Socio-ecological network mapping for post-disaster recovery:

A case study in Yamae Village and Kuma Village, Kumamoto, Japan

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1. Introduction

Weather-related disasters are increasing in frequency and intensity worldwide and have regional and local impacts. These impacts are both tangible and intangible, causing changes in landscape dynamics (Kreibich et al., 2022). As landscape is a spatio-temporal complex socio-ecological system where multifunctionality and multi-actors are present (Sayer et al., 2013), Landscape Approaches (LAs) have emerged as a framework to foster consensus among actors towards restoration and effective risk management (CARE Netherlands, 2017). Since forest landscapes are shaped by unique local contexts (Pedroza et al., 2022), policy alignment, operationalization, and participation remain challenging (Mansourian and Sgard, 2021). Therefore, a broader range of cases in diverse contexts needs to be studied (Mann and Plieninger, 2017). Furthermore, despite the increasing interest in landscape governance studies, local actor landscape dynamics and collaboration in post-disaster recovery remains understudied, for which this research aims to address this gap.

The general objective of this research is to analyze patterns among identified landscape-related elements, referred to as nodes, and the connections among them referred to as edges. This study has three specific objectives: (1) to examine how post-disaster recovery efforts intersect with landscape-related efforts and dynamics at the local level, (2) to co-create a participatory Socio-Ecological Network (SEN) with local key actors, and (3) to analyze the Socio-Ecological Network Analysis (SENA) on patterns of influence, interest, and edges.

2. Methodology (including model)

Study Site

The selected study sites were Yamae Village and Kuma Village. In July 2020, a torrential rain disaster in the Kuma River Basin resulted in casualties, economic impacts, and migration. As part of the recovery policies, both villages are implementing Reconstruction Plans which emphasize the villagers as the leading actors and the need for cooperation between organizations.

Data collection and analysis

This research used SENA approach as an analytical method. The research flow consisted of firstly, a qualitative analysis of secondary sources (e.g., policy documents, flyers, and websites), followed by semi-structured interviews with the local government and field visits. Then, a pilot was conducted with staff from the Planning and Coordination Division in March 2025. Later, the SEN mapping participatory workshops were conducted in April 2025 in each village. The organizations were selected based on previous typification to focus on those local, on-site, and with landscape thematic relevance. 6 to 8 key actors were invited using purposive and convenience sampling (Bayala et al., 2023) with the collaboration of the focal points at the local government.

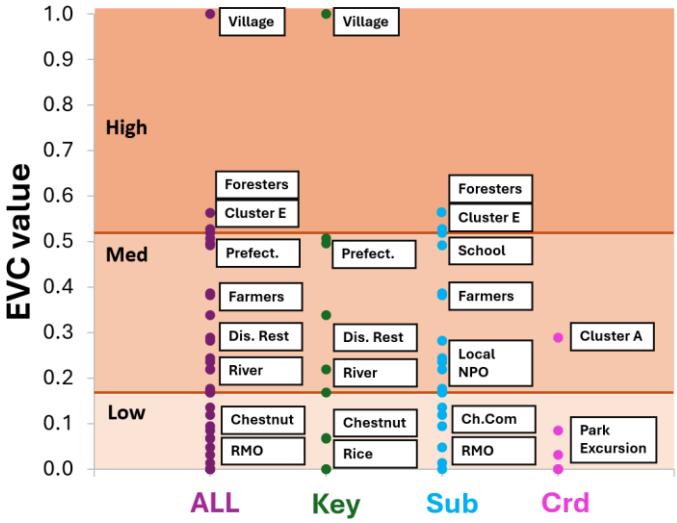
SEN was mainly based on Net-map methodology, a paper-based mapping tool in a structured participatory process that helps visualize the nodes and edges within a specific landscape (Schiffer and Hauck, 2010; Ball et al., 2022). In this study, nodes included organizations and natural or cultural landscape features, while edges represented flows of information, money, and requests. The level of influence and interest of the nodes were also incorporated as variables. Next, the SENA qualitative content analysis of the interviews was carried out using Excel for data systematization. Nodes were categorized according to the interest-influence levels (Reed et al., 2009). After that, the quantitative analysis of the network used Gephi software v.010.1 to determine centrality measures (total degree and eigenvector centrality (EVC)) (Ball et al., 2022; Ciasca et al, 2025). Spearman correlation was also

calculated (Paletto et al., 2016), and EVC was plotted and ranked (percentiles). Finally, a cross-analysis of EVC and the interest-influence categorization was made.

3. Results

The key findings of the SENA show that most of the mapped nodes were categorized as high interest-low influence, 54% for Yamae and 49% for Kuma, including local organizations such as foresters and farmers in the former and the forestry association and residents in the latter. 42% of the edges were perceived as negative in Yamae, whereas 1.35% were in Kuma. The node with highest centrality measures was the village for Yamae (total normalized DG of 0.513 and EVC of 1.0) and the village hall for Kuma (total normalized DG of 0.500 and EVC of 1.0), but also the foresters (0.158 and 0.564) in Yamae and the forestry association (0.235 and 0.687). Furthermore, Spearman correlation showed that there was insufficient statistical evidence to conclude that there was a correlation between perceived influence and structural centrality in Yamae. This can be observed in the cross-analysis of EVC and the interest-influence categorization that shows how some nodes with high EVC value were perceived to have low influence (e.g., foresters, cluster E). In contrast, nodes with medium and low EVC were perceived to have high influence (Farmers, river, RMO) (Figure 1).

Figure 1. EVC- interest-influence relation



4. Discussion

The centrality measures show that although some of the local organizations were perceived to have low influence, they still have a central role in the network, revealing a gap between perceived influence and the structural position. On the other hand, some of the nodes that were perceived as key actors have a low centrality and low relations towards central actors in the network. This resonates with studies that mention how local actors may be structurally embedded in a system but are under-recognized or perceived with less influence on planning and decision-making processes (Reed et al. 2017). The negative edges in Yamae's map also denote the perception of information and communication gaps (Kusters et al., 2020) for horizontal and vertical integration (Alam and Ray-Benett, 2021; Hernández et al., 2021; van Oosten, 2021).

While this study does not aim to directly compare the two villages, the mapped SENs show certain local particularities. In Kuma Village, participants included nodes beyond administrative borders such as the Kuma River Fisheries Association and people outside the village. Montbell was also mentioned as an influential actor. This may reflect Kuma's greater dependence on external actors, partly due to its remoteness, smaller population, and the centrality of the Kuma River in the local landscape. In contrast, although no external actors were mapped in Yamae's SEN asides from the government levels, the interview and document data revealed some cross boundary collaboration as well, including educational initiatives linking downstram-upstream actors (Kongō school in Yatsushiro city).

Even if some differences of the SENs may be attributed to the individual backgrounds of the key actors, they also illustrate the importance of considering local actors and local socio-ecological contexts in policymaking and implementation. More so if it pertains to landscape-related challenges, these SEN case studies offer empirical insights into dynamics and gaps that are often difficult to observe or quantify. They also highlight the need for horizontal integration across sectors to enhance collaboration among actors towards recovery and risk management.

References

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