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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 associations¹, 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

¹ 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 article² to manage a formative evaluation process through the ASIRPA real time

² 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

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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