted participants to consider how the Systemic Cycles approach could be adapted to fit their communities' unique needs and contexts, recognizing that cycling might not be suitable for all. It is uncommon for participants to discuss with researchers the method's implications and limitations while participating. The physical engagement in the landscape with other actors provided participants with a tangible space to think about their unique contexts and networks. Furthermore, the interactive booklet unexpectedly became a communication tool for broader engagement. After the event, the first author used the booklet to facilitate conversations with key local figures during a donor dinner for a regional conservation organization. This sparked ideas on integrating outdoor embodied practices into Mammoth Lakes' tourism campaign to foster stewardship among urban visitors and locals, such as regenerative woodworking courses using felled trees from a local fire resilience project.

Discussion

5.1 Reflecting on methodological pluralism in the messiness of real-world contexts

In this paper, we presented practice-based illustrations of how systems oriented design as a "dialect" within systemic design can be used to reflexively understand and engage in sustainability transformations. This project's research-by-design, exploratory nature shed light on uncovering the messiness of real-world contexts through the systemic application of plural methods and practices. Each community was governed by place-specific, emergent phenomena that were impossible to understand fully. However, this was not done aimlessly—our responses to these "unknown unknowns" were intentionally designed and carefully curated concerning all the different aspects of the project – research aims, place specificity, stakeholder and collaborator relationships, resource constraints, etc. The researchers' transdisciplinary expertise and support from place-based institutions like the MonViso Institute offered a strong foundation for guidance during uncertain phases of the project. Moreover, the relational and reflexive approach of systems oriented design was key to understanding the individual outcomes of applying a particular method/practice in one community and the broader effects of systemically prototyping plural methods and practices in all three communities.

As illustrated in Section 4, working with plural methods and practices also produced a network of interdependencies and unpredictable effects (Figure 3). We reflect on navigating methodological plurality in the "real world," addressing Midgley's types of philosophical, psychological, and cultural challenges as outlined in Section 2. From a philosophical challenge, applying each method/practice across different contexts helped us understand their limitations and how other methods and practices might address these shortcomings (Figure 3). This relates to the psychological challenge of learning and using new methodologies from the researchers' and participants' perspectives. Despite efforts to ensure inclusivity in communication and execution, we observed varying levels of participant willingness to engage in new methods, possibly influenced by individual worldviews, educational background, task framing, familiarity with researchers, and other factors (see Section 4.2, Examples 2 and 3). Likewise, our diverse backgrounds in sustainability science, architecture, and design influenced the selection of methods and provided a rich space to expand our disciplinary worldviews. For example, the first author underwent a broad learning journey beyond their architecture disciplinary background. Learning and working with SNA led to developing interactive teaching methods and integrating network theory during gigamapping sessions and semi-structured interviews.

From a cultural challenge of knowledge separation, communicating methods and practices became essential when working with stakeholders with different interpretations of sustainability transitions. The first author allotted substantial time to try and understand these patterns and adjust how each method/practice was communicated. This required constantly connecting to the broader, common aim of each method and practice, which was to stimulate greater awareness of our roles in the systems we inhabit. By reiterating this common goal, the epistemological differences between methods and practices (like

quantitative SNA and embodied practices) and local knowledge systems could better coexist as plural possibilities rather than in competition.

Making sense of and communicating these plural interactions between knowledge, methods, contexts, and roles through visualization is a core aspect of this research. Research-by-design artifacts, such as diagrams, interactive booklets, synthesis maps, and gigamaps, were used to grapple with the mechanisms behind these different interactions, reveal "snapshots" of underlying patterns, and build narratives to share with community members. Visualizing provided the opportunity to reflect on these complex relationships through various positions, scales, and perspectives. However, drawn lines and shapes can only symbolize the deeper knowledge and experiences of engaging in these unique places over time. Visualizing complex systems may be a step towards more holistic thinking for those from more reductionist or linear backgrounds. Yet, for groups that already have deep embodied understandings of complexity, such as local knowledge holders, Indigenous communities, performance artists, and more, flattening these relationships to two-dimensional formats can exclude many other possible means of expression. Thus, reflexivity is crucial for understanding to what extent a format or vessel for communicating complexity is appropriate for a given place, culture, or context.

5.2 Effects of multimodal reflexivity to navigate plurality in practice

Furthermore, we reflect on the value of using multiple modes of reflexivity for the mountain communities, for us as researchers, and for others engaging in similar work (Table 3). As discussed in Section 2, reflexivity is not a given but a process of building awareness to open doors for intentional action (Vink, 2022). A goal of this research was to foster reflexivity to encourage future community-led interventions. For example, a valuable outcome of systemically applying plural methods and practices was not the data collected but the combined, *indirect effects* or the "invisible fabrics of interrelated actions" (Senge, 2006, p. 7, as cited in Goodchild, 2022). In Ostana, the social impact of the student groups who helped restore old ruins at the MonViso Institute was less on the physical outcomes but more on the deeper trust-building process that occurred with elderly neighbors. During the Mammoth Lakes Systemic Cycles tour, participants became aware of their roles in the method, leading to unexpected opportunities to influence the regional tourism campaign.

Embracing emergence was at the core of this multimodal reflexive and plural approach, such as being open to and nurturing unforeseen possibilities outside the original research agenda. We could not have predicted that our initial engagement in Hemsedal would evolve into a partnership with the municipality and key stakeholders, co-creating the soft infrastructure of a local innovation hub and wider regional network of regenerative initiatives. Being aware of and tracking the different interactions of context, method, interpersonal dynamics, etc. (i.e., different modes of reflexivity) provided a compass for us as researchers in navigating emergent possibilities and supporting stakeholders in facing unknown future challenges. This highlights the important yet underdeveloped practices of curating, facilitating, and situating in systemic design. In Table 3, we have synthesized key actions for practitioners and researchers alike that can help advance these processes in practice.

5.3 Limitations

The emergent nature of this project required continuous synthesizing and boundary framing to understand what information was included, excluded, or "enough" to engage in a particular system. This decision-making process was entangled with the researchers' worldviews and biases, as well as those of stakeholders. As outsiders to these complex and culturally specific communities, we tried to approach this process as humble learners and fully recognize our limitations in understanding and engaging with these unique places. We also acknowledge that our Western European/American and English-speaking backgrounds limit our ability to fully engage with diverse methods and contexts. For example, English as a noun-based language can emphasize binary and linear thinking, unlike Indigenous languages that are "process, context, land, and verb-based," which offer more relational ways of knowing and being (Goodchild, 2022, p. 59).

As described in Section 3.3, our social networks in each community were shaped by our initial contacts. Due to limited physical presence, the first author aimed to diversify these networks as much as possible, especially in Mammoth Lakes. This process was mostly done through interviews with community members in their own spaces, such as a conversation with an Indigenous food sovereignty specialist during a public community garden event. While we also tried to use the participatory workshops as another relationship-building tool, there was a lack of representation of the regions' varied cultures. Despite the events being free, voluntary, and advertised widely across multiple channels, the participants who joined mainly came from the recreational, political, and educational sectors engaged in similar work. We reflected with the participants on the underlying systems that permitted them to join the activities – i.e., conventional work schedule, resources for daycare, etc. Likewise, we reflect on how the events hosted by us as researchers – as urban, white, Western academics—might be perceived by groups who have been systemically oppressed by settler colonialism, such as the regional tribal communities. Thus, more attention should have been given at the start of the project to initiate relationship-building processes across diverse social groups so that more fruitful opportunities for mutual learning could happen later.

The process of working in multiple communities was time-consuming and required flexibility. The researchers had to adapt to unpredictable factors like weather, COVID-19, and stakeholder dynamics, which required a malleable schedule. We acknowledge that such flexibility is not accessible to everyone. While all the research methods were comparatively applied across all three communities, one exception was the inability to integrate student courses in the research activity done in Mammoth Lakes. This was due to limited connections with universities and student groups and a lower physical presence in the area. Likewise, each method and practice could only provide a "snapshot" of a particular phenomenon through a specific disciplinary lens and format. Gigamapping was limited to its "flatness," the content depends on who was present, and there is potential researcher bias in the facilitation process. This extends to semi-structured interviews and participant observation as well. Lived experiences described through oral histories and embodied cultural practices can never be adequately transferred into a written text.

Similarly, synthesis maps, landscape mapping, and interactive booklets can only attempt a filtered understanding of complex phenomena. The quantitative strengths of social network analysis and social economic census data lie in direct comparability and transferability, yet these methods lack situatedness. On the other hand, while curated embodied practices open wider possibilities to engage in complexity, the insights can be challenging to translate to contexts like policymaking where numerical facts are needed. This relates again to the need for a wide and diverse portfolio of methods and practices to choose from when limitations are revealed.

5.4 Implications for future systemic design research

This research process prompted reflection on future avenues to explore methodological plurality and reflexivity in systemic design research. As discussed in Section 3, the ten methods and practices prototyped here are just one possible combination of many. Using broadly applicable methods and situated practices requires a multidimensional understanding of their real value and who benefits from it. This project highlighted the need for systemic design research to focus more on facilitation processes to invite participants to embrace the complexity in their lives. Embodied practices like immersive outdoor experiences show promise, but there is a need for more effective ways to capture and record the resulting emotional and experiential interconnectedness that occurs.

Furthermore, we suggest further exploration into how quantitative scientific methods like life cycle assessment, carbon footprint analysis, social network analysis, and agent-based modeling could be incorporated with participatory gigamapping or embodied practices. Our work with municipalities highlights that systemic designers could benefit by gaining deeper knowledge in policy, financial analysis, and market research. Likewise, recent research at the MonViso Institute shows that real-world laboratory methods, like serious games co-designed and played with diverse audiences, are promising practices integrating different aspects: data-based, interactive, reflexive, scalable, and situated.

Based on what we learned from this reflexive research process, we also see a need to incorporate contemplative and psychological practices in systemic design that focus on inner resilience.[14] However, we echo the concerns raised by many that without proper care, cultural appropriation can be risked when taking such practices, like mindfulness, outside the specific ethnic, religious, and Indigenous contexts in which they have originated (Mehta & Talwar, 2022). This relates to a key future need in expanding plurality in systemic design – to more deeply engage in the messiness of "everyday" systemic design (Vink, 2023) where a reflexive culture of "living the questions" (Wahl, 2016) becomes a habitual and collective practice.

[14] Inner resilience is developing capacities "to become more fully who we really are and share all our unique gifts and creative passions with our community" (Wahl, 2016). The Inner Development Goal framework outlines five aspects: being, thinking, relating, collaborating, acting (Henriksson et al., 2021).

5. Conclusion

We illustrated how a reflexive, SOD-focused systemic design inquiry informed ways of engaging in communities undergoing sustainability transformations. Prototyping a systemic application of plural methods and practices in messy real-world contexts in an emergent yet intentional way highlighted an overlooked aspect: the indirect, meta-level impacts of facilitating and curating relational processes. This work contributes to systemic design research by demonstrating reflexivity's essential role in applying methodological plurality in practice—as an intentional weaving of practices, places, people, and processes across time, scale, and worldviews. From this weaving process, our place-based insights derived from scientific inquiry, design, and embodiment, and communicated through visualizations, can help advance "scaling deep" (Riddell & Moore, 2015) systems awareness across other communities and contexts. The more systemic design can pluralize its ways of knowing, doing, and making through reflexive, question-based approaches, the greater its potential to help us act under uncertain and complex circumstances.

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