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# Unveiling Research Intermediations in Citizen Science

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# 1 Unveiling research intermediations in 2 citizen science

## 3 Abstract:

4 Drawing on the conceptual framework of intermediations in grassroots  
5 innovation for sustainability, this paper presents the first in-depth analysis of  
6 the role of third sector organizations in citizen science. The empirical data are  
7 derived from 31 case studies of associations (representing 80% of third sector  
8 organizations in France). We identify two clusters of associations (social  
9 innovation and natural sciences) based on research domain. They differ in  
10 epistemic cultures, but they both value experiential and actionable knowledge.  
11 We present an analytical framework to characterize the role of these  
12 associations in citizen science. Derived from systemic intermediations for  
13 transitions, it is based on the association's position in networks,  
14 infrastructures, and projects. Our results reveal three categories of  
15 intermediations which depend on the organization's position in the network,  
16 the degree of structuration of its partnerships with academics, and the goals  
17 and achievements in the projects in which it is involved. In addition to  
18 articulating different knowledge in projects and learning in networks,  
19 associations perform the boundary work required to build hybrid infrastructures  
20 with institutions. A fourth category unveils the complexity of structuring hybrid  
21 epistemic communities for sustainability. This 4-way categorization of  
22 intermediations highlights the crucial roles of associations in a systemic  
23 approach to citizen science.

24 **Keywords** : innovation studies - community based research - participatory  
25 research - actionable knowledge - inclusion

## 27 **Introduction**

28           This article is intended to characterize the role of third sector organizations in  
29 citizen science (CS), with an emphasis on the systemic dimension of knowledge  
30 production (July 2020). The third sector concept is related to the Anglo-Saxon three-  
31 sector societal framework which includes the state, the market, and the third sector  
32 (Alcock 2010). According to Alcock, the third sector is associated with values and  
33 principles which may balance those of the state and the market. In France, third  
34 sector organizations are mostly associations<sup>1</sup>, and little is known about their role in  
35 CS. To fill this knowledge gap, we mobilize the concept of grassroots innovation for  
36 transitions (Seyfang and Smith 2007). This literature explains how grassroots  
37 organizations experiment to solve local problems, and network with institutions to  
38 contribute to the achievement of the United Nations Sustainable Development Goals  
39 (SDGs). These third sector organizations coordinate the contributions of citizens to  
40 research, translate and circulate knowledge, and contribute to the problematization of  
41 otherwise unaddressed research questions (Seyfang and Smith 2007). Göbel et al.  
42 (2021) describe three main roles of these organizations in CS: (1) a technical role in  
43 the production of data and knowledge; (2) a governance role in the deliberation on  
44 research activities and risk assessment; and (3) an advocacy role by campaigning for  
45 transformative knowledge. In social innovation systems, they may be social  
46 innovation hubs, open labs, and transfer centers (Terstriep, Rehfeld and Kleverbeck  
47 2020).

48           To conceptualize the roles of third sector organizations in CS, we draw on  
49 intermediations in grassroots innovation. Intermediations are the activities developed  
50 by agents to induce and facilitate interactions between actors coming from different  
51 worlds to co-produce knowledge for sustainability transitions. We will therefore  
52 combine the frameworks of transition intermediation and grassroots innovation for  
53 sustainability to analyze the activities of third sector organizations in CS. We will

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<sup>1</sup> Under French law, an association is an "agreement by which two or more persons permanently pool their knowledge or activities for a purpose other than to share profits" (our translation, law of July 1, 1901).

54 address the following research questions: Who are the actors involved? How do they  
55 work to foster and facilitate interactions? What are the objectives of such  
56 intermediation? What networks and infrastructures are they involved in? We will trace  
57 how the actors mobilize and translate their values, knowledge, and rules to solve the  
58 challenges they encounter.

59 The paper is organized in four parts. First, we introduce our conceptual  
60 framework, research design, and case study methodology. Second, we present the  
61 results in two separate sections. In section 2, we compare goals, role and epistemic  
62 practices in 31 associations involved in CS. In section 3, we propose an analytical  
63 framework of CS intermediations. This framework highlights the crucial role of  
64 associations in a systemic approach to CS. Third, we discuss our findings in light of  
65 the literature. We conclude with some reflections that might inform future research on  
66 CS for sustainability, and help stakeholders and policymakers identify critical aspects  
67 for the societal impact of CS.

## 68 **Conceptual Framework and Research Method**

69 Our conceptual framework draws from two theoretical fields, innovation  
70 intermediation and grassroots innovation for sustainability. We mobilized a qualitative  
71 methodology to trace how the actors translate their values, knowledge, and rules into  
72 projects, networks and infrastructures to solve the challenges they encounter.

### 73 ***Conceptual framework***

74 Grassroots innovation for sustainability was conceptualized originally by  
75 Seyfang and Smith (2007) as « innovation networks of activists and organizations  
76 that lead to bottom-up solutions for sustainable development, solutions that respond  
77 to the local situation and the interests and values of the communities involved »  
78 (p.587). Smith et al. (2017) suggest three features that typify grassroots innovations  
79 (which may be social or socio-technical). First, they are grounded in third sector  
80 organizations which follow different strategies and forms of engagement with  
81 institutions. Second, they use alternative forms of knowledge production to dominant  
82 ones: public participation, epistemic justice, openness, and common good. Third,  
83 they are political actors and adapt their strategies of alliances with institutions to  
84 advance their own objectives. Similar to social enterprises, they are able to weave

85 together the market, state, and community contexts (Terstriep, Rehfeld and  
86 Kleverbeck 2020; Unceta et al. 2020).

87 The notion of grassroots innovation is grounded in the Multi-Level Perspective  
88 (MLP), a conceptual framework developed for sustainability transitions (Geels, 2002).  
89 MLP analyzes the dynamics of transitions at three analytical levels: the niches where  
90 grassroots innovation can develop away from regime selection pressures, the socio-  
91 technical regimes (the rather stable research and innovation systems with  
92 technologies, practices, and institutions), and the exogenous socio-technical  
93 landscape (external contextual factors such as climate change or Covid crisis). Yet,  
94 compared to mainstream market innovation, grassroots innovations face different  
95 challenges for their effective diffusion, replication and upscaling processes which  
96 may be overcome by activities conceptualized as intermediations.

97 Intermediation refers to the involvement of entities or individuals that facilitate  
98 and enhance the flow of knowledge and collaborations between different actors  
99 within an innovation system (Klerkx and Leeuwis 2009). In the context of  
100 sustainability transitions, intermediations facilitate critical reflection and empowering  
101 in niche (Smith et al. 2016), and help aggregate lessons across experiments  
102 (Matschoss and Heiskanen (2017). Intermediations also aim at reconfiguring socio-  
103 technical systems through lobbying activities (Klerkx and Leeuwis 2009; Seyfang et  
104 al. 2014), political advocacy work (Smith et al. 2016), championing strategies  
105 (Martiskainen and Kivimaa 2018), institutional rule-changing (Polzin, von Flotow and  
106 Klerkx 2016), and disrupting incumbents of the dominant regime (Klerkx and Leeuwis  
107 2009; Seyfang et al. 2014). Previous research on grassroots innovation also  
108 highlighted the crucial role of intermediations to support volunteer communities with  
109 professional skills, and establishment of links between niche actors and regime  
110 resource holders in multi-level institutional environments (Hargreaves et al. 2013;  
111 Lang, Chatterton and Mullins 2020). Based on a literature review, Sovacool et al.  
112 (2020) identified 18 different functions or activities as intermediations. Van Welie et  
113 al. (2020) reduced this typology to three: 1. Articulation of activities required to  
114 support experimentation and generalization of innovation, 2. Alignment of dispersed  
115 resources and talents through networks, and 3. Learning and training-related  
116 activities to enhance stakeholder capabilities and share goals and culture i.e. to

117 establish new institutions. This last function includes knowledge development,  
118 knowledge dissemination, entrepreneurial activities, and legitimation of action.

119 All these authors highlighted the boundary work that agents performk in  
120 networks (Kanda et al. 2020; van Welie, Boon and Truffer 2020), and in  
121 infrastructures (Hargreaves et al. 2013) to demarcate their activities from other forms  
122 of knowledge production. Drawing on this conceptual framework, we will characterize  
123 intermediations in third sector organizations both at the project (niche) and at the  
124 system (regime) levels. In this systemic approach to CS, our analytical framework  
125 gives importance to actors, networks, and infrastructures which are vectors of  
126 knowledge creation and social change (Loconto 2023). Such an approach depends  
127 on the socio-historical context, the actors involved in the process, and the chronology  
128 of events prior to and during a CS project.

### 129 ***Methodology and analysis***

130 We collected the empirical material between 2019 and 2022, as part of a  
131 formative evaluation of an experimental subsidy to CS. In France, associations  
132 receive wage subsidies for their cultural and educational activities through a measure  
133 called FONJEP (Ministry of National Education and Youth) and through public  
134 policies on Public understanding of sciences funded by the Ministry of Higher  
135 Education, Research and Innovation. They are not eligible to public fundingfor social  
136 innovation (Bouges, Zieds, Marielle, and Barth, Mickael 2022). To overcome this  
137 imbalance, FONJEP-Recherche, a new public policy instrument was piloted to fund  
138 the wage of ½ salaried position dedicated to CS for a period of three years. Between  
139 2019 and 2021, the Ministry of National Education and Youth launched 3 calls for  
140 projects for FONJEP-Recherche and selected 60 projects. As part of the pilot, the  
141 steering committee of the call for projects commissioned the first author of this  
142 article<sup>2</sup> to manage a formative evaluation process through the ASIRPA real time

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<sup>2</sup> She is a member of a think tank advocating for support and structuration of a third sector in research and innovation since 2013. This think tank lobbied for the experimentation of the Fonjep-recherche.

143 method (Matt, Robinson, Joly, Van Dis et Colinet, 2023). This method uses a real  
144 time impact assessment tool (called impact pathway) to help project managers to  
145 maximize societal impacts of transformative research. The first author participated in  
146 the steering committee meetings prior to and after each call, in the three selection  
147 processes of grant winners, and co-organised three meetings of the professional  
148 network-to-be. She regularly presented and discussed her results with the steering  
149 committee. In addition, she conducted 50 interviews: 1. with members of the steering  
150 committee, and 2. with staff members of 35 associations (including grant winners).  
151 She also performed several days of participatory observation in four associations,  
152 and co-organized three one-day meetings to nurture a professional network of grant  
153 winners. At the end of the formative evaluation (2022), both authors organized three  
154 focus groups with the grant winners (22 participated) and three volunteers of the  
155 steering committee. The participants were invited to contribute to the impact pathway  
156 of the FONJEP-Recherche through their own experience of the experimentation.  
157 They were asked the following questions. What have you achieved in the last 2  
158 years? What new and old players and partners have been involved? What changes  
159 have you observed in your organization? Among your partners? What hasn't worked?  
160 What impact on society do you think FONJEP-Recherche can contribute to?

161 Data analysis involved several steps. The interviews were transcribed and  
162 encoded using NVIVO software together with field notes. We also read websites and  
163 documents provided by interviewees. First, we produced a summary of each  
164 association that received a subsidy, based on interviews and on information  
165 contained in the application form to the FONJEP-Recherche call. Overall, the history,  
166 mission, size, sector, values, projects, networks, and infrastructures are detailed for  
167 each association in thirty-five synthetic data sheets and two overview tables  
168 (supplemental material). We paid special attention to the organizations' relationships  
169 with research institutions, network membership and coordination, and any other  
170 activities related to knowledge production and knowledge circulation. Second, we

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These embedded practices allowed her to develop of a deep knowledge of the actors, networks and institutions involved in citizen science in France.

171 produced an analytical framework of research intermediation categories drawing on  
172 the literature on transition intermediations. In addition to data provided by the  
173 interviews and application files, this framework was fed with progress reports that the  
174 grant winners produced during participatory observations *in situ* and meetings of the  
175 professional network. Finally, the focus groups allowed us to assess the changes  
176 interviewees had observed, along with the barriers and levers of their contribution to  
177 CS. This allowed us to enrich our analysis framework with the contexts, realities, and  
178 difficulties of the research activities in the case studies.

179         Among the 35 associations that received subsidies, 31 were actually involved  
180 in CS processes, and therefore included in this case study. Since it is not possible to  
181 describe extensively the research intermediations for each case in a single article, we  
182 presented the results in three formats. Detailed data are provided in the supplement  
183 files: interview guide, synthetic data sheets, and overview tables. The impact  
184 pathway has been published separately (Lhoste and Sardin 2022). In the following  
185 sections, we focus on a smaller number of cases which represent archetypal  
186 examples from the various dimensions we have identified as essential.

## 187 **Goals, Roles, and Epistemic Cultures of the Case Studies**

188         In this first section of results, we discuss the associations' research domains  
189 and values, and other descriptive characteristics. We posit that they all are involved  
190 in grassroots innovations since their research projects aim at satisfying unmet needs,  
191 and that contributing to at least one of the SDGs was mandatory for eligibility to  
192 FONJEP-Recherche. Table 1 gives an overlook of the variety, with 11 associations  
193 we consider as archetypal from the different categories. For some of them, producing  
194 knowledge is the central objective, while for others, it is a means to fulfill their goals  
195 (see column "activity"). Their beneficiaries may be either lay people, professionals, or  
196 organizations (see column "beneficiaries"). We differentiated two clusters of  
197 associations for CS: social innovation and natural science. There were twenty-six in  
198 the first cluster and five in the second one.

199         At first glance, the two clusters differ in type of production (science vs.  
200 innovation), epistemic practices (phenology vs. action-research), administration of  
201 evidence (practical implementation vs. scientific publication), and more broadly in



202 epistemic culture i.e. in epistemologies, history, values, and visions of a scientific field  
203 (Knorr-Cetina 1999). Indeed, attitudes to objectivity and neutrality in research  
204 practices and to experiential knowledge differ in both clusters. Naturalists seem  
205 closer to the professional identity of public scientists they work with. They view citizen  
206 participation as a way to raise awareness and develop new skills in lay people. They  
207 engage in research projects with social scientists to understand the effects of  
208 participation on these individuals –towards science and the environment-, the  
209 objectivity and validity of the scientific data produced, and on how to raise  
210 engagement of volunteers. They rarely examine how citizen participation might  
211 transform epistemic cultures in academia and in research organizations. Overall,  
212 these questions are much less self-reflexive than those addressed in the social  
213 innovation cluster.

214         A more detailed analysis of the epistemic cultures within associations also  
215 reveals commonalities between the two clusters. They both value experiential and  
216 actionable knowledge since they are involved in action, whether nature protection or  
217 social services. Indeed, several associations were funded by scientists seeking to  
218 reconcile action and research. They also share epistemic practices. Observation is  
219 an instrument for both nature conservation and social innovation. In fact, the  
220 naturalist associations of our case studies have set up their own observatories. There  
221 are also several in social innovation. For example, MA-HdF administers surveys and  
222 manage observatories to observe social and cultural practices in France.

223

224 Table 1. Activities, beneficiaries, research field and epistemic practices of 11  
 225 associations.

Case	Activities	Beneficiaries	Research field	Epistemic practices
PN	observes, protects and studies the fauna of Picardy	amateurs, scientists	natural science	observational sciences/ phenology
Tela Botanica	leading and managing a collaborative platform of botanists	amateurs, scientists	natural science	observational sciences/ phenology
CREA	Explore the impact of climate change on mountain biodiversity, raise awareness of high altitude ecosystems, and provide expertise to policy makers.	scientists, public authorities, professionals	natural science	observational sciences/ phenology / social sciences
BIO-OC	develop and promote organic agriculture through technical support, training, information, research/experimentation.	organic food sector	social innovation	action-research
Evaleco	steers a bundle of social and environmental research and innovation activities	inhabitants, public authorities	social innovation	action-research
Fab'lim	Brokering of a research-action-innovation cluster for sustainable and inclusive agri-food systems.	scientists, public authorities	social innovation	action-research
AF-UPP	Resource center for action-research projects organised by collectives with/for parents experiencing exclusion.	associations	social innovation	action-research
MAHdF	lobbying, community developpement, coaching of associations, networking for local developpement of associative life.	associations	social innovation	action-research / observational sciences
RNMA	support for the development of association centres throughout the territory (advice and support for communities in the project).	associations	social innovation	action-research/observational sciences
FAPI	improve the care of unaccompanied minors from West Africa.	social workers	social innovation	action-research
APPUII	advice to residents' groups in the field of urban renewal.	inhabitants	social innovation	observational sciences

226

227 **Social innovation**

228 In the social innovation cluster, CS is aimed at producing actionable  
 229 knowledge (Table 1 column “Activities”). There are three categories of associations:  
 230 leader associations, innovation brokers or service associations. Leader associations

231 manage a professional network and mutualize resources for their members. They  
232 provide a bundle of services which include facilitation and coordination of action-  
233 research projects in multi-actor networks. For instance, BIO-OC represents the  
234 interests of the organic food sector in the Occitanie Région. It supports change in  
235 practices through action-research projects. Innovation brokers orchestrate innovation  
236 networks (Batterink et al. 2010). For instance, Fab'Lim is a research-action-  
237 innovation center for sustainable and inclusive food systems which steers and  
238 advises social innovation in the Occitanie region (*territoire*). The association  
239 manages hybrid networks to address local problems, in partnerships with public  
240 authorities and research institutions. Service associations organize action-research  
241 projects to improve guidance services to a variety of excluded populations, and  
242 support services to professionals, whether social workers, sex workers, or artists.  
243 They identify emerging problems and co-create innovations in multi-actor networks.  
244 They may also produce relevant data for policy makers. They value epistemic justice  
245 and adopt strategies to build trust in science among excluded populations. For  
246 example, AF-UPP is a network which support parents' groups (popular universities)  
247 in action-research projects on education. The interviewee of AF-UPP testifies that at  
248 the beginning, parents suspect scientists to be lesson-givers and disrespectful of  
249 their experiential knowledge. Therefore, AP-UPP signs up with analysts from  
250 unrelated disciplines, to design a scientific protocol with groups of parents. They also  
251 develop participatory methods that respect the weaknesses of the most vulnerable  
252 members of society.

### 253 ***Natural sciences***

254 This cluster includes associations generally considered as intermediaries  
255 between academia and non-professional scientists, although this notion has never  
256 been detailed. Most of these associations have a long-term engagement in natural  
257 resources management, and some of them are local activists. For example, PN has  
258 been involved in compiling lists of biodiversity in various marine species including  
259 seals since 1970 together with seal watching in the Somme bay. Unlike other  
260 naturalist associations which claim neutrality, PN regularly file a complaint against  
261 poachers, and engage in local controversies on wildlife regulation. They consider that  
262 these social actions do not counter to their scientific thoroughness.

263 Naturalist associations are recognized as community managers for amateur  
264 naturalists (Table 1 column “Activities”). Simply put, a community manager negotiates  
265 the connection between scientists and amateurs. But “amateur” refers to a  
266 heterogeneous category in terms of expertise (whether academics or field  
267 experience), degree of motivation for collecting samples (for pleasure or work),  
268 occupational status (employee or volunteer), and relations to knowledge (bird  
269 watcher or resource management). At the end, PN members may be more motivated  
270 by seal surveillance than by sample picking. The community manager has to mobilize  
271 her knowledge on the community’s preferences, on animals’ lifestyle and behavior,  
272 and on scientists’ expectations, to design suitable collection protocols. She has also  
273 to enroll researchers in new research programs initiated by the expert amateurs.

#### 274 **Networks, Institutions, and Roles of Associations**

275 In the previous section of results, we differentiated associations according to  
276 epistemic cultures, and goals of the associations. In this second section, we propose  
277 a typology of research intermediations based on the analyses of the 31 cases for the  
278 association’s position in networks, infrastructures, and projects (Table 2). We  
279 observed that they play as transition intermediaries in CS system. They develop  
280 strategies, tools, and methods to identify goals, link stakeholders, and formulate  
281 research questions. They allow actors from different backgrounds and cultures to  
282 interact. They provide networks with technical and engineering knowledge. They help  
283 these networks to identify unsolved problems, mobilize researchers and  
284 stakeholders, and formulate research questions. They may manage an infrastructure,  
285 whether open lab or observatory. They advocate for transformations of public  
286 policies. As Barré puts it (2020), they “facilitate exchanges and reflexivity while  
287 managing conflicts, and promote the cross-fertilization of knowledge and shared  
288 decisions” (*authors’ translation*). Intermediations allow the development of common  
289 knowledge and collective learning about others’ representation, contexts and  
290 activities.

291 In our case studies, each of these activities meet a specific need at a given  
292 time or, on the contrary, constitute the association's mission. We ordered them in  
293 three categories according to whether they are related to projects, networks, or

294 infrastructures. These three categories are not mutually exclusive. In practice,  
295 networking can lead to new research projects and/or the creation of infrastructure.  
296 Infrastructures such as observatories are fed with the data collected during research  
297 projects while open labs require networking with local stakeholders. We also  
298 identified a fourth category related to facilitation between citizens and scientists. This  
299 fourth category is essential to the success of CS, each association creates tools and  
300 methods adapted to its research field and to the actors involved in projects.

301



Case	Role of association	Network leader	Network member	Manager of an infrastructure	Function in CS projects
PN	community manager	no	3 disciplinary networks	observatory in phenology (database)	1. to develop interactions between researchers and volunteers, 2. to maintain regular relations with the other local actors and 3. to be (re)known as a local actor of seal protection.
Tela Botanica	community manager	no	1 network	Digital platform /observatory (data base)	The association runs several participatory research programs: data base management, community management, support researchers in communication and outreach activities.
CREA	community manager	no	none	Collaborative platform and observatory (data base)	1. to value the data collected by participatory research with respect to contributors and stakeholders 2. to understand the motivations of contributors, 3. to compare image analyses according to 3 methods: the expert researcher, the automatic recognition of animals (machine learning), and crowdsourcing.
Evaleco	innovation broker	no	none	Open lab	To animate the third place while developing and structuring a hybrid epistemic community made up of actors from higher education and research, field actors and residents of the open lab.
Fab'lim	innovation brokers	no	3 networks	no	to create, manage and support social innovation projects for sustainable and inclusive food systems based on economic cooperation between local stakeholders.
BIO-OC	network leader	yes	National and regional networks	no	to structure the network in terms of action-research and expertise to support change and improve agri-food practices.
AF-UPP	network leader	yes	1 network	no	After 20 years of UPP, AF-UPP uses its newly formed scientific council to help participants identify new research question, disseminate knowledge in cross-fertilization through training courses for social workers, organizes the restitution of the results of UPP, and advocates on social issues.
MAHdF	network leader	yes	2 networks, 2 associations	no	produce knowledge on regional associative life: survey on the needs/interest of associations in terms of research and development, co-sponsorship of a research program with the French Institute of the Associative World.
RNMA	network leader	yes	1 network	no	share the analysis of local databases, support members in creating a laboratory for digital transformation on a inter-regional scale, develop local partnerships with the academic world, - coordinate a research-action to analyze the different types of structuring of local associations.
FAPI	service provider	no	4 networks	no	Research projects with social workers from both France and African countries: 1/ organize a hybrid research-action seminar on the social accompaniment of unaccompanied minors. 2/capitalize the results of these experiments in the NGO networks and towards institutional actors, 3. disseminate participation of the staff in training programs for social workers, and of the director in union network.
APPUII	service provider	no	1 european network	observatory of urban transitions	Transversal projects for capitalization and advocacy: 1. mapping of urban and social transformation, 2. study of the renewal of forms of solidarity in the context of Covid crisis, 3. evaluation of the cost of destroying solidarity and the energy cost of demolition/reconstruction.

303 ***Framing and coordinating CS projects***

304 Our case studies illustrate the diversity of CS projects. They also offer an  
305 overview of the complexity of nurturing an epistemic community, i.e. a group of  
306 people with shared interests, focused on generating and spreading knowledge within  
307 a specific field. This community slowly emerges through a bundle of intermediations  
308 accomplished during the projects. Intermediations change over time, from animating  
309 heterogeneous collectives to framing research questions to disseminating output and  
310 outcomes. Dissemination includes scaling of innovations through replication,  
311 advocating for policies, and training of professionals to transform rules, cultures and  
312 norms within a system. Our case study abounds with examples in a variety of  
313 sectors. In urban planning, APPUII offers counter-expertise to a non-participatory  
314 rehabilitation project, establishes shared diagnosis with inhabitants, and proposes  
315 alternative projects. In social work and inclusion, FAPI co-construct and assess  
316 action-research programs with a network of researchers and West African and  
317 French child protection non-governmental organizations (NGOs). The organization  
318 has developed a social program based on the needs of unaccompanied minors and  
319 exchanges between French and Senegalese social workers. Its participation in an  
320 Erasmus Plus program should allow its extension to other parts of West Africa and  
321 Europe. The association also organizes the generalization of practices within  
322 professional networks and allows “learning in project and remembering in networks”  
323 (Grabher 2004).

324 The above examples draw from social innovation. In natural sciences, the  
325 goals and challenges of intermediations are different. We observed that managing an  
326 amateur community involves more than just mobilizing citizens to collect data for  
327 scientists. The case studies highlight the often-ignored expertise of the association’s  
328 staff. The naturalist associations manage either small communities of volunteers  
329 collecting and handling biological samples, or large virtual communities uploading  
330 data on a digital platform. In either case, associations are intermediaries. In PN, a  
331 professional ecologist supervises the volunteers who count seals and monitor their  
332 mating habits on Picardy beaches. She trains non-experts, validates their  
333 observations directly in situ, and can even award them expert status. She also  
334 translates the volunteers’ experiential knowledge into protocols co-written with



335 academic researchers not involved in the fieldwork. The digital platform of Tela  
336 Botanica has been developed to provide training and meeting facilities for  
337 communities to manage themselves. Tela Botanica also organizes on-site gatherings  
338 for community members. The staff encourage scientists to attend these meetings,  
339 and assists them in their communication and outreach activities. In addition, the  
340 integration of the repository of French names produced by the Tela Botanica's  
341 community into the national taxonomic repository of the flora required a time-  
342 consuming boundary work.

### 343 ***Designing and co-managing infrastructures***

344         Several of the associations studied manage infrastructures for intermediation:  
345 collaborative platforms for community management, a variety of observatories, open  
346 labs, and publishing houses (Table 2). The open labs claim to enact sustainability  
347 transitions in territories. For instance, Evaleco has been created for this purpose. The  
348 association manages an open lab for research and innovation. Intermediations aim at  
349 building co-learning strategies in hybrid groups, experimentation, and raising  
350 questions on socio-economic models and governance. Our observations confirm  
351 previous results on open labs showing that they provide niches to nurture social  
352 innovations and experiment with new ways of governing and learning (Lhoste 2020;  
353 Terstriep, Rehfeld and Kleverbeck 2020). At the local level, the association's goal is  
354 to extend the collective and its portfolio of projects, and to bring together  
355 organizations and research institutions into research and innovation networks. At  
356 regime level, these open labs belong to national networks and thus can contribute to  
357 transformation of the system.

358         Observatories are fed by the associations' databases and co-managed with  
359 institutions. In natural sciences, both Tela Botanica and CREA manage two  
360 supplementary virtual collaborative platforms and their corresponding databases. The  
361 first one was created by CREA to observe the impact of climate change on mountain  
362 fauna and flora and the second one was co-founded by Tela Botanica and CNRS in  
363 2008 to monitor the phenology of flora and fauna in the plains of metropolitan France.  
364 Both platforms work in partnership and share their data and results. In social  
365 innovation, La Fonda manages a digital database of social innovations in  
366 collaboration with a public organization, the General Commission for Territorial

367 Equality (*Commissariat général à l'égalité des territoires*) and RNMA manages local  
368 observatories of associative life, a result of a long-term collaboration with a CNRS lab  
369 (Tchernonog and Prouteau 2019).

370 Observatories embody partnerships between associations and institutions.  
371 Intermediations allow the construction of coalitions around a common vision for  
372 transitions. But the governance of these hybrid networks often does not favor  
373 associations. In natural sciences, the staff of Tela botanica testified to the difficulties  
374 they encountered in managing data ownership with public research organizations.  
375 This is due to the fact that the latter have normalized intellectual property with their  
376 private partners, but they confuse public goods with commons. This raises questions  
377 about the governance of data collected in CS projects.

### 378 ***Networking with institutions***

379 Networks and infrastructures connect associations to institutions. Networks  
380 facilitate reflexivity, organize working groups, and steer research projects. They may  
381 also merge with other networks to organize training and advocacy, and construct  
382 coalitions around a common vision. These networks are connected to institutions at  
383 the local and national levels, and their boundary work progressively transforms them.  
384 For example, one of the parents' groups who participated to an AF-UPP program is  
385 working together with a police station to improve their relationships with families and  
386 youth. At the national level, AF-UPP is connected to *Caisse nationale d'allocations*  
387 *familiales*, a public institution that finances all family benefit schemes, and the  
388 Ministries of Health and Solidarities, and of National Education. This hybrid network  
389 brings together associations, professionals, and institutions to change public policy  
390 and establish new rules and practices.

391 Networking with institutions is a long, time consuming, and uncertain process.  
392 Our observations reveal how it is constructed in action. Whether an association  
393 networks with academics depends on the association's history. Half of our case  
394 studies have been established by scientists who are often affiliated to a public  
395 laboratory. Most of them invite researchers to sit on their boards or create scientific  
396 councils that facilitate regular exchanges with academics outside the research  
397 partnership. They also organize seminars involving academic researchers and field

398 workers. They participate in training programs: students play an important role in the  
399 creation of links between labs and associations through Master's level research often  
400 supervised by a senior in the association (master degree or PhD).

#### 401 ***Facilitating interactions between citizens and scientists***

402 Intermediations include knowledge brokering between citizens and scientists.  
403 Knowledge brokering is bidirectional between actors from different worlds (Kivimaa et  
404 al. 2019). In other words, associations symmetrically translate knowledge and  
405 cultures for both parties. When they are community managers, they first negotiate  
406 between human and non-human agents - whether living creatures or objects- to  
407 articulate the expectations of every type of contributor. They develop tools and  
408 intermediary objects to enable the building of trust, construct a common vision, and  
409 identify the barriers to participation of both scientists and citizens. They are key  
410 actors of more horizontal relationships in CS processes. Secondly, they ensure that  
411 the association's program is consistent with the aspirations of the extended peer  
412 community, whether the contributors are full members of the association, or  
413 volunteers with no decision power in the association's board. The community  
414 managers constantly adapt to transformations of the community and anticipate  
415 conflicts and trade-offs between differing motivations, interests and functions within  
416 the community. For example, Tela Botanica recently revised its strategic action plan  
417 after staff members realized that most of its contributors were not hobbyists anymore,  
418 but professionals who were using biodiversity monitoring as a tool for decision-  
419 making.

420 Intermediations in CSs often include legitimizing experiential knowledge.  
421 Association staff and expert volunteers are not only spokespersons for excluded  
422 people; they encourage them to speak out to assert their experiential knowledge.  
423 They can manage tensions among actors, design and use adapted tools and  
424 resources, and convince either volunteers or scientists to contribute to mixed groups  
425 and CSs projects. They also design new governance frameworks with boards  
426 including representatives of each category of participants. For example, the board of  
427 AF-UPP includes parents, academics, stakeholders, and social workers. AF-UPP  
428 developed a method of knowledge cross-fertilization based on over 20 years of  
429 action-research with groups of parents. AF-UPP organized the publication of

430 research results and their presentation during a congress for academics and  
431 stakeholders.

432 Finally, associations engage in advocacy activities for inclusion and  
433 legitimization of experiential learning. Obviously, social innovation needs more  
434 intermediations for crossing knowledge, whether within research projects or  
435 governance bodies, and it is also the domain where it is the most actively defended.  
436 In more academic disciplines like natural sciences, we have observed tensions within  
437 associations which stay at the boundary between two worlds, that of normal science  
438 and that of amateur practices.

### 439 **Discussion**

440 We characterized the role of third sector organizations in CS with an emphasis  
441 on the systemic dimension of knowledge production (July 2020). The concept of CS  
442 gives undue importance to interactions between lay individuals and scientists in  
443 temporally limited projects, and neglects the role of organizations in these systems.  
444 Institutions characterize CS according to the type of knowledge produced and the  
445 level of citizen participation in scientific projects. Briefly, they refer either to  
446 crowdsourcing or to participatory research, i.e. co-production of knowledge with lay  
447 people, in accordance with the scientific literature on CS (Cointet and Joly 2016;  
448 Strasser et al. 2019). None of these typologies acknowledges the role of  
449 organizations. Consequently, the transformative potential of CS has been studied at  
450 the individual level (development of individual skills and awareness), but seldom at  
451 the system level (organizational and institutional levels) (Bela et al., 2016). Yet, the  
452 knowledge co-produced by AIDS treatment activists (Epstein 1995), patients'  
453 associations (Callon and Rabearisoa 2008), and environmental justice movement  
454 (Ottinger 2010) transformed society. Opposite to CS, the concept of sustainable  
455 transitions posits that organizations are part of a socio-technical regime of knowledge  
456 production. It also posits that integrating third sector organizations in the system is  
457 transformational at the regime level (Schot and Steinmueller 2018).

458 We used the theoretical framework of grassroots innovations for sustainability  
459 to conceptualize intermediations in a system of CS. Our results first reveal that  
460 associations are engaged in various forms of co-production of knowledge with

461 academics and other stakeholders. We recognized them as observational science  
462 and social innovation. In our case studies, most associations were involved in social  
463 innovation and therefore part of a recently described Social Innovation System  
464 (Bouges, Zieds, Marielle, and Barth, Mickael 2022; Unceta et al. 2020).  
465 Observational science is not exclusive to naturalist associations. They aim at  
466 producing both scientific articles and actionable knowledge. The contribution of these  
467 associations to CS aims to serve the strategy of the association with regard to SDGs.  
468 Second, our results reveal that associations are transition intermediaries (Kivimaa et  
469 al. 2019). Transition intermediaries are “actors and platforms that positively influence  
470 sustainability transition processes by linking actors and activities, and their related  
471 skills and resources, or by connecting transition visions and demands of networks of  
472 actors with existing regimes in order to create momentum for socio-technical system  
473 change, to create new collaborations within and across niche technologies, ideas and  
474 markets, and to disrupt dominant unsustainable socio-technical configurations”  
475 (Kivimaa et al. 2019, p.1012). We identified three categories of transition  
476 intermediaries in associations. The first one, innovation broker, exactly matches the  
477 definition of transition intermediaries as this is their chore business. In the two other  
478 categories (leader associations, and service providers), transition intermediations are  
479 only part of their business. Our typology may not be exhaustive since the 31 cases  
480 do not represent the diversity of CS but only associations that submitted a proposal  
481 to the Ministry of Education, a selection process that may have favored associations  
482 aware of this finance desk, yet excluding activist associations such as those  
483 described in (Göbel, Ottolini et Schulze, 2021). Yet, it differs from Kanda’s typology of  
484 intermediaries (2020) which depends on three system levels within which  
485 intermediation occurs: (i) in-between entities in a network, (ii) in-between networks of  
486 entities, and (iii) in-between actors, networks, and institutions. Our results reveal that  
487 associations act indifferently at these three system levels, depending on their needs  
488 to overcome the challenges emerging along the way. We also confirmed that  
489 although essential to CS, associations are mostly unaware of their systemic function  
490 (Hodson, Marvin and Bulkeley 2013; Moss 2009).

491           Whatever the purpose of the research to which the associations contribute  
492 (natural science or social innovation) and whatever the category to which they

493 belong, our results show that they carry out a variety of intermediations. These  
494 intermediations vary in nature and intensity over time as challenges emerge on the  
495 way to sustainability transitions, and as a function of the strategic purposes of the  
496 organization. We describe four functions, three emphasize the systemic dimension of  
497 CS, and a last one highlights their role in the interaction between individual citizens  
498 and scientists. They facilitate co-construction and monitor participation of individuals  
499 in projects. They also facilitate individual and organizational learning in networks and  
500 infrastructures. Yet they contribute to the transformation of organizations, rules,  
501 cultures, and epistemologies and to a complete new knowledge structure and  
502 cognitive framework (Irwin 2014).

503 Our case studies confirm the variety of activities and the complexity of  
504 intermediations which have previously been described in the literature on grassroots  
505 innovation systems. In CS, the results are still scarce although they also  
506 demonstrated that third sector organizations were key to a CS system (Göbel, Ottolini  
507 and Schulze 2021). In the French context of CS, Barré (2020) identified three key  
508 objectives of intermediations : 1. To provide novel responses to new or unsatisfied  
509 social needs, 2. To strengthen actors' capacities for action, and 3. To develop and  
510 disseminate social innovation. His results also reveal that in practice, intermediations  
511 are distributed within networks and spread across time.

## 512 **Conclusion**

513 This article unveils the neglected role of associations in CS. We propose an  
514 analytical framework to better understand the complexity of intermediations occurring  
515 at the system level of research and innovation. This framework highlights the role of  
516 CS in advancing sustainability transitions (or transformative change more broadly). It  
517 is important to articulate the needs of third sector and research organizations, and  
518 organize social learning in projects, networks and infrastructures. This should  
519 contribute to the generalization of strong participatory paradigms in CS. Future  
520 research should examine if and how values, rules and norms are transformed.

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## 528 **Data Availability Statement**

529 As part of the evaluation process of a public funding, interviews, focus groups,  
530 meetings and observations in associations were mandatory for the association's staff.  
531 Informed consent was not declared. Interviewees have agreed for the diffusion of  
532 verbatim in the report to FONJEP steering committee. Data are not available as  
533 consent was not sought for this article.

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