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SPECIAL FEATURE: EDITORIAL

Networks of Action Situations in Social-Ecological Systems Research

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Networks of action situations in social–ecological systems: current approaches and potential futures

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Abstract

"Action situations"—instances of decision-making and agency—have become central to studying social–ecological systems. This special feature collects research using the network of action situations (NAS) approach to structure the way these action situations are embedded into broader interdependent instances of decision-making in different policy or discursive realms, spatial and jurisdictional context, or at different institutional levels. In this editorial, we summarize the key themes that emerged throughout the collection of the 17 articles included in this special feature. The editorial emphasizes the value of NAS in appropriately and sensitively reconstructing relations while pursuing consistency in modes of analysis. It highlights as key themes the complementarity of and disconnects between situations, temporality of NAS, and how NAS can structure the analysis of power in SES. Going further, we suggest expanding on the relational turn, developing NAS archetypes, and studying polycentric governance theories and hypotheses using the NAS approach.

Keywords Situational analysis · Situation-relational networks · Ecology of games · Polycentricity · Social–ecological systems · Networks of action situations

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Introduction

Action situations (ASs) are "the social spaces where individuals interact, exchange goods and services, solve problems, dominate one another, or fight" (Ostrom 2011, p. 11). ASs have become an important unit of analysis in the social sciences, such as in actor-centred institutional analysis (Scharpf 1997; Mayntz 2004; Ostrom 2011), actor perspectives in development sociology (Long 2003), and transaction-oriented (Commons 1931; Hagedorn 2008; Lejano and Stokols 2013) and process-oriented research (Pahl-Wostl et al. 2010; Weik 2015; Carter et al. 2016). The power of situations in shaping behaviour is also at the core of situationist perspectives in social psychology (Kelley et al. 2003; Rauthmann et al. 2014) and political science (Farr 1985).

Changing situations can induce transformative behavioural, institutional, and biophysical change. The structure of an AS is shaped by social and biophysical conditions (Ostrom 2011). Any single AS can be influenced by multiple linked situations (McGinnis 2011). Experiences from related situations can be transmitted, for example, in spillovers of pro-environmental behaviour (Truelove et al. 2014). Situations can also be physically connected, like in irrigation systems (Pham et al. 2019). Hence, we need to consider the broader network of situations that affect a situation of interest. Such Networks of Action Situations (NAS) are the topic of this special feature.

Empirical studies show that many sustainability challenges are more constructively tackled if we study the actors' multiple institutionally or physically connected situations (Kimmich et al. 2022). However, different methods are used to identify and analyse NAS across different sustainability problems in diverse social–ecological systems. To advance research on NAS, this special feature aims to (1) document the portfolio of existing situation-centred network research approaches, (2) consolidate common knowledge and shared understandings of current conceptualizations and methods, and (3) identify types of ASs in empirical cases that are critical for sustainable development. This editorial summarizes the articles in this special feature, displays their key contributions, and provides an outlook for future NAS research in sustainability science.

Key themes across contributions

First, the special feature systematically reviews empirical research on NAS until 2021 (Kimmich et al. 2022). Out of 72 articles explicitly dealing with NAS, 23 present empirical research using an NAS approach. The need for a case-sensitive approach is clearly visible in each study, but lack of systematic reporting made it difficult to identify some of the methods used, such as for identifying relevant ASs, boundaries, or links. The review discusses the NAS approach within the broader "ecology of games" literature, including its qualitative and quantitative strands, and provides a checklist for future NAS research.

The subsequent contributions extend the NAS approach along three theoretical dimensions. First, the temporality of relations between ASs is critical for understanding governance challenges of co-evolving sustainability problems. Baldwin et al. (2022) study how changes in national forest planning led to a shift from timber production to recreation and ecosystem management and institutionalized public participation in US Forest Service planning. Their comparative case study constructs conceptual maps of historical NAS from archived documents. Delaroche et al. (2022) demonstrate how the intertemporal challenges of governing multiple SESs can be tackled in an NAS approach. They study the spatial and temporal interrelations of managing agricultural expansion, reducing deforestation, and mitigating urban floods in the Brazilian Amazon. Ruseva (2023) uses the NAS approach diagnostically for understanding interactions among decisions for forest carbon commoditization in a subnational climate mitigation system. She shows how technically complex rules create interdependencies via multiple long-term contracts and how participation costs increase relative to uncertain future payoffs.

A second strand focuses on complementarities and disconnects of ASs. Ortiz-Riomalo et al. (2022) analyse social–ecological outcomes of participatory interventions in two watersheds in Peru and Colombia. Disconnects between ASs hindered emergence of collective action in Colombia, whereas the intervention in Peru coordinated actors across linked ASs and collective action emerged. Warbroek et al. (2022) focus on ASs in the implementation of renewable energy in the Netherlands. They find that intrasectoral institutions produce sector-specific ASs and imply less integrative outcomes, which could be achieved through redesign of rules for integrative ASs spanning across sectors. Kasymov et al. (2022) analyse Mongolian herders' mobility choice in relation to pasture use and conservation policies. Using game-theoretic models of herding mobility and the political economy of policy implementation, they find that a critical mass of complying herders leads to institutional complementarity across ASs. Kellner (2022) combines the NAS approach with systems thinking to identify leverage points for shifting water–energy–food nexus cases towards sustainability. In transdisciplinary co-production, this approach facilitates joint understanding of system dynamics and envisioned impacts of potential interventions on the NAS and their outcomes. Unnikrishnan et al. (2023) show that the NAS approach helps to diagnose interdependencies in

mid- to large-scale SES. Their analyses of connected lakes in India and wheat-breeding systems in Germany suggest that resource systems operate at different (nested) scales and that ASs account for interdependencies in such SES. Hoffmann and Villamayor-Tomas (2022) review the literature on the effects of technological modernization investments on water use conservation across irrigation associations. Although they find direct linkages between the modernization–investment and water-saving ASs, most of them happen through situations typically associated with the collective management of irrigation systems (like the water application or infrastructure maintenance situations). Cazcarro et al. (2023), explain the relative lacks and challenges for public treatment plants in Aragon, Spain, to cope with peak overloads from the wine industry by pointing to specificities of the waste production situation and deficits in in-house treatment and regulatory enforcement situations, where coordinated investment also points towards a promising solution. Hedlund et al. (2022) address collaborative water governance in the Norrström basin, Sweden, and show how policy actors associated to different problem issues often avoid collaborating when the issues exhibit reinforcing interdependencies due to a perceived sense of infeasibility and how they do not consider counteracting interdependencies ('trade-offs') at all when collaborating.

A third strand of contributions highlights strategic actors, power, and discourses. Oberhauser et al. (2022) offer a diagnostic of the overexploitation of groundwater resources in Azraq, Easter Jordan, and reveal that a diversity of ASs, including water, agricultural, environmental, energy, and land governance, but also the monarchy's underlying social contract and the informal concept of wasta, influence outcomes on the ground. Robinson et al. (2022) study institutional arrangements of climate adaptation in small island states. They identify four ASs central to collective action in climate adaptation in each of the studied islands and found that few strategic actors involved in all situations lead to reinforcing arrangements. Partelow and Manlosa (2022) introduce a process-based, relational perspective of commoning to structuralist analysis of NAS. They argue that merging the analysis of commoning and associated power with the analysis of NAS requires epistemic pluralism because power structures human relations in many ways. Hurlbert and Akpan (2022) integrate non-human objects' agency and discourses in NAS in their analysis of alternatives and futures of electricity production in Saskatchewan. They show how discourses in other provinces, respectively, the national government, shape discourses about local non-human actants. Finally, Méndez et. al. (2022) use the NAS approach together with analysis of power to understand the stalemate of water and wetland governance in the Doñana estuary–delta social–ecological system in Spain. They identify governance, institutional, informational, and power

mechanisms that prevent further degradation of the SES and, paradoxically, pose both risks and opportunities for sustainability associated with the implementation of large infrastructural projects.

Diverse paths and common grounds

The studies in this special feature display several methodological approaches, which this section highlights in addition to pointing out unique approaches. Although the contributions are diverse, there is common ground, as the structured account of the articles summarized in Table 1 suggests. The table also helps to quickly identify studies that are of interest to different readers.

Many studies addressed more than one issue or sector, highlighting the relevance for nexus research, while six studies focus on one sector or issue. The NAS approach is used for empirical purposes or to develop a new method or model. Research designs of empirical articles include single, comparative, or multi-site case studies. The variety of mostly qualitative and mixed methods mainly generate data from interviews and document analysis, followed by survey and secondary data, clearly displaying the pluralist tradition of situation-centred research (Beckmann and Padmanabhan 2009; Poteete et al. 2010). Two studies also employ game-theoretic models (Kasymov et al. 2022; Méndez et al. 2022), and one uses quantitative multilevel network analysis (Hedlund et al. 2022). This conceptual network diversity is also in line with the pluralist approach to the ecology of games that currently exists and has been discussed in the review article in this special feature (Kimmich et al. 2022), including qualitative approaches (Dutton et al. 2012), quantitative network analyses (Mewhirter et al. 2018; Berardo and Lubell 2019; Angst et al. 2022), the game-theoretic strand of nested (Distefano and D'Alessandro 2021) and connected games (McGinnis 1986; Khachaturyan and Schoengold 2018; Venkateswaran and Gokhale 2019), and the analytic narrative approach (Bates et al. 2000; Kimmich 2016), among others.

Types of ASs and NAS vary considerably across the studies. Types of ASs include governance and management functions, different stages of participatory processes, and many others. The situations mostly address operational and collective choice, but five studies also cover constitutional choice. The studies mainly attend to institutional, social, and informational links between ASs, whereas five studies also capture physical links. Most of the studies delineate the boundaries of ASs along the social interactions that influence the outcome of interest. ASs are often identified from use or governance functions for different resource systems such as water or energy systems. Others delineate the boundaries of ASs along jurisdictions or identified ASs along value chains. Three studies identified ASs from a policy's

Table 1 A structured account of all contributions to the special feature

Author(s)	Issue /sector	Research design	Method	Data	Types of ASs	Levels of ASs	Types of links between ASs	Identification of ASs and the NAS
Temporality of relations between ASs								
Baldwin et al. (2022)	Forestry	Comparative or multi-site case study	Qualitative	Document analysis, secondary data	Planning jurisdictions: e.g. national forest planning, US Forest Service planning, regional forest planning	Collective, constitutional	Institutional	Inductive: social interactions (with causal influence on outcomes); jurisdictional boundaries; governance functions
Delaroche et al. (2022)	Agriculture, forestry, water	Comparative or multi-site case study	Geospatial analysis, qualitative	Interviews, ethnography, field site visits, document analysis, survey, secondary data, GIS	Governance functions: appropriation, monitoring, rule making	Operational, collective	Institutional, physical, social	Inductive: social interactions (with causal influence on outcomes); resource systems or uses; jurisdictional boundaries; activities in value chains; telecoupling
Ruseva (2023)	Forestry, climate	Single case study	Qualitative	Interviews, document analysis, process tracing	Governance functions: e.g. provision, production, and financing; verification, registration, and issuance	Operational, collective	Social, institutional	Inductive: social interactions (with causal influence on outcomes); governance functions
Complementarities and disconnects between ASs								
Ortiz-Riomalo et al. (2022)	Water	Method or model development (with empirical illustration)	Conceptual advances with empirical illustration	Interviews, secondary literature, transdisciplinary methods, action research	Stages in participatory process: e.g. knowledge generation, coordination, collective choice, and connected processes	Operational, collective choice	Institutional, informational, physical, social	Inductive: social interactions (with causal influence on outcomes)
Warbroek et al. (2022)	Water, energy, climate	Single case study	Qualitative	Interviews, document analysis	Mixed: integration of water, energy, building, environmental and farming sectors in energy infrastructure planning and development	Operational, collective	Institutional	Resource systems or uses; sectors
Kasymov et al. (2022)	Pastoralism	Method or model development (with empirical illustration)	Formal game-theoretic model building, qualitative	Interviews, survey	Governance functions: e.g. leasing and certification; establishing user groups	Collective, constitutional	Institutional	Intended outcome of policy design; resource systems or uses; governance functions

Table 1 (continued)

Author(s)	Issue /sector	Research design	Method	Data	Types of ASs	Levels of ASs	Types of links between ASs	Identification of ASs and the NAS
Kellner (2022)	Water, energy, food (nexus)	Single case study	Conceptual advances with empirical illustration	Interviews, field site visits, document analysis, transdisciplinary methods	Governance functions: e.g. national laws and strategies, interactions to develop water rights; management decisions	Operational, collective, constitutional	Informational; social	Inductive: social interactions (with causal influence on outcomes); resource systems or uses
Unmikrishnan et al. (2023)	Water	Method or model development (with empirical illustration)	Conceptual advances with empirical illustration	Interviews, document analysis, secondary data, GIS	(n.a., theoretical paper)	(n.a., theoretical paper)	n.a	Inductive: social interactions (with causal influence on outcomes)
Hoffmann and Villamayor-Tomas (2022)	Water (irrigation)	Comparative or multi-site case study	Network visualization, qualitative	Secondary literature	Management functions: e.g. water allocation, cropping, infrastructure maintenance	Operational, collective	Institutional, informational, physical	Inductive: social interactions (with causal influence on outcomes); resource systems or uses; governance functions
Cazzaro et al. (2023)	Drinking water (pollution), agriculture, wine industry	Single case study	Quantitative and qualitative	Interviews, document analysis, secondary data	Value chain: e.g. wine production, upstream treatment enforcement, downstream treatment investments	Operational, collective	Institutional, informational, physical	Inductive: social interactions (with causal influence on outcomes); activities in value chains; governance functions
Hedlund et al. (2022)	Water	Single case study	Social network analysis, qualitative	Interviews, survey	Mixed/policy issues: e.g. environmental monitoring of non-native species, Maintaining fish connectivity, Protection of cultural heritage	Operational	Institutional, physical, social	Inductive: social interactions (with causal influence on outcomes); intended outcome of policy design
Strategic actors, power, and discourse								
Oberhauser et al. (2022)	Ground water, irrigation, energy, urban	Single case study	Qualitative	Interviews, secondary literature	Mixed: donor group, water governance, energy governance, social contract, science and policy advice	Operational, collective	Institutional, informational	Resource systems or uses; jurisdictional boundaries
Robinson et al. (2022)	Climate change adaptation	Comparative or multi-site case study	Qualitative	Interviews	Governance functions: e.g. adaptation policy making, adaptation funding, adaptation research	Collective, constitutional	Institutional, informational	Inductive: social interactions (with causal influence on outcomes); intended outcome of policy design; jurisdictional boundaries

Table 1 (continued)

Author(s)	Issue /sector	Research design	Method	Data	Types of ASs	Levels of ASs	Types of links between ASs	Identification of ASs and the NAS
Partelow and Manlosa (2022)	Tourism, aquatic food production	Two illustrative single case studies	Qualitative	Interviews, document analysis, field site visits, secondary literature,	Governance functions: e.g. self-organization, coral reef use, waste production and management	Operational, collective	Institutional, functional	n.a
Hurlbert and Akpan (2022)	Energy production	Single case study	Statistics, qualitative	Interviews, focus groups, survey, secondary data	Mixed: e.g. transnational regulatory spaces, Canadian federal jurisdiction, media, power production	Operational, collective	Institutional, informational	Resource systems, jurisdictional, and narrative
Méndez et al. (2022)	Water, wetland conservation, ports, agriculture	Single case study	Game theory, qualitative (analytic narrative approach)	Document analysis, primary and secondary sources	Mixed: e.g. scientific commission, knowledge generation, water planning, supranational government	Operational, collective, constitutional	institutional, informational	Inductive; jurisdictional boundaries; resource uses; activities in value chains

intended outcomes, but most combined multiple logics to construct boundaries.

Implications for sustainability science

Boundary specification can become even more challenging when using NAS approaches in transdisciplinary research, as social network analysis in a participatory setting suggests (Prell et al. 2021). More fundamentally, quantitative methods that capture the complex NAS structure are only recently emerging (as discussed in Kimmich et al. 2022). This leads us to at least five contributions that NAS can make to sustainability science.

NAS in a relational turn

A relational, process-oriented perspective to NAS research has been most explicitly proposed by Partelow and Manlosa (2022) in this special feature. Their focus on commoning rather than commons helps to explicate manifestations of power and the inseparable relationships of society and nature. This resonates well with the relational turn recently suggested for sustainability science (West et al. 2020). Whereas some NAS research remains substantivist and interactionist, most empirical studies in the review and in this special feature expand on the relational turn needed to address current sustainability concerns.

Because the NAS approach helps identifying connected ASs it prevents omission of key governance variables impacting ASs (Delaroche et al. 2022). Institutional silos arranged around a particular sustainability problem or established sectors are typically not fit for purpose when multiple sustainability problems need to be addressed (Kellner 2022; Warbroek et al. 2022). Looking at NAS in governing relational resources such as groundwater can uncover adjacent ASs of resource users in and peripheral ASs that are important context (Oberhauser et al. 2022). Principal–agent relationships can extend from one AS to another, especially when monitoring is critical to governance (Ruseva 2023). Spatially distant biophysical relations of different sustainability problems are a challenge that can be addressed with the explicit study of information flows and telecoupling that connects different ASs (Delaroche et al. 2022). Relating ASs effectively requires integrative institutions and ASs that connect the siloed ASs through reinterpretation of rules and mutual learning (Warbroek et al. 2022).

Network analysis can identify ties between actors and ties with issues to suggest reinforcing or contradictory interdependencies of policy issues and respective ASs (Hedlund et al. 2022). Actor–network theory can add to NAS, because it helps to explore relations of both human and non-human objects in mid-range explanations of institutional change

in NAS (Hurlbert and Akpan 2022). Also, the commoning perspective is centred around unfolding relationships that can take non-human objects and their context into account in process analysis of socio–ecological issues (Partelow and Manlosa 2022).

Studying power in NAS

Making complex NAS transparent can help overcome the power of inside experts and facilitate experimentation and innovations (Ruseva 2023). However, power to influence a social–ecological system can be unevenly distributed in an NAS (Unnikrishnan et al. 2023). A case from Jordan identified an important role of ad hoc ASs founded on informal rules that sit in permanent NAS and reproduce traditional power relations that challenge sustainability in non-democratic systems (Oberhauser et al. 2022). Likewise, the combination of an NAS approach with a polycentric and discursive view on power can uncover power relations that undermine sustainability-supporting formal arrangements and knowledge (Méndez et al. 2022). The analysis of commoning also suggests that power can be insufficiently attended to, when only devising formal concepts that neglect power (Partelow and Manlosa 2022). Finally, participatory governance of social–ecological systems requires empowerment of stakeholders that depends on how ASs are arranged in an NAS (Ortiz-Riomalo et al. 2022).

Going beyond panaceas through NAS research

The NAS approach invites analysts to look beyond local cases and to identify governance factors that originate from other locations, sectors or environmental issues (Delaroche et al. 2022). Attention to issues and evolving insights into them require evolving NAS and respective flexibility of institutions (Warbroek et al. 2022). However, care is needed that identification of NAS is not guided too much by formal institutions, because informal institutions can be important in explaining governance networks (Oberhauser et al. 2022). Further research is frequently recommended to verify whether NAS-related findings apply in other spatial, topical and social contexts (see, e.g. Hurlbert and Akpan 2022). It is also important not to delimit boundaries of an NAS too strictly, as more distant ASs can significantly impact on a case (Ortiz-Riomalo et al. 2022). While standardized approaches certainly help to diagnose potentially cross-cutting features of cases (Unnikrishnan et al. 2023), they can imply omission of particularities of cases, when not going beyond standardized conceptions, because NAS can vary greatly between cases (Hoffmann and Villamayor-Tomas 2022). Ultimately, solutions to sustainability problems may become even less simple when the NAS approach

uncovers the complexities of cases. This suggests caution when extrapolating from individual cases (Cazcarro et al. 2023).

Towards NAS archetypes

The diversity of case-specific terminology, content and numbers of ASs is representative of the current state of the art in this field (Kimmich et al. 2022): 'knowledge generation', 'coordination' and 'collective choice' are the three focal ASs in Ortiz-Riomalo et al. (2022), for example, whereas Kellner (2022) traces how 11 ASs explain coordination gaps between food, water, and energy uses of water resources. Such case-specific NAS often explain specific outcomes, rather than general questions, for example about participation or learning. However, the growing diversity of NAS studies raises the question whether archetypal ASs or situation networks exist, i.e., ASs that arise recurrently in the governance of social–ecological systems. The NAS approach may remain 'only' an analytical approach that helps researchers to analyse empirical cases. If, by contrast, archetypal situations and networks exist, then the NAS approach may contribute to the development of middle-range theories over time (Cumming et al. 2020).

An archetypal NAS could be the integration of sector-specific governance approaches (Warbroek et al. 2022), for example. There also appears some promise in identifying archetypal NAS even when NAS tend to be different across cases of a similar issue area such as irrigation modernization (Hoffmann and Villamayor-Tomas 2022). NAS archetype development can also build on experiences with situation archetypes. Rauthmann et al. (2014) recently proposed a situation taxonomy in psychology. Bruns and Kimmich (2021) deductively derived archetypal situations, including coordination, assurance, and social dilemmas, among others, but it remains unclear to what extent such archetypes explain the diversity of empirical situations that involve a multitude of actors, choices, or frames, among others.

NAS to open the black box of polycentric governance?

For decades, using the lens of polycentric governance, institutional analysts have addressed interactions between de facto autonomous but interdependent agents, wondering how such constellations perform in comparison to more centralized, hierarchical or more decentralized, market-based governance (Ostrom et al. 1961). These constellations have been evaluated regarding effectiveness, legitimacy, and transparency. More recently, also system-level criteria were mobilized, such as adaptiveness and resilience. The concept of ASs has been extensively used to evaluate the inner workings of collective action among individual and collective

actors (Ostrom 2011). In contrast, the analysis of interactions between ASs, as we observe it in polycentric governance, has been lacking an equally consistent conceptual lens. In this regard, we argue that NAS provides a promising level at which to conceptualize and open the black box, i.e. the inner workings of polycentric governance.

Thus far, the literature on polycentric governance particularly emphasizes its structural features, for example within a heterarchy typology (Cumming et al. 2020). In contrast, we argue that NAS can help us to disentangle the structural constellations within polycentric governance and their connections to contextual elements, such as characteristics of the agents and rules that structure polycentric governance. Further, it allows us to track the polycentric processes to their performance, a key gap in the field. The contributions to this special feature illustrate their potential to extend research on polycentric governance. We suggest using NAS to consistently operationalize research on polycentric governance.

Characterizing a NAS and its context in such a way may help us to unpack and typify the complexity of polycentric governance and to understand the conditioning factors and roles of hierarchical, competitive, or cooperative connections between ASs.

Conclusions

As illustrated through this editorial and the detailed original research presented in this SF, embedding micro-analytic situational analysis into NAS has triggered fruitful insights into the adjacent and contextual drivers of actors' interdependent decision-making. In our view, this provides a useful frame also to disentangle questions of relationality, power, and polycentric governance. The approach allows scholars to fruitfully navigate case specificity and convergence on common adjacent and contextual elements and relational aspects that drive processes and outcomes. The identification of archetypes of NAS may eventually help in diagnosing settings more systematically and identifying leverage points for changing their course, a key concern in sustainability science (Leventon et al. 2021). The NAS approach could provide a crucial structuring device to such analysis, particularly where it addresses processes constituting ASs at different levels of governance in interrelated situations. Coupling NAS with systems analysis and analysis of feedbacks over longer periods of time seems promising to navigate the situational and dynamic complexity and diversity of social–ecological systems. These and many more aspects of furthering situation-centred analysis of sustainability transformations are highlighted within this special feature.

Declarations

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