Environmental Science and Policy 144 (2023) 43–52

Contents lists available at ScienceDirect

Environmental Science and Policy

journal homepage: www.elsevier.com/locate/envsci

Organising inter- and transdisciplinary research in practice. The case of the meta-organisation French LTSER platforms

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ARTICLE INFO

Keywords:
Interdisciplinary research
Transdisciplinary research
Boundary organisation
Meta-organisation
French LTSER platforms

ABSTRACT

This article studies the reorganisation of research communities in a context characterised by tension between increasing calls for inter- and transdisciplinary research (ITDR) and the persistent structuring, functioning and evaluation of scientific research on a mainly disciplinary basis. We focus on the case of the French LTSER platforms, the 'Zones Ateliers' (ZAs), which are committed to ITDR on social-ecological systems, drawing on in-depth interviews with their leaders, analysis of their applications for creation or renewal and bibliometric data. We use the two concepts of boundary organisation and meta-organisation to analyse the organisational aspects of ZAs. We show that ZAs are not only quasi boundary organisations, as is often emphasised, but also research-based meta-organisations, which is ignored but has important implications for their functioning and dynamics. Our study also shows that ZAs have so far had a limited impact on the organisation of research communities, and that the levels of inter- and transdisciplinarity in their bodies, projects and publications have recently increased but remain relatively low. Our article contributes to the literature about LTSER platforms by exploring the relationship between their type of organisation and what they can achieve to promote ITDR. It also contributes to the literature about boundary organisations and meta-organisations, by clarifying their similarities and differences, as well as their limitations and added value for investigating the organisational aspects of initiatives to promote ITDR.

1. Introduction

Disciplinary academic research, which is conducted in universities and research centres in relative isolation from the rest of society, is increasingly considered ill-suited to addressing many problems facing contemporary societies (Hirsch-Hadorn et al., 2008). Indeed, a growing number of these problems are complex, interconnected and present a high degree of uncertainty. They cut across scientific disciplines and affect a broad range of societal actors with diverse and often conflicting interests, knowledge and perspectives on these problems. Because of these characteristics, such problems have been labelled 'wicked problems', a term proposed by urban planners in the 1960 s and 70 s (Rittel and Webber, 1973) and now widely adopted. Many scientists share the conviction that wicked problems can only be tackled by bringing together research actors from various scientific disciplines, as well as societal actors interested in or affected by the problems at hand, i.e., through inter- and transdisciplinary research.

According to the widely accepted definition, interdisciplinarity (ID) refers to production of scientific knowledge that integrates information, data, methods, perspectives, concepts and/or theories from multiple disciplines (Kates, 2011; National Academy of Sciences, 2004). The notions of transdisciplinarity (TD) and transdisciplinary research (TDR) have been the subject of much more discussion (Klein et al., 2001; Jahn et al., 2012) and have generated academic debates. However, TDR has increasingly referred to collaboration between academic actors and people outside academia to investigate and address so-called real-world problems (Wickson et al., 2006; Lang et al., 2012), especially in the English-language literature. This is the definition we adopt herein.

Calls for inter- and transdisciplinary research (ITDR) emerged as early as the 1970 s (OECD, 1972) and multiplied in the early 1990 s with the publication of highly influential books (e.g., Gibbons et al., 1994) and papers (e.g., Funtowicz and Ravetz, 1993). Since the 2000 s, they

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https://doi.org/10.1016/j.envsci.2023.03.009
Received 15 April 2022; Received in revised form 4 November 2022; Accepted 8 March 2023
Available online 16 March 2023

have been gaining even more ground (Bozeman and Boardman, 2014). For example, handbooks of inter- (Frodeman et al., 2010) and transdisciplinary research (Hirsch-Hadorn et al., 2008) have been published to provide newcomers to the field with concepts, approaches and case studies to help them engage with these modes of research. Examples of publications promoting ITDR now abound in environmental science and emerging scientific fields oriented towards tackling environmental problems, such as sustainability science (Kates, 2011; Komiyama and Takeuchi, 2006; Lang et al., 2012). Beyond academic literature, science policies have also increasingly encouraged and expected researchers to develop inter- and transdisciplinary projects. Many funding processes at local, national and international levels now foster such projects (Cundill et al., 2015; for an example, see Horizon 2020: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/excellent-science).

However, scientific disciplines have meanwhile remained the basic unit of academic structure and functioning (Hirsch-Hadorn et al., 2008). For example, scientists are still mostly evaluated by disciplinary committees according to disciplinary agendas and criteria, at least in France. There is therefore a major tension between the promotion of ITDR and the mainly disciplinary structure of academia (Guimarães et al., 2019). Several studies have explored this tension by investigating how research actors respond to calls for ITDR and seek to become inter- and transdisciplinary within a predominantly discipline-based framework (Augsburg, 2014; Guimarães et al., 2019; Fam et al., 2016). Research communities also deserve close attention, since organisations, infrastructures and platforms committed to ITDR have been created. The growth of ITDR is therefore not just about individuals, but also about research communities (Grove and Pickett, 2019).

Studies at the research community level have chiefly focused on processes such as trust building and mutual learning (e.g., Scholz, 2001; Jahn et al., 2012; Cundill et al., 2015; Mascarenhas et al., 2021), and have paid less attention to organisational issues. In general, the impact of organisation on research content is poorly understood (Gläser and Laudel, 2016; Leahey and Barringer, 2020). In her study of nanomedicine, Louvel (2021) showed that the sociopolitical order produced by interdisciplinary policies has only some of the characteristics of full-fledged sociopolitical orders and complements rather than replaces or contradicts the disciplinary organisation of contemporary science. Leahey and Barringer (2020) found that universities' commitment to ITDR has a positive effect on the quantity of interdisciplinary research but no effect on its quality. We seek to contribute to this body of work by documenting and analysing to what extent, in what ways and with what effects research communities are reorganising in the face of rising calls for ITDR.

We base our analysis on an empirical study of French organisations – Zones Ateliers (ZAs) – which aim to promote ITDR to investigate the functioning and dynamics of social-ecological systems[1] facing global changes. We specifically investigate the following research questions: What kind of organisations are ZAs? Does the way they organise themselves influence the level of inter- and transdisciplinarity of the research projects[2] they support and their outputs? Clarifying the type of an organisation is important not only from a theoretical perspective but also from an operational one. Indeed, it helps in understanding its functioning and dynamics, e.g., at what rate it can change, the type of challenges it is likely to face and what it can and cannot achieve.

We first introduce two concepts – boundary organisation and meta-organisation – that have been used for analysing organisations bringing together heterogeneous actors around environmental issues and we discuss their similarities and differences. We then present the characteristics of ZAs that matter for investigating organisational issues and the mixed methods we used to collect and analyse the data. The next two sections present and discuss our findings on the organisational arrangements of ZAs and the level of inter- and transdisciplinarity in their advisory and governing bodies, research projects and publications.

2. Boundary organisations and meta-organisations

Designing organisations that can facilitate collaboration between research actors and other societal actors, in particular public policy communities, has been identified as a powerful means of achieving ITDR (Parker and Crona, 2012). Such organisations have been referred to as boundary organisations (BO, Guston, 1999, 2001) by science and technology scholars. Derived from principal-agent theory, the concept of BO aims to provide an understanding of processes taking place at the interface between science and policy. Guston (1999) proposed this concept to account for forms of organisation aiming to create collaborative processes that allow both science and policy to achieve their goals while stabilising the boundary between them. According to his definition, BOs must meet three criteria. First, they must facilitate the creation and use of boundary objects[3] and standardised packages.[4] Second, they must involve the participation of actors from both sides of the boundary. Third, they are accountable to each social world according to its own criteria. The concept has been widely taken up and enriched to render it more dynamic, complex and sensitive to power imbalances (Gustafsson and Lidskog, 2018). BOs have been increasingly described as involving several blurred and moving boundaries rather than a single clear-cut and fixed boundary between science and policy and having to navigate contradictory demands and tensions between a long-term and a short-term focus, basic and applied research, disciplinary and interdisciplinary research and autonomy and consultancy (Parker and Crona, 2012).

However, the concept of BO does not refer to a specific form of organisation, and it is silent on crucial organisational issues such as membership and leadership (Gustafsson and Lidskog, 2018). As a result, BOs encompass a wide variety of organisational arrangements. This lack of attention to organisational issues is a serious limitation of the BO concept for studying how research communities reorganise to respond to calls for ITDR. To overcome this limitation, we mobilised the concept of MO that was developed by two organisation scholars, Göran Ahrne and Nils Brunsson.

First, Ahrne and Brunsson (2008, 2011) clarify what is and what is not an organisation: an organisation is an attempt to establish a decided order to achieve a certain goal (in our case promoting ITDR, seen as a condition for addressing the wicked environmental problems facing contemporary societies). Full-fledged organisations have members, a hierarchy, rules, positive and/or negative sanctions and ways of monitoring their activities to track their progress towards their goal. Because they are based on explicit decisions that can always be questioned, organisations are more fragile and exposed to contestation than other types of social orders, such as networks and institutions (Ahrne and Brunsson, 2011). Networks consist of informal structures of non-hierarchical relationships between social actors, and institutions are built by common beliefs and norms and are taken for granted (Ahrne

[1] Developed in the 1990 s, the notion of social-ecological systems (Berkes and Folke, 1998) expresses the idea that social systems and ecological systems are closely interconnected and cannot be studied separately. It invites a focus on their interactions and the complex adaptive systems they form (Preiser et al., 2018).

[2] Research projects are 'temporally, financially and staff-wise limited units of activities in relation to one or more related research goals' (Newig et al., 2019: 149).

[3] In a seminal article, Star and Griesemer (1989) defined boundary objects as 'both adaptable to different viewpoints and robust enough to maintain identity across them'. Boundary objects play a key role in the capacity of different social worlds to cooperate.

[4] 'Standardised package' is another concept used for analysing collective action. It involves standardised methods aiming to produce relatively stable facts across social worlds (Fujimura, 1992).

and Brunsson, 2011).

Second, Ahrne and Brunsson (2005, 2008) distinguish between individual-based organisations, whose members are individuals, and meta-organisations (MOs), whose members are organisations themselves. Being an individual-based organisation or a meta-organisation has important implications for the functioning and dynamics of organisations. For example, MOs have access to resources through their member organisations from the outset and are therefore immediately operational: they are a cheap way to set up collective action (Berkowitz and Dumez, 2016). They tend to have a small and stable membership, which may lead to a monopolisation of decisions and low capacity for change. Other characteristics of MOs such as a culture of consensus increase their tendency to inertia (König et al., 2012). Moreover, members of MOs generally have as much power as the MO itself – or sometimes more – and can initiate the same type of activities, which may generate competition between MOs and their members.

The concept of MO was originally developed to account for organisational processes in sectors where MOs bring together one single type of members, such as firms in the same industry (Berkowitz et al., 2020). As a result, similarity among members was considered a key characteristic of MOs (Cropper and Cropper and Bor, 2018). This assumed homogeneity of MOs was a major weakness of the concept for the study of organisational arrangements in ITDR, which is precisely predicated on the idea that a wide range of actors should collaborate to address wicked problems. However, MOs have proliferated (Berkowitz and Dumez, 2016) and are increasingly found in sectors that rely on the collaboration of heterogeneous actors, including research actors, to tackle wicked sustainability problems such as climate change (Chaudhury et al., 2016), ocean degradation (Berkowitz et al., 2020) and poverty (Pradilla et al., 2022). The concept of MOs has thus been extended to organisations whose members hold different and potentially contradictory views on the problems to be addressed (Berkowitz et al., 2020, 2022b).

Drawing on the case of ocean degradation, Berkowitz et al. (2020) identified four conditions for a MO to effectively address sustainability problems: 1) it should be a governing MO, i.e., it should have at least some of the attributes of a full-fledged organisation (rules, hierarchy, leadership, monitoring, rewards and sanctions) and offer a neutral inter-organisational space; 2) its governance should involve multiple, cross-sectoral stakeholders who each contribute their expertise and views on the problem at hand; 3) it should be spatially embedded, to be able to attend to local social-ecological specificities; and 4) it should gain actorhood, i.e., be considered responsible for its decisions and accountable to its members and to external actors.

The BO and MO concepts have therefore both been used to account for and analyse organisations designed to facilitate collaboration between research actors and societal actors in order to address wicked sustainability problems. While they were developed separately and emanate from two distinct bodies of literature (science and technology studies for the BO concept and organisation studies for the MO concept), they have recently converged in some works, which note that multi-actor MOs can act as BOs (Berkowitz and Dumez, 2016: 151; Berkowitz et al., 2020). As for BOs, they are often, but not necessarily, MOs. Analysing BOs as MOs, when applicable, helps to understand the limits of their ability to achieve ITDR by focusing on organisational aspects that are otherwise ignored.

Well-known empirical examples in the environmental field include Birdlife International and the International Whaling Commission (Berkowitz and Grothe-Hammer, 2022) for MOs, and the IPCC and the IPBES for BOs. MOs and BOs cover a wide range of scales from local to global. We focus here on local organisations, the French Zones Ateliers (ZAs).

3. The Zones Ateliers as organisations committed to place-based and long-term ITDR

ZAs were named after the objective they seek to achieve: 'zones' refers to the fact that they are spatially bounded and embedded, and 'ateliers' (from the Latin *astula*, meaning a small piece of wood) designate places where people work together. ZAs are a major tool used by the French national centre for scientific research (CNRS) to promote place-based and long-term ITDR (Lévêque et al., 2000; Lagadeuc and Chenorkian, 2009; Bretagnolle et al., 2019). They are the French representatives of the long-term social-ecological research (LTSER) sites at the international level (iLTER) (Dick et al., 2018). 14 ZAs have been created in diverse social-ecological contexts over the last two decades, some of them having pre-existed their official recognition. They are widely distributed in space and vary considerably in size and shape.[5] A national 'network' of ZAs was created by CNRS in 2000 to encourage exchanges and synergies between them.

ZAs are ideal for studying the reorganisation of research communities. Indeed, they are bottom-up initiatives that their leaders submit to CNRS to be recognised as ZAs and admitted to their national 'network'. CNRS gives them few organisational guidelines in return, i.e. they are relatively free to organise themselves as they wish to achieve ITDR. This allows identifying and comparing the organisational decisions of different research communities. Additionally, their longevity allows observation of how research communities change their organisation over time and how they may experiment with successive organisational arrangements.

Another reason for investigating ZAs is that we are deeply involved in their management: two of us have each been co-leading a ZA (ZA Plaine & Val de Sèvre for many years and ZA Alpes since 2020) and one of us also led the national 'network' of ZAs from 2014 to 2020. We therefore have in-depth knowledge of the organisation, activities and outputs of two ZAs and their national 'network', as well as easy access to detailed data on the other 12 ZAs through their 'network'.

4. Data collection and analysis

Following Gläser and Laudel (2016), we used a mixed-methods design, inspired by science policy studies, science and technology studies and bibliometrics, to investigate the relationship between research organisation and research content.

We conducted semi-directed remote interviews with the leader(s) of each ZA during spring 2020.[6] We asked them about the human and financial resources of their ZA, its governing and advisory bodies, and the goals and composition of these bodies. We also asked them about the level of ID and TD in the projects and publications of the ZA. Most informants distinguished between two types of ID: narrow or restricted ID between research actors from scientific domains they consider to be close, and what they called extended or radical ID between human and social scientists (HSSs) on the one hand, and life or earth scientists on the other hand. We focus here on extended ID (EID) because it is easier to identify than narrow ID (informants disagree about when ID begins), and because informants generally considered EID to be more important and difficult to achieve. We recorded and transcribed the interviews, which lasted approximately two hours. We used qualitative analysis software (MaxQDA) to analyse them, coding all passages relating to organisational aspects of the ZAs as well as to the levels of EID and TD in the ZA bodies, projects and publications.

In addition, we collected the last application for creation or renewal submitted to CNRS by each ZA. These applications covered five-year periods and dated from 2017 to 2020 depending on the ZA. Following a template developed by CNRS, they consisted of four parts: i) a two-page overview indicating the members, bodies, academic and societal partners and the spatial extent of the ZA; ii) a ten-page summary of the past period, if applicable; iii) a ten-page project for the coming period

[5] For a detailed description of the ZAs, see Bretagnolle et al. (2019).

[6] Out of the 22 ZA leaders we interviewed in total, 15 are men and 18 have a background in natural sciences (13 in life sciences, 5 in earth sciences).

and iv) appendices including lists of publications and projects associated with the ZA during the past period, if applicable.

Drawing on this material, we first identified the number and types of governing and advisory bodies of each ZA. We then evaluated their level of EID and TD, distinguishing three levels (low, intermediate and high). We considered that the TD level of a ZA governing and advisory bodies was low when none of these bodies involved societal actors or if one of them involved only societal actors; intermediate when some of them involved both research actors and societal actors; and high when most or all of them did. We followed a similar logic to evaluate the level of EID, by focusing on the proportion of advisory and governing bodies involving both HSSs and life and/or earth scientists. We did a similar exercise to evaluate the level of EID and TD in the ZA research projects, basing our evaluation both on the interviews and on the applications for creation or renewal. We considered the level of EID (or TD) to be low when only a minority of projects involved both life or earth scientists and HSSs (or academic actors and societal actors), intermediate when this was the case for around half of the projects and high when this was the case for a majority of the projects. We based our evaluation of the level of EID in the publications on the list included in the applications for renewal. We considered the level of EID in publications to be low when less than 10% of peer-reviewed articles were co-authored by life or earth scientists and HSSs. All ZA leaders were given the opportunity to respond to our preliminary results, which led us to slightly modify our evaluation of EID in the research projects of one ZA.

Using univariate linear regression models (lm procedure in R), we analysed the existence of relationships between the following EID and TD levels: EID and TD levels in ZA bodies; EID and TD levels in ZA projects; EID levels in ZA bodies and projects; TD levels in ZA bodies and projects.

5. Results

5.1. Tinkering with organisational arrangements

All ZAs had one or several leader(s) and, except for ZA Plaine & Val de Sèvre, convened an annual general assembly. Otherwise, they had very diverse organisational features. The number and titles of their governing and advisory bodies varied greatly (for a detailed presentation, see Table 1). Some ZAs had up to five bodies beyond the leading team, others only two, one of which may have been dormant, such as the governing board of the ZA Alpes in 2020. The number of advisory and governing bodies also changed over time for a given ZA. For example, the ZA Terres Uranifères had recently set up a stakeholders' committee; simultaneously, the ZA Loire had decided not to set up a planned monitoring committee, which should have included local managers and stakeholders, because 'their involvement at the project and workshop site level has increased significantly in recent years and this level no longer seemed relevant' (excerpt from the renewal application of ZA Loire). Thus, no single organisational arrangement prevailed over the others: each ZA established and tested its own organisational arrangements.

5.2. Quasi boundary organisations

All ZAs clearly stood at the interface between science and policy. They encouraged using what can be considered boundary objects to facilitate collaboration between research actors and societal actors. This is visible in the social-ecological systems they identified. For example, the ZA Arc Jurassien considered the meadows used to produce a local cheese (*comté*) as a key social-ecological system; this social-ecological system was meaningful for both research actors and societal actors (farmers, cheese producers and local representatives), but they related to it in different ways. Another example of a boundary object was the very perimeter of the ZAs, which in most cases had been delineated to include important research sites and to ensure that the ZAs were relevant entities for societal actors. This was notably the case for ZAs associated with a mountain range (the Alps, the Pyrenees or Jura) or a large watershed (the Seine, Loire, Rhône or Moselle); their extension allowed research actors to take into account various gradients and fitted territorial units, such as mountain range committees or watershed agencies, that were relevant for societal actors. Moreover, all ZAs involved both societal and research actors, albeit to very different extents, as well as individuals who straddled science and policy (e.g., individuals with a robust scientific background working in protected areas, local communities or water agencies). In turn, they submitted their outcomes and project to CNRS only: they were essentially accountable to the research world, rather than to both science and policy, as the definition of boundary organisations would require. Thus, ZAs fully met the two first criteria defining BOs (boundary objects and involvement of actors from both worlds), and only partly the third one (accountability to both science and policy).

5.3. Research-based meta-organisations

During the interviews, the ZA leaders designated the people participating in their activities as their 'members'. Some had established a list of individual members of their ZA, for example by drawing on the list of participants in the annual general assembly: 'Membership is relatively flexible, well, you had to know who was a member of the general assembly. However, this is very difficult to determine, so we have a real problem of governance, which we are having trouble resolving' (interview with a leader of a ZA).[7] The leaders of a ZA envisaged establishing such a list and asking their 'members' to agree to a charter indicating their rights and duties. The CNRS institute in charge of ZAs, entitled *Institut Ecologie et Environnement* (INEE), also encouraged them to indicate how many 'members' they actually had. In other words, their leaders and supervising authorities saw ZAs as individual-based organisations.

However, the creation and renewal applications clearly showed that the members of ZAs were not individuals, but research labs (or research programmes in the case of ZA Antarctique et sub-Antarctique). Indeed, these documents started with a list of the research units that were members of the ZA at the date of application. As their members were themselves organisations, ZAs can be defined as MOs, and their national 'network' as a meta-meta-organisation (Ahrne and Brunsson, 2005; Berkowitz et al., 2022). This has several important implications. First, there was little turnover in membership; in particular, member labs seldom left a ZA. Second, some member labs were more powerful than others for various reasons: because they had played a major role in the creation of a ZA; because they were larger, had more resources or managed major research sites; or because they were closer to INEE. The ZA leaders were almost always from these labs; INEE required that at least one co-leader of the ZAs belong to a lab affiliated with INEE. The few member labs with a strong HSS orientation had joined the ZAs only recently and had less weight than the member labs with a strong life sciences orientation that had contributed to the creation of ZAs. Third, with few exceptions (e.g., ZA Bassin du Rhône), ZAs tended to have far fewer human and financial resources than their members. ZAs received very limited annual financial support from INEE, which only some of them managed to supplement, for example through partnerships with societal actors interested in their activities or through the organisation of joint research calls with organisations sharing similar goals. Most ZAs had insufficient financial means to hire staff to help them achieve ITDR; in fact, their status did not allow them to recruit, receive funds or establish partnerships, so they necessarily depended on their member labs to carry out these activities. Fourth, any member of the member labs could participate in and benefit from the activities of the ZAs, even if

[7] Unlike the excerpts from creation and renewal documents, interview excerpts are anonymised.

Table 1
The ZAs and their organizational arrangements.

Name (year of official creation, year of last renewal)	Main topics	Members	Societal partners	Advisory and governing bodies		
ZA Alpes (2008, 2017)	Trajectories and functioning of mountain social-ecological systems in the Anthropocene	8 labs including 2 interdisciplinary labs and 1 lab in HSS	Protected areas, Alpine botanical national conservatory, Grenoble Alpes Metropolis	**Leading team** Before 2020: 2 ecologists Since 2020: 1 soil scientist + 1 sociologist	**Board of directors (*comité de direction*)** Lab directors + directors of local scientific federations + representatives of supervising scientific authorities	**Governing committee (*comité de pilotage)*** Representatives of member labs + representatives of societal actors
ZA Antarctique et sub-Antarctique (2000, 2020)	Long-term dynamics of biodiversity and ecosystems of the French Antarctic and sub-Antarctic Territories	15 research programmes including 1 in HSS	Natural reserve (*Terres australes et antarctiques françaises*)	**Leading team** 2 life scientists	**Scientific council (*conseil scientifique*)** The PI of each research programme + leading team	**Governing committee (*comité de pilotage)*** Scientific council + scientific director of Institut Paul Emile Victor (IPEV) + director of the natural reserve
ZA Arc Jurassien (2013)	Impacts of the past and present evolution of climate and landscape on populations and communities, and on relationships between the environment, ecology and human health in the Jura range	9 labs including 1 in HSS	Organisations for the study and prevention of zoonoses, organizations promoting local cheese production, hunting organizations, local water authorities, environmental authorities, farming authorities, conservationist NGOs, protected areas, national botanical conservatory of Franche-Comté , local communities	**Leading team** 2 life scientists	**Steering and governing council (*conseil d'orientation et de pilotage*)** Under construction Leading team + coordinators of scientific axes and of the 'observatories and modelling' workshop	**Scientific committee (*comité scientifique*)** Leading team + observatory coordinators + theme coordinators + directors of member and associate research units
ZA Armorique (2002, 2017)	Ecological and socio-technical functioning and dynamics of agricultural and urban landscapes	9 labs including 1 in HSS	Farming organisations, regional environmental NGOs, local and regional communities, protected areas, local water authorities, Rennes metropolis, farmers	**Leading team** 3 life/earth scientists	**Scientific steering committee (*conseil d'orientation scientifique*)** A new body designed to involve societal actors more strongly in scientific discussions and the definition of the ZA research strategy	**Governing committee (*comité de pilotage)*** Leading team + 1 representative per lab + 1 referent for the ZA urban site
ZA Bassin du Rhône (2001, 2018)	Functioning, dynamics and restoration of the heavily transformed Rhône hydro-sociosystem	24 labs including 4 in HSS	Water authority (agence de l'eau Rhône-Méditerranée-Corse), Compagnie nationale du Rhône, Electricité de France, French biodiversity agency (OFB), protected areas, regional environmental authorities, Lyon metropolis, etc.	**Leading team** 2 vice-presidents elected by the governing board (one life scientist and one water scientist) + 1 director nominated by the board of directors	**Board of directors (*comité de direction*)** 20 representatives of member labs including a minority of human and social scientists	**Scientific coordination commission (*commission de coordination scientifique*)** Members of governing board + persons in charge of scientific themes + persons in charge of key sites **Advisory committee (*comité consultatif*)** Scientific coordination commission + societal partners Each key site has its own advisory committee
ZA Brest Iroise (2012, 2017)	Functioning and evolution of the coastal social-ecological system in a context of change and with a view to integrated management	6 labs, mainly in life and earth sciences	Companies (Terra Maris), Océanopolis, Parc Naturel Marin d'Iroise, Brest Metropolis	**Leading team** 1 bio-geo-chemist and 1 geomorphologist	**Towards a scientific or a steering committee (*comité d'orientation*)?** The creation of this committee was under discussion at the period of the last application for renewal. It was ultimately not created.	**Governing committee (*comité de pilotage)*** Leading team + coordinators of scientific themes and transversal axes + representatives of scientific supervising authorities + societal partners
ZA Environnement Urbain (2010, 2020)	Functioning of the urban social-ecological system centred on the Strasbourg conurbation and its relations with neighbouring social-ecological systems	12 labs including 3 in HSS and 2 interdisciplinary	Strasbourg Eurometropolis, water agency, environment and energy authorities, local and regional communities, environmental NGOs	**Leading team** 2 researchers + 2 representatives of Strasbourg Eurometropolis	**ZA council (*conseil de ZA)*** 2 referents per thematic group and per transversal axis (when possible one research actor and one person from the Strasbourg Eurometropolis)	**Governing committee (*comité de pilotage*)** Leading team + scientific supervising authorities + representative of Strasbourg Eurometropolis

(*continued on next page*)

Table 1 (*continued*)

Name (year of official creation, year of last renewal)	Main topics	Members	Societal partners	Advisory and governing bodies					
ZA Hwange (2010, 2020)	Functioning of the social-ecological system including Hwange national park	22 labs with a low involvement of labs in HSS (involved in general discussions rather than projects)	Zimbabwe national park, forestry commission, Hwange Rural District Council, Zimbabwean farming authorities and veterinary services, CAMPFIRE NGO, conservation NGOs, French Embassy, Foundations, FAO	**Leading team** 2 life scientists	**Governing committee (*comité de pilotage*)** Researchers particularly involved in the ZA activities (mostly ecologists)	**Stakeholder meetings** The ZA participates in i) a research platform called 'Produce and conserve in partnership' (RP-PCP) that involve French research institutes and Zimbabwean universities, ii) stakeholder meetings, which are organized in the frame of collaborative projects and which involve societal actors (traditional chiefs, prefects, forestry agencies, conservation and development agencies, mining industries, tourism companies)			
ZA Loire (2001, 2019)	Loire hydrosystem and human societies in the Loire watershed and their co-evolution	15 labs including 6 in HSS, and 1 interdisciplinary	Environment/Culture authorities/ Water/Navigation/Hunting authorities, Local and regional communities, protected areas, French biodiversity agency, environmental NGOs, botanical national services, Etc.	**Leading team** 3 life scientists	**Bureau (*bureau*)** leading team + coordinators of structuring projects	**Board of directors (*comité de direction*)** lab representatives + bureau			
ZA Moselle (2000, 2020)	Impact of human activities on the quality of water resources in the Moselle watershed	14 labs including 1 in economy, 1 in agronomy and 1 in geography	Farming organizations, local and regional communities, water/forest authorities, water agency, NGOs	**Board of directors (*comité de direction*)** 4 life and earth scientists	**Partnership committee (*comité partenarial*)** Board of directors + coordinators of research axes + representatives of scientific supervising authorities + societal actors	**Scientific council (*conseil scientifique*)** Board of directors + coordinators of research axes + representatives of member labs			
ZA Plaine & Val de Sèvre (2009, 2017)	Design and implement socio-ecological experiments to conserve biodiversity and investigate impacts of human activities on the functioning of agro-ecosystems	9 ecology labs including 1 research team in ecology that manages the ZA	Local communities, water syndicates, hunting federations, organic farming federation, environment/ farming authorities, NGOs, schools, local representatives, farmers, beekeepers, citizens	**Leading team** 2 life scientists	**Board of directors (*directoire*)** Leading team + 5 other scientists deeply involved in the ZA. Designed in 2017 but abandoned by 2020.	**A scientific and technical committee (*comité scientifique et technique*)** involving researchers from the ZA managing team, other researchers and societal partners was envisaged in 2020.			
ZA Pyrénées Garonne (2017)	Dynamics of interactions between human societies and the functioning of ecosystems in the Pyrenees and the Garonne watershed	17 labs, including 4 in HSS and one interdisciplinary	Water companies, Adour-Garonne Water agency, water/forest/ farming/environment/hunting/ culture authorities, farming organisations, local and regional communities, Toulouse metropolis, botanical services, protected areas, environmental NGOs.	**Leading team** 2 life and earth scientists	**Scientific committee (*comité scientifique*)** Coordinators of structuring research questions + coordinators of main research sites + coordinators of the ZA observatories	**Governing committee (*comité de pilotage*)** Board of directors + heads of each member lab + representatives of scientific supervising authorities représentants des tutelles + societal partners			
ZA Seine (2001, 2020)	Seine watershed: functioning of the watershed as a social-ecological system (PIREN-Seine), flows of urban micropollutants (OPUR), restoration of the ecological functioning of an anthropised estuary (Seine-Aval)	Comprises 3 programmes (PIREN-Seine, OPUR, Seine-Aval) involving 64 labs; each programme has its own sites, and topics	Example of PIREN Seine: Seine-Normandie water agency, water sanitation syndicate, local communities (Large Paris Metropolis, Paris municipality, etc.), regional water syndicate, water/navigation authorities, water companies	**Leading team** 4 scientists including 1 in HSS	**Scientific council (*conseil scientifique*)** 1 for each programme	**Council of institutional partners (*conseil des partenaires institutionnels*)** 1 for each programme			
ZA Terres Uranifères (2015, 2019)	Short and mid-term risks of low-dose radionuclides for people and ecosystem services	26 labs and a multidisciplinary environmental research federation, recent arrival of some labs in HSS	Nuclear safety authority, regional environmental authorities, manager of radioactive springs, company owning regulated area, natural regional park, 3 local communities, local NGO for the control of radioactivity	**Leading team** 3 CNRS researchers (life sciences, radiochemistry, radiobiology)	**Governing committee (*comité de pilotage*)** One representative per member lab; project and axis coordinators, data management coordinator	**Supervisory committee (*comité des tutelles*)** representatives of CNRS and of research partners	**Scientific council (*conseil scientifique*)** 5 people in 2019, including 1 in HSS	**Coordinators of overarching projects**	**Committee of stakeholders (*comité des parties prenantes*)** Under construction

Table 2
Levels of extended interdisciplinarity in the ZA bodies, projects and peer-reviewed publications and levels of transdisciplinarity in the ZA bodies and projects. 1 = low, 2 = intermediate and 3 = high.

Name of ZA	Level of extended interdisciplinarity in			Level of transdisciplinarity in	
	advisory and governing bodies	projects	peer-reviewed articles	advisory and governing bodies	projects
Alpes	2	1	1	2	3
Antarctique et sub-Antarctique	1	1	1	1	1
Arc jurassien	2	2	1	1	2
Armorique	3	3	1	2	3
Bassin du Rhône	2	1	1	1	3
Brest Iroise	2	1	1	1	2
Environnement urbain	3	3	1	3	2
Hwange	2	2	1	1	3
Loire	2	1	1	1	1
Moselle	2	1	1	1	1
Plaine & Val de Sèvre	2	2	1	1	3
Pyrénées-Garonne	2	2	NA	1	1
Seine	2	1	1	2	2
Terres uranifères	1	2	1	1	1

they did not share their goals. ZA leaders had to accept that participants in the ZA activities were not always interested in ITDR: 'We try to find gentle ways for people to adhere to the collective approach of the ZA; if we impose it with a steamroller, the risk is that no one will be behind us when we turn around'.

Another important point is that societal actors were not members but partners of the ZAs. This means that they were not on an equal footing with the member labs and did not have the same rights. For example, the ZA Alpes could only fund projects that were led by a member of one of its member labs. ZAs were therefore research-based meta-organisations, although some of them had established and maintained strong partnerships with a variety of societal actors. Thus, they fulfilled only some of the conditions identified by Berkowitz et al. (2020) for meta-organisations to deal effectively with wicked environmental problems: they were formal, spatially embedded, but not multi-stakeholder, meta-organisations and they were not accountable to societal actors, as mentioned earlier when discussing them as boundary organisations.

5.4. A limited level of ITD in the ZA bodies, projects and peer-reviewed articles

We found the level of TD to be low in 10 ZAs (see Table 2), in particular in their governing bodies (see Table 1 for a detailed presentation). It was high in only one ZA (ZA Environnement Urbain), the leaders of which had decided that research actors and societal actors would sit equally on all the ZA bodies, including the leading team. Societal actors participated in a governing body and played a significant role in decision-making in few ZAs. This was the case for ZA Alpes, and it was not by accident: protected area managers had played a major role in its creation, and a strong collaborative culture had been nurtured for decades among protected area managers and research actors. The level of EID in ZAs tended to be higher than the level of TD. However, it was low in two ZAs, and medium in most. Importantly, a large majority of the ZA leading teams did not include HSSs.

Concerning the levels of TD and EID in the ZA projects, we found much variation across the ZAs. They were high in the projects supported by five and two ZAs, respectively. The level of TD tended to be higher than the level of EID in the projects, contrary to what we found in the ZA bodies. In other words, the research projects supported by ZAs more often involved societal actors than HSSs, whereas the opposite was true for the ZA bodies.

We found that the level of EID in all the ZA peer-reviewed publications was low, which is consistent with the results found by Dick et al. (2018) for the three ZAs included in their international study of LTER platforms' outputs (Armorique, Bassin du Rhône, Environnement Urbain). Focusing on peer-reviewed articles is known to lead to underestimation of ID productions (Katz and Martin, 1997; Roux et al., 2010). However, the consideration of other types of written publications in the publication lists, including reports, did not change the overall picture. It should also be noted that some applications went back several years. The interviews suggested that the level of EID in publications had recently increased, without changing the situation radically. Overall, the publications associated with the ZAs remained mainly disciplinary or narrowly interdisciplinary.

We found a statistically significant positive relationship between the level of EID and the level of TD in the ZA bodies (adjusted $R^2 = 0.535$, $F_{1,12} = 15.96$, $P = 0.002$), and between the level of EID in the ZA bodies and projects (adjusted $R^2 = 0.526$, $F_{1,11} = 14.30$, $P = 0.03$). No other tested relationships were significant.

In the interviews, the ZA leaders identified a number of obstacles to EID and TD. Some of these obstacles may be related to the organisational characteristics of the ZAs and their societal partners, although our informants did not mention this relationship.

5.5. Obstacles to EID and TD associated with organisational issues

We observed an enduring difficulty in opening up the ZAs to HSSs. Most ZA leaders reported having struggled to involve HSSs in the ZA bodies and projects: 'We still have difficulty in mobilising HSSs, certainly because we are doing it the wrong way. Personally, I did not know these sciences well. We don't have the same protocols, we don't have the same publication strategies, we don't really have the same way of working at the moment. We are getting closer little by little, but there is still a lot of work to do.' ZA leaders identified the fear of being instrumentalised by natural scientists and turned into social engineers as one major reason for the HSSs' reluctance to get involved in a ZA. The ZAs mainly oriented towards natural sciences particularly faced this difficulty. However, it was also the case for the ZA Plaine & Val de Sèvre, which had increasingly sought to open up to HSSs and experiment with ways of transforming its territory, and where attempts to closely and sustainably involve sociologists and economists sharing this goal had so far failed.

Concerning TD, the ZA leaders mentioned different obstacles depending on the type of societal organisations involved. They reported that research actors were often reluctant to involve politically and economically powerful societal actors out of fear of jeopardising the ZA's scientific autonomy: 'We had a debate about involving the SNCF *[national railway company]*. When this possibility was raised, the scientific council objected on the grounds that it might impair our way of working and our results'. The leaders of another ZA decided not to involve two powerful organisations in their ZA's field of investigation until the ZA had defined its own scientific strategy: 'since this year, we have integrated *[the two organisations]* into the scientific projects, now

that we have a robust academic scientific strategy, and insofar as we have been able to show that we remain neutral with regard to these aspects and that we are here to do science and not to proselytise for one side or the other'. Involving weak societal actors raised other types of challenges. Politically weak actors might fear that the ZA research projects would challenge and threaten their legitimacy: 'On some issues, it was and is sometimes a bit difficult because they *[a public service managing natural resources]* are always afraid of being contested.' Economically weak organisations demanded financial compensation for the participation of their staff in ZAs: 'Bringing in protected area managers for one or two days cost me €20,000 in a €200,000 project. It's horribly expensive!' Finally, some ZA leaders found it almost impossible to involve citizens who were not part of a formal organisation: 'Research actions involving citizens cannot be funded, at least not easily. Funders ask us for letters from partners, which can be NGOs, but registered NGOs. Citizens' collectives are not NGOs, they are not trade unions, they are not declared, they exist but are not recognised.'.

6. Discussion and conclusion

ZAs were explicitly established to spur environmental ITDR in France (Lévêque et al., 2000). They have played an important role in bringing together research actors from distant scientific domains and societal actors. They have initiated many encounters and contributed to mutual learning and trust building (Mauz et al., 2012), which are crucial to ITDR (e.g., Cundill et al., 2015).

In this article, we focused on organisational issues in ZAs, which have received little attention in research. In the following, we discuss 1) the limited impact of ZAs on the reorganization of research communities; 2) the relatively limited level of EID and TD in their bodies, projects and publications; and 3) the contribution of boundary organisation and meta-organisation concepts to our study and vice versa. We conclude with a plea for enhanced reflexivity on organisational issues in organisations committed to addressing wicked environmental problems through ITDR.

6.1. A limited impact on the reorganisation of research communities

The reorganisation of research communities in ZAs to achieve ITDR has so far been limited. Undeniably, both research actors and societal actors are involved in the functioning and dynamics of ZAs, and sometimes in their creation. However, they generally consider that they belong to two distinct social worlds and that maintaining the boundary between them is important, even if this boundary is moving or blurred and other boundaries between societal actors and between research actors are also relevant. As for the ZAs, they regard research labs, but not other societal organisations, as their direct members. Moreover, a marked imbalance persists among research actors, to the detriment of HSSs.

The limited impact of ZAs on the reorganisation of research communities suggests that the calls for ITDR have not been sufficient to counterbalance the weight of the discipline-based structuring of scientific research. In the tension between discipline-based science and ITDR, the former continues to be stronger, at least in research-based MOs such as ZAs. The discrepancy we have highlighted between the ideals of ITDR and what is actually achieved is not restricted to French LTSER platforms but applies to LTSER platforms internationally (Zimmerman and Nardi, 2010; Mauz et al., 2012; Dick et al., 2018; Holzer et al., 2018).

However, things have recently started to change (Dick et al., 2018). For example, there are now more HSSs in the ZA governing bodies and even leading teams, including in ZAs originally restricted to natural sciences. Moreover, the leaders of several ZAs have recently become more openly engaged in ITDR, and the current and former leaders of the national 'network' of ZAs have even become ITDR champions (see Ragueneau, 2020; Bretagnolle, 2021; Berthet et al., 2022). The high proportion of inter- and transdisciplinary contributions to the colloquium of the 'network' in 2020 (Falk and Charpentier, 2021) is another sign of this evolution, which seems to have been strongly encouraged by the recent adoption of a common conceptual framework centred on the notion of social-ecological ecosystem (Bretagnolle et al., 2019) and the emergence of sustainability science in France. Although they share the inertia common to MOs (König et al., 2012), it is becoming increasingly difficult for ZAs to only pay lip service to ITDR.

6.2. Limited levels of EID and TD

The levels of EID and TD we found in bodies, projects and publications were surprisingly low for organisations committed to ITDR. A question logically comes to mind here: is this a consequence of the limited impact of ZAs on the reorganisation of research communities? Arguably, the fact that ZAs are research-based MOs reduces the range of organisational arrangements available to them. In particular, they cannot try out arrangements in which societal actors are members and not just partners. Moreover, their historical roots in natural sciences make it difficult to involve HSSs. In other words, the fact that they are anchored in natural sciences frames and limits their capacity to achieve ITDR. However, the case of ZAs only enabled us to shed some light on the relationship between organisation and research content. Clarifying this relationship further would require extending the investigation to other types of organisations, beyond the case of research-based MOs such as ZAs. This would allow for study of the effect of considering societal actors as genuine members of an organisation aiming to promote ITDR, rather than involving them as partners of a research-based MO.

It is important to note that there were both similarities and differences between levels of EID and TD in the ZA bodies and projects. The positive relationship between EID and TD in governing and advisory bodies may be due to the HSSs' capacity to convince their colleagues that these bodies should be more open to societal actors. It is probably no accident that a social scientist was co-leading the sole ZA with systematically transdisciplinary bodies (ZA Environnement Urbain). EID in bodies and EID in projects are positively related, but this is not the case for TD. Research actors can clearly collaborate with societal actors without involving them robustly in advisory and governing bodies, which is the path taken by at least some ZAs (e.g., ZA Plaine & Val de Sèvre, ZA Hwange). As to the low level of EID in publications irrespective of the organisational arrangement, which may come as a surprise, it may be partly due to the very recent rise of EID in bodies and projects in most ZAs: achieving publications co-authored by natural scientists and HSSs takes more than a few years (Dick et al., 2018).

6.3. Contribution of boundary organisations and meta-organisations concepts to our study and vice versa

The BO and MO concepts enabled us to define the kind of organisations that ZAs are (quasi BOs and research-based MOs) and to understand their limitations as organisations committed to ITDR. Indeed, both fields of literature have identified a set of conditions that organisations should fulfil to effectively bring together research actors and societal actors around environmental issues. This has helped us grasp that ZAs meet only some of these conditions: they are formal, place-based, meta-organisations that involve a variety of actors and rely on boundary objects. On the other hand, they are not accountable to societal actors, a condition highlighted by both concepts. Furthermore, they do not consider societal actors as members, but as partners. Because it pays special attention to organisational issues and distinguishes between membership and partnership, the MO concept enabled us to highlight this aspect more clearly than the BO concept.

The distinction between membership and partnership, which we found particularly illuminating for our study, has recently been discussed in the MO literature. In their study of the compositional dynamics of a health MO, Cropper and Bor (2018) underline the major contribution of partners, not just members, to the functioning and dynamics of

the MO. They consider that Ahrne and Brunsson (2005) have overemphasised the distinction between members and partners and suggest that it should be toned down. On the contrary, we believe that drawing this distinction is an important advantage of the MO concept in clarifying organisational issues and understanding one source of limits to the ability of organisations to achieve ITDR. Our study also underlines the importance of examining power asymmetries between members. In our case, early members were clearly more influential than late ones, but further studies are needed to clarify the influence of seniority as there may be confounding factors (early members happen to be natural sciences labs).

Despite its analytical value in examining organisational issues, the MO concept has intriguingly not been mobilised thus far in the literature on LTSER platforms. In contrast, we regularly encountered the BO concept in this literature and in our interviews with ZA leaders. Thus, it seems that ZAs are readily recognized as BOs but ignored as MOs. Far from being specific to ZAs, this ignorance is common in MOs (Ahrne and Brunsson, 2008: 9–12). We offer three explanations for this difference in the use of the two concepts, two of which are related to their respective dynamics and characteristics and the third to the roles and positions of ZA leaders.

First, the BO concept has had both the time and ease to spread in the LTSER community as it dates back to the early 2000 s, and was developed from the outset for organisations bringing together research actors and societal actors. In contrast, the MO concept emerged a few years later and was initially developed for homogeneous MOs. As a result, the use of the MO concept for organisations committed to ITDR is still in its infancy. Second, the MO concept may be considered 'boring' (Ahrne and Brunsson, 2005; Berkowitz and Dumez, 2016), whereas the BO concept has a high capacity to convey positive value (Gustafsson and Lidskog, 2018). It is easily appropriated by ZA leaders, not so much because it accurately describes their organisation, but because it is rhetorically effective in portraying ZAs in a positive way: as organisations that help bring science and policy together, without pointing out organisational issues such as hierarchy between members or the distinction between members and partners. Third, ZA leaders are also leaders and members of projects that involve both research actors and societal actors, so the BO concept fits with their perception of ZAs as organisations that bring together different communities. In turn, the fact that the members of ZAs are labs and not individual research or societal actors remains minimally visible at the level of the ZA leaders, and even less so at the level of the mere participants in ZA activities. The invisibility of these organisational issues makes discussing them all the more important.

6.4. Need for pragmatic reflexivity

Organisational issues are rarely discussed collectively in ZAs, either at a national or individual ZA level. This lack of collective reflection and debate prevents a full understanding of the consequences of ZAs being research-based MOs and of organisational issues more generally. ZA leaders do not associate obstacles to ITDR with the kind of organisation ZAs are. Enhanced collective reflection could also help them take full advantage of the range of organisational arrangements they can experiment with. The idea is certainly not to identify an organisational arrangement that would be suitable for all ZAs. Rather, it is to draw on a diversity of experiments at work to feed a pragmatist approach to reflexivity regarding the organisation of ZAs, in line with the open-ended and adaptive character of ITDR (Popa et al., 2015).

Finally, it is important to recall that ITDR is a means to help face contemporary wicked environmental problems rather than an end in itself. To what extent it contributes to achieving this goal is a question we did not address here, but which is of paramount importance.

CRediT authorship contribution statement

Isabelle Arpin: Conceptualisation; Funding acquisition; Investigation; Methodology; Project administration; Supervision, Writing – original draft; Writing – review & editing, **Kristina Likhacheva:** Investigation; Data curation, Writing – review & editing, **Vincent Bretagnolle:** Supervision, Writing –review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

Acknowledgements

This work was carried out within the framework of the COLLAB^2 project funded by the French National Research Agency (ANR-19-CE03-19-0002). It was also supported by the LABEX ITTEM (ANR-10-LABX-50-01) within the program « Investissements d'Avenir » operated by the French National Research Agency (ANR). We warmly thank our informants for sharing their knowledge on the organisation of Zones Ateliers and the related knowledge production. We also thank two anonymous reviewers for insightful comments on a previous draft of this paper.

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