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# Collective action as a tool for agri-environmental policy implementation. The case of diffuse pollution control in European rural areas

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► **To cite this version:**

Laurence Amblard. Collective action as a tool for agri-environmental policy implementation. The case of diffuse pollution control in European rural areas. *Journal of Environmental Management*, 2021, 280, pp.111845. 10.1016/j.jenvman.2020.111845 . hal-03095373

**HAL Id: hal-03095373**

**<https://hal.inrae.fr/hal-03095373>**

Submitted on 2 Jan 2023

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37 **Collective action as a tool for agri-environmental policy implementation. The case of**  
38 **diffuse pollution control in European rural areas.**

39

40 **1. Introduction**

41 The European Union (EU) Water Framework Directive, adopted in 2000, set the objective of  
42 achieving good water status for all bodies of surface waters and groundwater (EU, 2000). Despite a  
43 significant reduction in levels of nutrients in European freshwaters over the past two decades, diffuse  
44 pollution from agriculture still poses a major threat to the quality of surface and ground waters in  
45 Europe. More particularly, nitrate and phosphorus pollution from agriculture accounts for the largest  
46 proportion of diffuse run off (EEA, 2018).

47 The policy tools available to address diffuse pollution include regulatory instruments, economic  
48 instruments (taxes/subsidies) and voluntary compliance approaches (Shortle and Abler, 2001).  
49 Because of the diffuse nature of nitrate pollution, it is not feasible to define policy instruments based  
50 on emissions by farmers such as emissions charges or standards (Shortle et al., 2012). The policies  
51 implemented rather aim at modifying the agricultural practices known as influencing the extent of  
52 nutrient leaching and runoff (McCann and Easter, 1999; Shortle and Abler, 2001). Reductions in  
53 organic and mineral nitrogen fertilization, the introduction of nitrate catch crops into the cropping plan  
54 and the establishment of riparian buffers along watercourses are examples of the different measures  
55 that may be implemented.

56 In the EU context, regulatory instruments (the EU Nitrate Directive) and incentive schemes targeting  
57 individual farms (agri-environmental schemes) remain the main policy instruments implemented to  
58 control diffuse nitrate pollution from agriculture. Yet, collective approaches to policy implementation  
59 have been recently developing (Polman et al., 2010; OECD, 2013; Westerink et al., 2017). Since 2014,  
60 the EU rural development policy gives an opportunity to groups of farmers to commit jointly to  
61 collective agri-environmental schemes (EU, 2013). There also exist some examples of voluntary  
62 cooperation among farmers (and other stakeholders) for achieving water quality regulatory objectives,  
63 e.g., in drinking water catchments (Brouwer et al., 2002; Grolleau and McCann, 2012; Amblard,  
64 2019).

65 Previous studies have assessed the relevance of cooperation for the provision of ecosystem services by  
66 farmers (Goldman et al., 2007; Stallman, 2011; Prager, 2015a; Westerink et al., 2017), including water  
67 quality management (Sarker et al., 2008; Stallman, 2011). The literature also stresses the need to  
68 compare individual and collective approaches as well as the range of policy instruments available for  
69 environmental public goods provision (Polman et al., 2010; Stallman, 2011; OECD, 2013). More  
70 particularly, there has been no systematic assessment of the costs and benefits of agri-environmental  
71 cooperation as a complement to regulatory or incentive policy tools for the prevention of diffuse  
72 pollution.

73 This article aims at assessing the potential of hybrid policy instruments relying on collective action  
74 among farmers for addressing diffuse nitrate pollution from agriculture. Collective action is defined as  
75 an “action taken by a group (either directly or on its behalf through an organization) in pursuit of  
76 members’ perceived shared interests” (Marshall, 1998). The hybrid arrangements considered involve  
77 public authorities using an external body (cooperative or association) as an intermediary to coordinate  
78 the actions of individual actors (Van Huylenbroeck et al., 2009). In particular, this paper seeks to  
79 identify: (i) the benefits and costs of collective policy approaches to diffuse pollution control and (ii)  
80 the factors that influence the success of collective action.

81 A conceptual framework combining the Social-Ecological System (SES) framework with transaction  
82 cost economics (Amblard, 2019) is used to identify the conditions under which hybrid policy  
83 instruments are likely to be environmentally effective and cost-efficient tools for diffuse pollution  
84 control. Transaction cost economics are used to assess the potential advantages of collective action as  
85 a complement to other agri-environmental policy tools. For these advantages to be effective, the gains

86 of collective action have to be superior to the associated costs, including transaction costs, for  
87 participating stakeholders. The conditions under which cooperation may be successful are identified  
88 using the SES framework (Ostrom, 2009; McGinnis and Ostrom, 2014). While the SES framework  
89 was originally designed for the study of common pool resource problems, its application to diffuse  
90 water pollution as an externality problem contributes to recent developments aimed at broadening the  
91 scope of application of the framework (Villamayor-Tomas et al., 2014; Bennet and Gosnell, 2015;  
92 Hinkel et al., 2015; Partelow, 2018).

93 A review of empirical studies focused on cases of collective action for agricultural water pollution  
94 prevention in the EU context serves as a basis for a first identification of the factors likely to affect the  
95 success/failure of such cooperation. This literature review is structured by the conceptual framework  
96 combining transaction cost economics with the SES framework. The analysis relies more particularly  
97 on two cases: the Environmental Cooperatives in the Netherlands and the “Ferti-Mieux” operations in  
98 France. While the Environmental Cooperatives in the Netherlands constitute an example of collective  
99 action initiated by farmers themselves, the “Ferti-Mieux” operations in France were initiated by public  
100 agencies. Furthermore, the comparison of two cases in different Member States allows for exploring  
101 the role played by factors related to the social, economic and political contexts at the national level.  
102 Previous comparative studies of collaborative arrangements in different Member States have focused  
103 on the role of collectives as bridging organizations (Prager, 2015b) or on the diversity of governance  
104 approaches to the spatial coordination of agri-environmental management (Westerink et al., 2017). To  
105 the best of the authors’ knowledge, no comparative analysis has been conducted before with the  
106 objective of assessing the potential of collective action for water quality management in agriculture.

107 The paper is organized as follows. The second section of the paper introduces the conceptual  
108 framework used for the analysis. Section 3 describes the methodology applied. Potential advantages of  
109 collective action as a complementary tool to achieve water quality objectives and factors identified as  
110 crucial for the success of cooperation are presented in Section 4. In the final section of the paper, the  
111 results are discussed from a conceptual and policy perspective.

## 112 **2. Conceptual framework**

113 A comparative perspective in terms of transaction costs is adopted with regard to the alternative policy  
114 instruments targeting individual farmers versus collectives (Section 2.1). The factors affecting the  
115 benefits and transaction costs of cooperation among farmers are identified on the basis of the SES  
116 framework (Section 2.2).

### 117 **2.1 A transaction cost analysis of policy options**

118 Transaction costs are the resources used to define, establish, maintain, and transfer property rights  
119 (Allen, 2000). Transaction costs arise because information is incomplete and asymmetrically held by  
120 parties to exchange (North, 1990). Depending on the characteristics of the good or service considered,  
121 the level of transaction costs linked to market coordination will be more or less important. Diffuse  
122 pollution, as an output of agricultural production affecting the utility of the production activities of  
123 other economic agents, is an externality. Externalities are present “whenever some individual A’s  
124 utility or production relationships, include real (that is nonmonetary) variables, whose values are  
125 chosen by others (persons, corporations, governments) without particular attention to the effects on  
126 A’s welfare” (Baumol and Oates, 1988). Water pollution, similar to many externalities, presents some  
127 characteristics of a public good (Holtermann, 1972; Baumol and Oates, 1988). Pure public goods are  
128 goods that are non-exclusive and non-subtractive (Samuelson, 1954; Head, 1962). The restoration or  
129 maintenance of water quality by farmers constitutes a public good, as (i) everyone can benefit from the  
130 resulting improvement in water quality without diminishing others’ benefits (non-subtractability) and  
131 (ii) it is difficult (impossible) to prevent anyone from enjoying the benefits of water pollution  
132 reduction (non-excludability). In this case, the transaction costs associated with decentralized market  
133 exchange are so high that the public good will be underprovided. For example, in the case of diffuse  
134 water pollution, the costs of identifying the sources of pollution and the other affected individuals will

135 highly constrain market coordination (Falconer, 2002). Some form of organization is needed to  
136 overcome the suboptimal provision of the public goods (Ostrom and Walker, 2000). However, the  
137 alternative institutional arrangements (including the diverse types of government intervention) also  
138 present transaction costs and the question is then which arrangement allows for the provision of the  
139 public good at the lowest costs.

140 Coase (1960) suggested adopting a comparative perspective on the relative benefits and costs  
141 (including transaction costs) of the different social arrangements. Such an approach has recently been  
142 developed in the field of environmental policy. A growing body of research seeks to include  
143 transaction costs in the analysis and evaluation of environmental policies (McCann et al., 2005;  
144 Coggan et al., 2010; Garrick et al., 2013; McCann, 2013). In this context, transaction costs correspond  
145 to search and information costs, bargaining and decision or contracting costs and monitoring,  
146 enforcement and compliance costs (McCann et al., 2005). Several studies have empirically measured  
147 the extent of transaction costs linked to the implementation of environmental policies, showing their  
148 high significance (McCann and Easter, 1999; Falconer, 2000; Falconer et al., 2001; Mettepenningen et  
149 al., 2009).

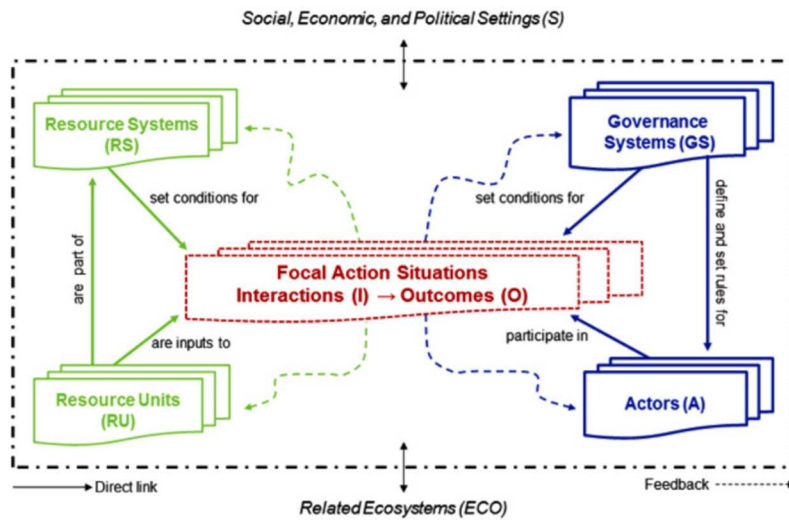
150 In the paper, hybrid policy instruments relying on collective action are compared to regulatory and  
151 individual incentive instruments in terms of relative benefits and costs, including transaction costs.  
152 The potential of collective action for diffuse pollution control further depends on the potential private  
153 benefits and transaction costs borne by participants.

154 As farmers do not primarily bear the costs of water pollution or do not enjoy the benefits of water  
155 quality improvements, they have generally little incentive to engage in collective action to reduce the  
156 level of pollution (preventing the public bad) or contribute to the maintenance of water quality  
157 (providing the public good). Still, they can draw indirect economic advantages as well as non-  
158 monetary benefits from such cooperation. In some cases, farmers may reap some private economic  
159 benefits from changing their agricultural practices towards less polluting practices. A better  
160 management of fertilization may lead to some savings in fertilizer expenses without any decrease in  
161 yields (Brouwer, 2003; Buckley and Carney, 2013). Another economic motivation for farmers to  
162 participate in collective action may include the possibility to maintain or increase their profits through  
163 the certification of their products (e.g., ecolabels) or through the development of activities based on  
164 the improved quality of the environment (e.g., agritourism) (Ribaud et al., 2010; Grolleau and  
165 McCann, 2012; OECD, 2013). Finally, besides economic benefits, nonmonetary incentives may play a  
166 role in farmers' willingness to participate in collective action. Farmers with preferences for  
167 environmental preservation will be more willing to participate in cooperation to reduce water pollution  
168 (Lubell et al., 2002; Dupraz et al., 2009). Transaction costs associated with collective action include  
169 the costs of defining actions to control diffuse water pollution (information and bargaining costs) and  
170 the monitoring and enforcement costs of actions. Collective action for the provision of environmental  
171 services with public goods characteristics such as the restoration/maintenance of water quality more  
172 particularly entails a potential free-riding problem due to the difficulty in excluding beneficiaries for  
173 failing to contribute to the maintenance of the public good (Ostrom, 2003). The extent of expected  
174 benefits and transaction costs and thus the effectiveness of collective action are influenced by a  
175 number of factors identified on the basis of the SES framework (Section 2.2).

## 176 2.2 Identifying the factors affecting collective action: the SES framework

177 The SES framework was developed as a tool for the analysis of complex Social-Ecological Systems  
178 (SESs) (Ostrom, 2007; 2009; Poteete et al., 2010). This ontological framework lists and structures the  
179 variables which have been found in previous research to influence the patterns of interactions and  
180 outcomes in diverse SES. The SES framework constitutes an extension of the Institutional Analysis  
181 and Development approach (Ostrom, 1998) with specific attention given to the characteristics of  
182 biophysical systems and their impact on natural resource management (Ostrom, 2011; McGinnis and  
183 Ostrom, 2014).

184 Focal action situations represent the diverse interactions occurring between actors within SESs (e.g.,  
 185 harvesting the resource, information sharing or self-organizing for resource management) leading to  
 186 social and ecological outcomes (Figure 1). The characteristics of the natural resource considered  
 187 (resource system and resource unit), the characteristics of actors involved and the characteristics of the  
 188 governance system are the first-tier variables considered as potentially important to analyze  
 189 interactions and outcomes achieved in a given SES. The broader social, economic and political  
 190 contexts and related ecosystems are also included as interacting with the other subsystems.



191  
 192 Figure 1: The SES framework (Source: McGinnis and Ostrom, 2014)

193 First-tier variables are further characterized by second-tier variables identified in previous studies to  
 194 influence interactions and outcomes in SESs (McGinnis and Ostrom, 2014) (Appendix 1). Among the  
 195 second-tier variables identified as potentially relevant, a subset of ten factors likely to affect the  
 196 benefits and costs of collective action is seen to be critical for the success of self-organization by users  
 197 of common-pool resources (Ostrom, 2009) (Table 1).

198 Table 1: The factors identified as crucial for self-organization by users for CPR management

First-tier variables	Second-tier variables
Resource system (RS)	RS3 – Size of resource system RS5 – Productivity of system RS7 – Predictability of system dynamics
Resource unit (RU)	RU1 – Resource unit mobility
Governance system (GS)	GS6 – Collective-choice rules
Actors (A)	A1 – Number of relevant actors A5 – Leadership-entrepreneurship A6 – Norms (trust-reciprocity)/social capital A7 – Knowledge of the SES A8 – Importance of the resource

199 Source: Adapted from Ostrom, 2009

200 The characteristics of the resource systems identified as affecting the likelihood of self-organization  
 201 by users include the size and productivity of the system (RS3, RS5) and the predictability of system  
 202 dynamics (RS7). A resource system of moderate size is seen as conducive to self-organization, as a  
 203 larger size means higher management costs while a smaller size may imply a less valuable flow of  
 204 products from the system (Chhatre and Agrawal, 2008; Ostrom, 2009). A moderate level of resource  
 205 scarcity (productivity of the system) is also likely to induce collective action by users, unlike situations  
 206 in which the resource is either already exhausted or abundant (Meinzen-Dick, 2007). A low  
 207 predictability of system dynamics will increase the management costs of the resource, thereby

208 reducing the likelihood of self-organization (Agrawal, 2001). Management costs also depend on the  
209 resource unit mobility (RU1), stationary units (e.g., water in a lake) being less costly to manage than  
210 mobile units (e.g., water in a stream) (Schlager et al., 1994; Agrawal, 2001). A larger number of users  
211 (A1) means higher transaction costs, however a small group size may constrain the pooling of  
212 resources needed to sustain collective action (Wade, 1987; Ostrom, 2010). The presence of well-  
213 respected local leaders (A5) and the existence of norms of reciprocity and/or social capital within the  
214 group (A6) are likely to decrease the transaction costs associated with collective action (Pretty and  
215 Ward, 2001; Meinzen-Dick, 2007; Poteete et al., 2010). The sharing of a common knowledge of the  
216 SES (A7) is seen as decreasing the perceived costs of organizing by users (Ostrom, 2009). The  
217 importance of the resource to users in terms of economic or noneconomic value (A8) will affect the  
218 expected benefits of collective action relative to its costs (Acheson, 2006). Finally, identified as  
219 crucial for the success of self-organization is the autonomy users have to define and enforce the rules  
220 governing resource management, i.e., their autonomy at the collective-choice level (GS6) (Ostrom,  
221 2009; Poteete et al., 2010).

222 The SES framework is used to identify the factors influencing collective action for the control of  
223 diffuse pollution from agriculture. More particularly, the subset of ten factors highlighted by Ostrom  
224 (2009) (Table 1) constitutes an initial set of assumptions with regard to the variables affecting the  
225 benefits and costs, including transaction costs, of cooperation.

### 226 **3. Methodology**

227 Section 3.1 introduces the case study approach adopted for the analysis. The next subsection briefly  
228 describes the cases of Environmental Cooperatives and “Ferti-Mieux” operations. Table 2 presents the  
229 main characteristics of the two cases.

#### 230 3.1. A case study approach based on a literature review

231 The analysis of hybrid policy instruments relying on collective action for nitrate pollution control  
232 relies on a review of empirical studies focused on cases of collective action for agricultural water  
233 pollution prevention in the EU context. Two cases are more particularly analyzed: the Environmental  
234 Cooperatives (ECs) in the Netherlands and the “Ferti-Mieux” operations in France. The two cases  
235 were selected because of their historical depth; both initiatives have developed since the beginning of  
236 the 1990s. Furthermore, while the ECs in the Netherlands constitute an example of collective action  
237 initiated by farmers themselves, the “Ferti-Mieux” operations in France were initiated by public  
238 agencies. Finally, the comparison of two cases in different Member States allows for exploring the  
239 role played by factors related to the social, economic and political contexts at the national level.

240 The secondary sources used include scientific and technical journal articles, research and policy  
241 reports, PhD and master theses as well as policy briefs. While the case of Environmental Cooperatives  
242 has been the subject of multiple analyses published in the academic literature, the Ferti-Mieux  
243 operations are mostly documented in technical outlets and policy reports.

244 The evidence from the diverse secondary sources was reviewed through the lens of the conceptual  
245 framework combining transaction cost economics with the SES framework. More particularly, the  
246 second-tier variables highlighted by Ostrom (2009) (Table 1) served as a frame for identifying the  
247 factors affecting the benefits and costs, borne by the participants to agri-  
248 environmental collective action. Other second-tier variables were selected in the list updated by  
249 McGinnis and Ostrom (2014) (Appendix 1) when identified as having an impact on cooperation in the  
250 documents reviewed. Third- and fourth-tier variables characterizing the second-tier variables (Basurto  
251 et al., 2013; Frey and Cox, 2015; Thiel et al., 2015) were also developed if the literature review  
252 suggested that they play a role in the success/failure of collective action. The references supporting the  
253 influence of each identified factor on cooperation are presented in Appendix 2.

#### 254 3.2. Two cases of collective action in the EU context

##### 255 *3.2.1. The Environmental Cooperatives in the Netherlands*

256 The ECs have developed as a new governance structure since the beginning of the 1990s (Glasbergen,  
257 2000; Renting and van der Ploeg, 2001). They are regional groups of farmers, including in some cases  
258 other rural stakeholders (e.g., environmental organizations and local authorities) (Wiskerke et al.,  
259 2003). Most ECs are formal associations, some are foundations, and a few have legal cooperative  
260 status (Polman et al., 2010).

261 By 2016, 160 associations involving 10% of the Dutch farming population (65% of which were dairy  
262 farmers) managed 25% of the rural area of the Netherlands. Their activities covered land areas ranging  
263 from 1,000 up to 130,000 hectares (Ministry of Economic Affairs, 2011; Terwan et al., 2016). The  
264 ECs' environmental activities are not restricted to water quality management and one EC can be active  
265 in several environmental "domains," including also biodiversity conservation or wildlife management  
266 (Franks and Mc Gloin, 2007a). In addition to nature management and the reduction of environmental  
267 pollution, some ECs have also developed activities in the fields of rural tourism and regional quality  
268 production (Renting and van der Ploeg, 2001; Franks and McGloin, 2007a).

269 The ECs are generally managed by a board elected annually. Subcommittees are responsible for  
270 managing individual projects and developing new activities. Regular meetings take place, as well as an  
271 annual general meeting at which changes to the group's plan and constitution can be made (Franks and  
272 McGloin, 2007a). Individual members decide for themselves whether to participate in any EC activity.  
273 While they can suggest programs for the ECs to be involved in, only those initiatives supported by a  
274 large share of members will be supported by the ECs (Franks, 2010).

275 The development of ECs led to innovations in the implementation of agri-environmental policy in the  
276 Netherlands. In some cases, ECs have been allowed to develop themselves the measures and  
277 instruments used to achieve the regulatory objectives defined by state agencies (Glasbergen, 2000;  
278 Renting and van der Ploeg, 2001; Wiskerke et al., 2003; Stobbelaar et al., 2009; Termeer et al., 2013).  
279 With regard to the implementation of agri-environmental schemes, priority has been given to  
280 collective rather than individual applications since 2000 (Franks and Mc Gloin, 2007a; 2007b). While  
281 some ECs had received and distributed payments to farmers, contracting with ECs as collectives  
282 turned out to be incompatible with the EU regulations at the time. From 2003, ECs were compensated  
283 by national funds for their role in coordinating their members' applications to agri-environmental  
284 schemes while payments were directed to farmers (Franks and McGloin, 2007b; OECD, 2013).

285 In anticipation of the recognition of farmer groups as eligible beneficiaries of agri-environmental  
286 payments in the 2014-2020 EU rural development program, the Ministry of Agriculture chose four  
287 ECs as pilot projects to assess the feasibility and added value of the collective implementation of agri-  
288 environmental measures (Ministry of Economic Affairs, 2011; OECD, 2013; Westerink et al., 2015).  
289 In 2016, the Dutch government chose to implement agri-environmental schemes through collective  
290 applications only. New farmer collectives were established as formal contract partners of the regional  
291 governments in charge of the implementation of agri-environmental policy. While some of the  
292 collectives were initiated by the original ECs, others were created by farmer unions (Terwan et al.,  
293 2016; Jongeneel and Polman, 2018). There are currently 40 new collectives, involving more than  
294 6,300 farmers and covering a land area of 68,000 hectares (Jongeneel and Polman, 2018).

295 There is no formal appraisal of the environmental impact of ECs, however, they are perceived as being  
296 ecologically effective for their positive influence on the participation of farmers in agri-environmental  
297 schemes and on the evolution of agricultural practices (Franks and Mc Gloin, 2007a; 2007b; Smits et  
298 al., 2008; Slangen et al., 2008; Van Dijk et al., 2015). Data collected between 1995 and 2000 on trends  
299 in the nitrogen surpluses of member farms of the two first ECs (VEL and VANLA<sup>1</sup>) and a regional  
300 reference group of farms show that member farms realized lower nitrogen surpluses and reduced these  
301 losses at a higher rate than the regional average over the five years (Renting and van der Ploeg, 2001).  
302 In 2000, 33% of VEL and VANLA dairy farmers reached nitrogen surpluses below the national policy

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<sup>1</sup> These respectively are the acronyms for Vereniging Eastermar's Lânsdouwe and Vereniging Agrarish Natuur en Landschapsbeheer Achtkarspelen.



303 objectives of 2003 while only 10% of dairy farms at the national level achieved this result (Sonneveld  
304 and Bouma, 2003).

305

306

### 307 3.2.2. *The “Ferti-Mieux” operations in France*

308 The “Ferti-Mieux” operations were launched in 1991 by the French Ministry of Agriculture. Managed  
309 by the National Association for Agricultural Development (ANDA)<sup>2</sup>, the goal was to promote and  
310 label local collective actions of farmers for a better management of nitrogen use at a water catchment  
311 level (Papy and Torre, 2002). Within this frame, farmers voluntarily committed to changing their  
312 practices to limit water pollution with no financial compensation, along collectively defined  
313 prescriptions. Participating farmers benefited from free technical support for modifying their practices,  
314 on the basis of a diagnosis of the local context (water resource system, farming systems, sources and  
315 risks of nitrate pollution). Participants also benefited from the label “Ferti-Mieux” as official  
316 recognition that their farming practices limited the risk of water pollution.

317 At the national level, a national steering committee gathering representatives from the Ministries of  
318 Agriculture and Environment, the Water Agencies and farmers’ organizations was in charge of  
319 defining the overall orientations of the “Ferti-Mieux” program. A national scientific and technical  
320 committee involving researchers and technical representatives of agricultural organizations was  
321 responsible for the evaluation of local operations as a basis for the decision to award the “Ferti-Mieux”  
322 label. At the local level, a steering committee and a technical committee involving farmers’  
323 organizations, local public agencies and in some cases water suppliers and agro-industrial cooperatives  
324 were in charge of the management of operations. A coordinator (usually working for a local  
325 Agricultural Chamber<sup>3</sup>) was responsible for defining, together with the participating farmers, nitrogen  
326 management plans (Sebillotte, 2003).

327 A pre-label was granted to local operations based on two criteria: (i) the area covered by the  
328 involvement of farmers in the water catchment and (ii) the adaptation of the nitrogen management  
329 plan to the local context. The official “Ferti-Mieux” label was granted and renewed if the agreed  
330 changes in farmers’ practices were effective (Ramonet, 2003).

331 Between 1991 and 2001, 65 operations were granted the “Ferti-Mieux” label, involving approximately  
332 35000 farmers and representing 4.6% of the agricultural area. The effects of the “Ferti-Mieux”  
333 operations on water pollution were mixed with no evidence of a decrease in nitrate rates in  
334 groundwater bodies; however, this could be attributable to the time lags in groundwater quality  
335 response to changes in agricultural practices. In areas where surface waters were targeted, more than a  
336 half of the operations led to a decrease or stabilization of nitrate rates, demonstrating the  
337 environmental relevance of the operations (Papy and Torre, 2002).

338 Following the dissolution of ANDA in 2002, the “Ferti-Mieux” operations were officially stopped at  
339 the national level. However, Agricultural Chambers and the Water Agency of the Rhin-Meuse water  
340 basin decided to undertake similar operations under the name “Agri-Mieux.” Indeed, the ongoing  
341 “Ferti-Mieux” operations in the area were evaluated as successful in terms of farmers’ involvement  
342 and water quality improvement. The new “Agri-Mieux” operations have the additional objective of  
343 reducing diffuse pesticide pollution (Bernard, 2004). In Lorraine, eleven “Agri-Mieux” operations  
344 gather 22% of farmers, covering 25% of the agricultural area in the region, while in Alsace, 4500  
345 farmers participate in eight operations in the plain area (Rettel and Revest, 2013; Burtin, 2014).

---

<sup>2</sup> This association, which was disbanded in 2002, had a mixed membership of representatives from agricultural interest groups and the State. Its role was to provide advice to the Ministry of Agriculture and to fund agricultural development programs.

<sup>3</sup> Agricultural Chambers in France are public organizations led by representatives of agricultural and other rural stakeholders. Agricultural Chambers are active at the regional and the department level.

346

347 Table 2: Two cases of agri-environmental collective action in the EU context: the Environmental  
 348 Cooperatives in the Netherlands and the "Fertimieux" operations in France.

	<b>Environmental Cooperatives (The Netherlands)</b>	<b>“Fertimieux” operations (France)</b>
<b>Initiative</b>	Farmers	Public agencies (Ministry of Agriculture)
<b>Composition</b>	Farmers or Farmers and non-farmers	Farmers and non-farmers
<b>Structure</b>	Formal organization	Ad hoc network
<b>Funding</b>	Member fees Public agencies (direct support, contracts)	Public agencies (Agricultural Chambers, Water Agencies, ANDA, local governments)
<b>Environmental “domain”</b>	Multiple (water quality, biodiversity, wildlife)	Water quality
<b>Activities</b>	<ul style="list-style-type: none"> <li>▪ Information sharing and advice provision</li> <li>▪ Coordination of changes in agricultural practices</li> <li>▪ Fundraising</li> <li>▪ Interest representation/lobbying</li> <li>▪ Research activities</li> </ul>	<ul style="list-style-type: none"> <li>▪ Information sharing and advice provision</li> <li>▪ Coordination of changes in agricultural practices</li> </ul>

349 Sources: Franks and McGloin, 2007a; Verron, 2007.

350 **4. Results**

351 The advantages of collective approaches to regulation and incentive schemes for diffuse pollution  
 352 control are specified in Section 4.1. Factors affecting the potential of cooperation are presented in  
 353 Section 4.2.

354 4.1 The advantages of hybrid policy instruments relying on collective action for diffuse  
 355 pollution control

356 Reaching the objectives of water quality improvement requires action that extends beyond farm  
 357 boundaries at the scale of the drinking water catchment or watershed. Coordination at the appropriate  
 358 scale of management can be achieved by regulations through zoning. For example, the EU Nitrate  
 359 Directive is implemented in areas designated as "vulnerable zones" for nitrate pollution. Agri-  
 360 environmental incentive schemes are also frequently offered in specific areas chosen to match the  
 361 environmentally relevant scales (Prager, 2015a; Westerink et al., 2017). However, the incentives  
 362 provided, on an individual farm basis, are not linked to the implementation of measures at a larger  
 363 scale (Goldman et al., 2007; Mettepenningen et al., 2013). Collective contracts with groups of farmers  
 364 allow environmental actions to be taken across land management boundaries (Falconer, 2000; Franks  
 365 and McGloin, 2007a; Mettepenningen et al., 2013).

366 The agricultural impact in terms of nitrate diffuse pollution shows high levels of spatial variation  
 367 depending on hydroclimatic conditions, soil types and agricultural practices. The adaptation of  
 368 measures to local conditions is thus of importance for an effective reduction of water pollution  
 369 (Lacroix et al., 2010). However, designing precise measures may be very costly for public agencies in  
 370 terms of information collection and processing. Relying on collective action permits taking advantage

371 of the knowledge held by farmers about their own farming system and local environment (Stuiver et  
372 al., 2003; Wiskerke et al., 2003; Franks, 2010). In turn, collective action among farmers favors their  
373 access to research and extension services (Slangen, 1994; Franks and McGloin, 2007b).

374 The level of information asymmetry between public agencies and farms is an important issue in  
375 monitoring diffuse nitrate pollution (Shortle and Horan, 2001). Relying on a collective for controlling  
376 and enforcing farmers' practices will lower public costs (Slangen, 1994; Renting and van der Ploeg,  
377 2001). Compared to public agencies, farmers' collectives may be advantaged by easier access to  
378 information and the possibility of using enforcement mechanisms such as trust or reputation (Falconer,  
379 2002; Franks, 2011; Westerink et al., 2015). Still, public agencies will remain ultimately accountable  
380 for the group's performance and thus will incur some monitoring and enforcement costs (OECD,  
381 1998; Falconer, 2002).

382 Farmers may be more willing to comply with measures they contribute to design than with measures  
383 externally imposed to them. There is growing empirical evidence on the effects of external  
384 interventions (positive monetary rewards or regulations with sanctions) on the intrinsic motivation of  
385 individuals (Frey and Jegen, 2001; Moller et al., 2006; Akers and Yasué, 2019). More particularly,  
386 external interventions may crowd out motivation if individuals affected perceive them to be  
387 controlling. As a result, individuals react by reducing their intrinsic motivation in the activity  
388 controlled (Frey and Jegen, 2001). Self-organization for the definition of actions to address diffuse  
389 pollution may thus improve the extent to which policy objectives are reached, by enabling farmers to  
390 endorse the policy goals (Stobbelaar et al., 2009; OECD, 2013).

391 Several studies have shown that significant transaction costs have been associated with the  
392 implementation of agri-environmental schemes in the EU context, both for implementation agencies  
393 and for the participating farmers (Falconer, 2000; Falconer et al., 2001; Mettepenningen et al., 2009;  
394 Mettepenningen et al., 2011). Transaction costs borne by farmers include the search and information  
395 costs involved in their decision to participate in an agri-environmental program as well as the  
396 contracting costs linked to the administrative tasks required with participation. Public agencies also  
397 incur contracting costs with the management of farmers' applications and monitoring and enforcement  
398 costs of farmers' compliance with the prescriptions. The transaction costs borne by farmers have been  
399 shown to constrain their participation in the schemes and thus the achievement of environmental  
400 objectives. In this regard, smaller farms may be relatively more affected due to the presence of high  
401 fixed transaction costs (e.g., required farm audits for participation) (Falconer, 2000).

402 Transactional economies of scale may be achieved by making collective management agreements  
403 (Falconer, 2000). Information and knowledge sharing about agri-environmental schemes and  
404 implications of participation within a group may reduce the costs of decision-making for individual  
405 farmers (OECD, 1998; Franks, 2010; Mettepenningen et al., 2013). Collective applications for  
406 participation in agri-environmental schemes may also reduce contracting costs, both for the farmers  
407 and for the public agencies in charge (Mettepenningen et al., 2011). Several studies report effective  
408 transaction cost savings achieved in the implementation of agri-environmental schemes in the  
409 Netherlands with the development of collective contracts between the administration and the  
410 Environmental Cooperatives (Franks and McGloin, 2007a; 2007b; Smits et al., 2008; Slangen et al.,  
411 2008; Franks, 2011; Prager, 2015b). Van Dijk et al. (2015) found, on the basis of a quantitative  
412 empirical study, that the facilitating role played by ECs in collective agri-environmental schemes was  
413 positively related to farmers' intentions to participate in the schemes.

414 Collective approaches to regulatory and incentive instruments may thus present some advantages for  
415 reaching water quality objectives in a cost-efficient way. The achievement of cooperation among  
416 farmers will however depend on a number of conditions identified on the basis of the SES framework.

417

418

## 419 4.2 The factors affecting the potential of collective action

420 The potential of collective action depends on the expected benefits and transaction costs associated  
421 with farmers' participation in cooperation. The first subsection presents the factors likely to affect the  
422 extent of benefits that farmers can draw from collective action oriented towards the management of  
423 water quality. In the second subsection, the variables that may influence the transaction costs of  
424 cooperation are reviewed. The variables identified through the literature review are presented in Table  
425 3. References for each variable are given in Appendix 2.

### 426 4.2.1. *The factors affecting the private benefits of farmers*

427 As discussed above, farmers have little direct economic incentive to engage in collective action for  
428 diffuse pollution control. In some instances, they can benefit from cost savings by changing their  
429 farming practices. However, the extent of these cost savings will vary according to the **type of**  
430 **farming system (A2.1)**. In a context of intensive crop farming, reducing mineral fertilization may  
431 induce high costs while cattle breeding farms have the potential to substitute organic for mineral  
432 fertilization to a certain extent (AE RMC, 2007b; Lacroix et al., 2010). Prevailing inefficiencies in  
433 production methods as well as personal characteristics of farmers (attitudes and skills) also affect the  
434 potential for increased economic benefits (Brouwer, 2003; Groot et al., 2006).

435 The development of ecolabels or ecotourism as additional economic motivations will depend on the  
436 existence of a demand for "green" products and activities (Ribaud et al., 2010; Grolleau and  
437 McCann, 2012; OECD, 2013). Several ECs have pursued initiatives related to regional marketing and  
438 agritourism to provide additional benefits to their members (Renting and van der Ploeg, 2001;  
439 Termeer et al., 2013). Conversely, if **market incentives (S5)** are such that participation in collective  
440 action leads to drastic income reductions, farmers will be less willing to engage into cooperation.  
441 Busca (2004) found farmers' participation in Ferti-Mieux operations to be lower in areas in which the  
442 economic weight of supply chains for high quality cereals was high. Restrictions on fertilization have  
443 a direct impact on farmers' capacities to access such supply chains in terms of product quality (e.g.,  
444 the high protein content of the produce) or quantity. Not surprisingly, the "Ferti-Mieux" operations  
445 involving agro-industrial cooperatives or other trading partners were identified as attracting stronger  
446 support from farmers (Busca, 2002; Verron, 2007).

447 Two further motivations can be identified in relation to the expected economic benefits associated  
448 with collective action. The **threat of regulations or penalties (S4.1.1)** may encourage voluntary  
449 collective action by reducing expected net farm profits (Ayer, 1997). This can be illustrated by the  
450 emergence of the first environmental cooperatives in the Netherlands. The two cooperatives VEL and  
451 VANLA were created in the Frisian Woodlands area as a reaction among farmers to a series of  
452 national regulations aiming at limiting the environmental impacts of agriculture (including the  
453 reduction of nitrogen losses by dairy farms) (Glasbergen, 2000; Stobbelaar et al., 2009). Farmers  
454 considered these policies to threaten the viability of their local farming systems and to be ineffective  
455 with regard to the environmental objectives targeted (Renting and van der Ploeg, 2001; Wiskerke et  
456 al., 2003). The two cooperatives negotiated with the Dutch government for exceptions concerning the  
457 application of state regulations and committed in exchange to undertake alternative actions to reduce  
458 nitrogen losses (Wiskerke et al., 2003; Franks, 2010). The threat of regulation by public water utilities  
459 was also identified as a factor favoring the participation of farmers in Ferti-Mieux operations in  
460 drinking water catchments (Bernard, 2004; AE RMC, 2007b).

461 Another motivation for cooperation can be to gain political weight. Farmer-led collectives may be  
462 seen by farmers as a political tool to influence policy decisions in favor of their economic interests.  
463 The Environmental Cooperatives have become major actors in agri-environmental policy definition in  
464 the Netherlands (Franks and McGloin, 2007a). Their emergence and success among farmers may be  
465 explained by the initial dominance of ecological expertise in the definition of environmental policies  
466 in the Dutch context, which led to a weak representation of farmers' interests (Daniel and Perraud,  
467 2009; Franks and McGloin, 2007a; 2007b; Franks, 2008; 2010). The role of **political representation**  
468 **(S4.1.2)** as a strong driver for environmental collective action was less important in France, where an

469 institutionalized co-management of agri-environmental policies between the State and farmers'  
 470 organizations has for a long time permitted farmers to effectively represent their perspectives (Brives,  
 471 1998; Daniel and Perraud, 2009). This may help explain the lack of support provided by agricultural  
 472 professional organizations to the national Ferti-Mieux program, which was identified as an obstacle to  
 473 its continuation after the dissolution of ANDA (Sebillotte, 2003).

474 Finally, a **stronger sensitivity to water protection (A8.1)** was identified as a factor influencing  
 475 farmers' participation in Ferti-Mieux operations (Sebillotte, 2003). In contrast, Stobbelaar et al. (2009)  
 476 and van Dijk et al. (2015) identified diverse attitudes towards environmental conservation among EC  
 477 members. This could be explained by the difference in the general objectives of the two cases of  
 478 collective action. While the Ferti-Mieux program promoted changes in farming practices without any  
 479 financial compensation, the ECs have aimed at improving both the ecological and economic  
 480 performance of agriculture.

481 Table 3: The factors identified as affecting the benefits and costs of collective action

First-tier variables	Second-, third- and fourth-tier variables
Social, economic and political settings (S)	S4 – Other governance systems <i>S4.1 – Larger scale governance systems</i> S4.1.1 – Regulatory threat S4.1.2 – Political representation of agricultural interests S4.1.3 – Support from public agencies
Resource system (S)	S5 – Markets RS3 – Size of resource system * <i>RS3.1 – Size of water catchment</i>
Governance system (GS)	RS7 – Predictability of system dynamics * GS6 – Collective-choice rules * <i>GS6.1 – Autonomy at the collective choice level</i>
Actors (A)	GS8 – Monitoring and sanctioning rules A1 – Number of relevant actors * A2 – Socioeconomic attributes <i>A2.1 – Type of farming system</i> <i>A2.2 – Heterogeneity of actors</i> A5 – Leadership-entrepreneurship * A6 – Norms (trust-reciprocity)/social capital * A7 – Knowledge of the SES * A8 – Importance of the resource * <i>A8.1 – Environmental preferences of farmers</i>

482 \* Second-tier variables identified by Ostrom (2009) as crucial for self-organization by users for CPR  
 483 management

#### 484 4.2.2. The factors affecting the transaction costs of collective action

485 Among the factors affecting the transaction costs of collective action, the characteristics of actors  
 486 involved were found to play a major role.

487 In the case of "Ferti-Mieux," the success of operations was clearly related to the **number of**  
 488 **participants (A1)** involved. Operations initially involving a large number of farmers either failed or  
 489 split up into smaller subgroups (Kockmann et al., 2003; Verron, 2007). The environmental  
 490 cooperatives in the Netherlands show great variation in the number of their members, ranging from 15  
 491 to 1700 members (Franks and McGloin, 2007a). Westerink et al. (2017) found that the larger size of a  
 492 cooperative positively influenced its organizational capacity and institutional capital while putting at  
 493 risk the social links between the association and its members. With regard to group composition,

494 **heterogeneity (A2.2)** in production systems and individual abatement costs of farmers may increase  
495 the bargaining costs of defining the actions to implement for the prevention of water pollution  
496 (Grolleau and McCann, 2012). Heterogeneity in preferences for environmental preservation of group  
497 members is also likely to constrain the agreement process (Lubell et al., 2002). The participation of  
498 farmers and non-farmers may also increase decision-making costs. In the case of the ECs, the different  
499 goals and perspectives of farmers and other stakeholders (e.g., environmental associations or water  
500 suppliers) could lead to conflicts (Franks and McGloin, 2007a). While heterogeneity in preferences  
501 and interests among group members appears to be a barrier to collective action, heterogeneity in terms  
502 of resources and skills may be a positive factor (OECD, 2013). In some ECs, the participation of non-  
503 farmers was also recognized as bringing complementary resources, knowledge and skills (Franks,  
504 2008; Uetake, 2014).

505 The **presence of a local leader/social entrepreneur (A5)** able to stimulate and animate collective  
506 action also appears to be an important factor (Davies et al., 2004). The most successful "Ferti-Mieux"  
507 operations were characterized by the involvement of a coordinator familiar with the local context and  
508 considered to be knowledgeable and trustworthy by farmers (Kockmann et al., 2003; AE RMC, 2007a;  
509 2007b; Verron, 2007). The role of respected leaders was identified as crucial in the emergence and  
510 success of ECs as well (Franks, 2008; 2011). Political and inter-organizational leadership also proved  
511 important for negotiating rules and policies favorable to the development of ECs with public  
512 authorities at the local and national levels (Franks, 2010; Termeer et al., 2013).

513 The existence of **trust and shared norms of reciprocity (A6)** was found to play a crucial role in the  
514 success of ECs and Ferti-Mieux operations (Polman and Slangen, 2002; Eshuis and van Woerkum,  
515 2003; Kockmann et al., 2003). Local networks in small communities favor the development of trust  
516 (Eshuis and van Woerkum, 2003). However, Lundqvist (2001) documents the case of a failed attempt  
517 to induce collective action in a water catchment in Sweden where collective memories of trust and  
518 reputation within the farming community seemed to rule out any possibility of cooperation. Further,  
519 Davies et al. (2004) stress that the match between the optimal management scale and informal social  
520 networks is context specific. The authors found in the Scottish context that, most often, strong social  
521 relationships do not fall in contiguous spatial patterns, but may be scattered throughout a local area.

522 Finally, the costs associated with the definition and assessment of actions depend on the **knowledge of**  
523 **the hydrogeological system (A7)**. In both EC and Ferti-Mieux cases, the definition of measures  
524 targeting nitrate diffuse pollution benefited from partnerships with research and technical institutes  
525 (Kockmann et al., 2003; Bernard, 2004; Stuver et al., 2003; Eshuis and Stuver, 2005; Van Der Ploeg  
526 et al., 2006; AE RMC, 2007a; 2007b). The monitoring of water quality may also serve as a tool for  
527 enhancing farmers' involvement in collective action to the extent that the response time of the water  
528 system allows for short-term and visible results of changes in farming practices (Bernard, 2004; AE  
529 RMC, 2007b; Verron, 2007).

530 Further, two variables characterizing the resource system were identified as influencing the level of  
531 transaction costs. In relation to the size and heterogeneity of the group of participants, the **size of the**  
532 **water catchment or watershed (RS3.1)** will affect the likelihood of successful collective action. A  
533 larger water basin means a larger number of farmers and potentially more heterogeneity in their  
534 farming systems (Brouwer, 2003). Ferti-Mieux operations located in large water basins usually split  
535 up into groups working at a sub-basin scale (Kockmann et al., 2003). The **predictability of water**  
536 **system dynamics (RS7)** is likely to affect the costs of defining the actions to implement and the costs  
537 of assessing their impact on water quality (Nimmo Smith et al., 2007; Grolleau and McCann, 2012).  
538 The short time lag between changes in agricultural practices and the evolution of nitrate concentrations  
539 in hydrosystems targeted by Ferti-Mieux operations in the Lorraine region facilitated an evaluation of  
540 the effectiveness of actions (Bernard, 2004; AE RMC, 2007b).

541 Transaction costs of collective action will also strongly depend on the rules defined for the decision-  
542 making process and the enforcement of decisions within the group.

543 The two cases of ECs and Ferti-Mieux operations highlight the positive effect of an **autonomous**  
544 **design of the rules by participants (GS6.1)**. In the Netherlands, all Environmental Cooperatives have

545 developed their own rules (Franks and McGloin, 2007a; Franks, 2008; 2011; Termeer et al., 2013). In  
546 France, farmers created independent structures (e.g., associations), through which they could define  
547 and enforce their own rules while remaining within the general "Ferti-Mieux" frame. This greater  
548 autonomy among farmers was identified as having a positive effect on the durability of operations  
549 (Kockmann et al., 2003; AE RMC 2007b).

550 Most cooperatives have developed **monitoring and sanctioning systems (GS8)**, involving members  
551 or external professionals. Sanctions used by ECs include warnings, exclusion from activities and/or  
552 financial penalties (Polman and Slangen, 2002; Eshuis and van Woerkum, 2003). The board of  
553 cooperatives may also exclude individual members who do not respect the agreed rules (Wiskerke et  
554 al., 2003). Evidence suggests that the use of a graduated system of sanctions, observed in some ECs, is  
555 effective in preventing free-riding from members (Polman and Slangen, 2002; Eshuis and van  
556 Woerkum, 2003; Termeer et al., 2013; Westerink et al., 2017). In the Ferti-Mieux case, the evaluation  
557 of farmers' practices was realized by the local technical committee and then validated at the national  
558 level. Evaluation was based on direct visits and checks of a representative sample of individual farms  
559 (Verron, 2007). The risk of non-renewability of the Ferti-Mieux label was real: 12% of the operations  
560 lost their label between 1991 and 2001 (Ramonet, 2003).

561 Finally, government policies can help lower the transaction costs associated with collective action  
562 (Lubell et al., 2002; OECD, 2013; Villamayor-Tomas et al., 2019). The Dutch Ministry of Agriculture  
563 supported the development of Environmental Cooperatives through grants to cover start-up costs  
564 (Glasbergen, 2000; Franks, 2008; 2010), by approving exemptions from general regulations and  
565 adjusting the national agri-environmental program to include an option of joint applications from EC  
566 members (Wiskerke et al., 2003; Franks and Mc Gloin, 2007a; 2007b; Franks, 2010; Westerink et al.,  
567 2015). **External support from public agencies (S4.1.3)** also included the provision of expert  
568 knowledge and administrative support as well as research funding (Glasbergen, 2000; Franks, 2010;  
569 Termeer et al., 2013). Termeer et al. (2013) note that the fragmentation of public organizations in the  
570 Netherlands could have acted as a constraint for collectives seeking access to various resources. In the  
571 French context, public funding compensated the extra-costs of coordination and follow up of the  
572 "Ferti-Mieux" operations (Verron, 2007). Public support also took the form of providing rules for  
573 framing collective action among farmers and the labeling of operations (Kockmann et al., 2003). It  
574 seems that such support was crucial to the emergence and durability of local collective actions. After  
575 the official stop of the policy at the national level, most operations collapsed, except in the Rhin-  
576 Meuse water basin area where the Water Agency decided to maintain a similar program at the water  
577 basin level (Bernard, 2004).

## 578 **5. Discussion and conclusions**

579 The analysis shows that collective action is a relevant tool to consider for improving the effectiveness  
580 and cost-effectiveness of regulatory and incentive policies targeting diffuse pollution from agriculture.  
581 Self-organization by farmers for reaching regulatory objectives will be associated with lower design  
582 and enforcement costs for public agencies. A greater participation of farmers in the definition of  
583 measures that they must implement is also likely to increase their compliance and thus foster the  
584 realization of water quality objectives. Collective action for joint applications to agri-environmental  
585 schemes allows for transaction cost savings both for farmers and for public agencies compared to  
586 individual schemes. Cooperation will also improve environmental outcomes, as water quality  
587 improvements require action at a larger scale than at the individual farm level.

588 However, as stressed by scholars in the field of institutional economics (Ostrom and Cox, 2010;  
589 Ménard, 2011), no single policy approach or instrument is likely to solve complex environmental  
590 problems in all settings. The results suggest that the success of collective action involving farmers  
591 depends on a number of conditions related to the characteristics of the resource, the actors involved,  
592 the governance of cooperation and the broader economic and political contexts (Table 3).

593 The size of the water system targeted, in conjunction with the number of potential participants and  
594 their degree of heterogeneity, was found to affect the likelihood of successful collective action, with a

595 collective management of larger basins or catchments involving greater transaction costs. The less  
596 predictable are the hydrogeological system dynamics, the higher are the management costs.

597 The level of management costs also depends on the knowledge available to participants regarding the  
598 impact of farming practices on water quality. Among the characteristics of actors involved, the type of  
599 farming system and the preferences of farmers were found to potentially influence the private benefits  
600 drawn from collective action. Farmers incurring fewer costs in changing their practices and/or having  
601 strong preferences for environmental preservation will be more likely to participate in collective  
602 action. The results suggest that a larger number of farmers together with a greater diversity in  
603 preferences and farming systems increase the costs of collective action. However, the participation of  
604 non-farmers in collective action was identified as a positive factor for pooling the resources needed for  
605 cooperation. The presence of a leader or the existence of trust and social capital within the group of  
606 participants were shown to decrease transaction costs.

607 Characteristics of the governance system are identified as a crucial factor for the success of collective  
608 action within the SES framework. Especially, the presence of a control and sanction system was found  
609 to be important in limiting free-riding from participants in the two cases (Environmental Cooperatives  
610 and “Ferti-Mieux” operations). The analysis also highlights the positive effect of an autonomous  
611 design of rules by the participants.

612 Most factors highlighted by Ostrom (2009) as crucial for self-organization by users of a common-pool  
613 resource were also identified in the case of collective action for water pollution control (Table 3). Two  
614 variables were not found relevant for the analysis of collective action for diffuse pollution control: the  
615 productivity of the resource system and the resource unit mobility, in relation to the non-subtractive  
616 character of water quality (Hinkel et al., 2015). Further, the nature of market incentives, the political  
617 context and the existence of government support were identified as strongly determining the  
618 emergence and sustainability of agri-environmental cooperation. The importance of these conditions  
619 can be related to the public good nature of diffuse pollution control by farmers. In the presence of few  
620 direct economic incentives, the success of collective action will substantially depend on external  
621 economic and political incentives.

622 From a policy perspective, the findings of this paper may serve as a basis for assessing whether  
623 conditions are gathered for collective action to be an effective and cost-effective tool for diffuse  
624 pollution control. When applied to a specific setting, such a diagnostic may inform policy choices  
625 regarding the adoption of a collective approach and/or the design of measures addressing the  
626 constraints identified as bearing on collective action.

627 Combining transaction cost economics with the SES framework proved useful to assess the potential  
628 of hybrid policy instruments relying on collective action for water quality management in agriculture.  
629 The results presented here were drawn from existing case studies mostly using different conceptual  
630 approaches to address this issue. Further investigation is needed, including direct empirical data  
631 collection to test the assumptions made on the factors identified as affecting cooperation for water  
632 pollution control.



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## Appendix 1: Second-tier variables of a social-ecological system (McGinnis and Ostrom, 2014)

First-tier variables	Second-tier variables
Social, economic and political settings (S)	S1 – Economic development S2 – Demographic trends S3 – Political stability S4 – Other governance systems S5 – Markets S6 – Media organizations S7 – Technology
Resource systems (S)	RS1 – Sector (e.g., water, forests, pasture, fish) RS2 – Clarity of system boundaries RS3 – Size of resource system RS4 – Human-constructed facilities RS5 – Productivity of system RS6 – Equilibrium properties RS7 – Predictability of system dynamics RS8 – Storage characteristics RS9 – Location
Governance systems (GS)	GS1 – Government organizations GS2 – Nongovernment organizations GS3 – Network structure GS4 – Property-rights systems GS5 – Operational-choice rules GS6 – Collective-choice rules GS7 – Constitutional-choice rules GS8 – Monitoring and sanctioning rules
Resource units (RU)	RU1 – Resource unit mobility RU2 – Growth or replacement rate RU3 – Interaction among resource units RU4 – Economic value RU5 – Number of units RU6 – Distinctive characteristics RU7 – Spatial and temporal distribution
Actors (A)	A1 – Number of relevant actors A2 – Socioeconomic attributes A3 – History or past experiences A4 – Location A5 – Leadership-entrepreneurship A6 – Norms (trust-reciprocity)/social capital A7 – Knowledge of SES A8 – Importance of the resource (dependence) A9 – Technologies available
Action situation: Interactions (I) - Outcomes (O)	I1 – Harvesting I2 – Information sharing I3 – Deliberation processes I4 – Conflicts I5 – Investment activities I6 – Lobbying activities I7 – Self-organizing activities I8 – Networking activities I9 – Monitoring activities I10 – Evaluative activities O1 – Social performance measures (e.g., efficiency, equity, accountability, sustainability) O2 – Ecological performance measures (e.g., overharvested, resilience, biodiversity, sustainability) O3 – Externalities to other SESs
Related ecosystems (ECO)	ECO1 – Climate patterns ECO2 – Pollution patterns ECO3 – Flows into and out of focal SES



## Appendix 2. The factors identified as affecting the costs and benefits of hybrid policy instruments

Table 2.1: The characteristics of the social, economic and political settings

First-tier variable	Second-tier variables	References	
		Environmental cooperatives	Ferti-Mieux operations
Social, economic and political settings (S)	S4 – Other governance systems		
	<i>S4.1 – Larger scale governance systems</i>		
	S4.1.1 – Regulatory threat	Glasbergen, 2000; Renting and van der Ploeg, 2001; Wiskerke et al., 2003; Stobbelaar et al., 2009; Franks, 2010	Bernard, 2004; AE RMC, 2007b
	S4.1.2 – Political representation of agricultural interests	Franks and McGloin, 2007a; 2007b; Daniel and Perraud, 2009; Franks, 2008; 2010	Sebillotte, 2003
	S4.1.3 – Support from public agencies	Glasbergen, 2000; Wiskerke et al., 2003; Franks and McGloin, 2007a; 2007b; Franks, 2008; Franks, 2010; Termeer et al., 2013; Westerink et al., 2015	Kockmann et al., 2003; Bernard, 2004; Verron, 2007
S5 – Markets	Renting and van der Ploeg, 2001; Termeer et al., 2013	Busca, 2002; 2004; Verron, 2007	

Table 2.2: The characteristics of the resource

First-tier variable	Second-tier variables	References	
		Environmental cooperatives	Ferti-Mieux operations
Resource system (RS)	RS3 – Size of resource system		
	<i>RS3.1 – Size of the water catchment</i>		Kockmann et al., 2003
	RS7 – Predictability of system dynamics		Bernard, 2004; AE RMC, 2007b

Table 2.3: The characteristics of actors

First-tier variable	Second-tier variables	References	
		Environmental cooperatives	Ferti-Mieux operations
Actors (A)	A1 – Number of relevant actors	Westerink et al., 2017	Kockmann et al., 2003; Verron, 2007
	A2 – Socioeconomic attributes		
	<i>A2.1 – Type of farming systems</i>	Groot et al., 2006	AE RMC, 2007b
	<i>A2.2 – Heterogeneity of participants</i>	Franks and McGloin, 2007a; Franks, 2008; Uetake, 2014	
	A5 – Leadership-entrepreneurship	Franks, 2008; 2010; 2011; Termeer et al., 2013	Kockmann et al., 2003; AE RMC, 2007a; 2007b; Verron, 2007
	A6 – Norms (trust-reciprocity)/social capital	Polman and Slangen, 2002; Eshuis and van Woerkum, 2003	Kockmann et al., 2003
	A7 – Knowledge of SES	Stuiver et al., 2003; Eshuis and Stuiver, 2005; Van Der Ploeg et al., 2006	Kockmann et al., 2003; Bernard, 2004; AE RMC, 2007a; 2007b ; Verron, 2007
	A8 – Importance of the resource		
	<i>A8.1 – Environmental preferences of farmers</i>	Stobbelaar et al., 2009; van Dijk et al., 2015	Sebillotte, 2003

Table 2.4: The characteristics of the governance system

First-tier variable	Second-tier variables	Environmental cooperatives	Ferti-Mieux operations
Governance system (GS)	GS6 – Collective-choice rules		
	<i>GS6.1 – Autonomy at the collective-choice level</i>	Franks and McGloin, 2007a; Franks, 2008; 2011; Termeer et al., 2013	Kockmann et al., 2003; AE RMC, 2007b
	GS8 – Monitoring and sanctioning rules	Polman and Slangen, 2002; Eshuis and Van Woerkum, 2003; Wiskerke et al., 2003; Termeer et al., 2013; Westerink et al., 2017	Ramonet, 2003; Verron, 2007