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Stakeholder’s practices of urban agriculture sustainability assessment reveal numerous original criteria and indicators

Authors

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Abstract

With the rapid growth of professional intra-urban agriculture (PIUA) projects in the Global North, sponsors, projects leaders and experts developing these projects are seeking to evaluate their sustainability. In the absence of an assessment tool directly applicable to PIUA projects, they establish their own assessment practices. Our study examines these practices to identify their original features, criteria and indicators used. To this end, we analysed 19 case studies of different PIUA projects. We identified four dimensions underpinning sustainability assessment, namely internal sustainability, external sustainability, the project leader’s credibility, and the innovative nature of the project – the latter two dimensions being particularly original compared to the sustainability dimensions usually found in the literature, such as environmental, social and economic dimensions. We also shed light on the wide diversity of the 67 assessment criteria identified, as well as the qualitative nature of 78% of indicators used. Our study also highlights that assessment practices evolve over time as the project progresses from ideation to implementation, according to the variety of assessment situations. Our study is the first to provide an in-depth exploration of PIUA actors’ sustainability assessment practices and to shed light on their original features. Our results afford a better understanding of the way the sustainability of PIUA projects is assessed, and contribute to reflection on the design of a flexible assessment tool, considering the diverse criteria and practices used by stakeholders to assess the sustainability of PIUA.

Keywords: evaluation, urban farming, innovation, internal sustainability, external sustainability, qualitative indicators, credibility

1. Introduction

Urban agriculture has been growing rapidly in countries of the Global North in recent years, a trend illustrated by the emergence of different types of projects with diverse purposes pertaining to the sustainability of cities. A recent study counted 417 projects in countries of the Global North (North America, Japan, Australia and Europe), with 24 of those being in France (Orsini et al., 2020). Among

34 them, professional intra-urban agriculture (PIUA) projects, which include multi-activity micro-farms,
35 greenhouses and indoor systems in urban areas, encompass a range of initiatives. It involves soil-based
36 agriculture, hydroponics, raised beds farming, and rooftop farming, with both outdoor and indoor
37 farming activity. These projects can pursue productive, environmental, social or educational
38 objectives, and sometimes combine several growing techniques and several objectives (Clerino and
39 Fargue-Lelièvre, 2020). Thus, some projects focus on a productive objective while others combine
40 productive and educational, or cultural and social objectives, as illustrated in Figure 1.



Photos P.Clerino

41 *Figure 1: The diversity of professional intra-urban agriculture projects in France: (a) Production-*
42 *oriented rooftop farm in Paris, using aeroponic systems; (b) Soil-based farm with a cultural and*
43 *social focus in Saint-Denis; (c) Raised beds farming with a productive and educational focus on a*
44 *rooftop in Saint-Denis.*

45 A range of sponsors support the development of these projects by providing land or funding to project
46 leaders, to develop their PIUA project, while experts advise sponsors and project leaders on projects'
47 development or selection. These actors vary as they might be public, private, or civil society
48 organizations. Sponsors include local authorities, social landlords, urban planners, banks, and
49 foundations. The project leaders may be urban farmers, civil-society organizations, specialized
50 consulting firms, real estate developers, local authorities, or architects. The experts include research
51 organizations, consulting firms, and public institutions such as the Chambers of Agriculture. Some
52 sponsors can also be project leaders, and project leaders may in some cases be called upon as experts.
53 Project leaders, sponsors and experts are concerned with assessing ex-ante the sustainability of the
54 PIUA projects, to guide projects' elaboration, identify their strengths and weaknesses or to compare
55 project proposals and select the winner of a call for proposals.

56 Several assessment tools or frameworks have been developed to assess projects' sustainability. Some
57 assessment methods are designed to measure impacts in an ex-post situation, once the project has
58 already been implemented or even completed. This is the case of the OECD method (OECD, 2019),
59 which proposes assessment criteria such as effectiveness and efficiency, estimated based on the
60 achievement of objectives. Such criteria cannot be used ex-ante, at the proposal stage of a project, as
61 they rely on field measurements and observations unavailable before project implementation. Also, the

62 ability to reach objectives set upstream depends not only on the resources allocated to the project
63 which are known at the proposal stage, but also on external factors that are difficult to predict (Samset
64 and Christensen, 2017), such as involvement of inhabitants in the case of PIUA. The assessment
65 methods proposed for agricultural development projects (Delarue and Cochet, 2013; World Bank,
66 2006) are also only suitable for ex-post use: these methods compare the impacts of projects to the
67 scenario that would have prevailed without them, and are difficult to apply ex-ante as they rely on
68 indicators measured when the project is implemented.

69 Other assessment tools are designed to evaluate ex-ante project proposals. However, many of them are
70 specifically designed for industries and investment in new technologies (Bhatnagar and Jancy, 2003;
71 Poteralska, 2017), which do not concern the majority of PIUA projects. They tend to focus on
72 economic criteria, with little consideration for the social and educational dimensions which are
73 important for many PIUA projects. Some decision-making methods can be used in agriculture, but are
74 applied at the plot scale rather than farm level, such as the MASC method (Sadok et al., 2009).

75 Some multi-criteria assessment methods are designed to assess the sustainability of farms, but the
76 literature has pointed out that these tools are unsuitable for multifunctional farms, as they focus on
77 agricultural activities and production, and fail to take into account non-agricultural activities (Barbier
78 and Lopez-Ridaura, 2010), whereas PIUA projects include educational and social activities that are not
79 strictly productive (Orsini et al., 2020). Also, they include criteria that are not applicable ex-ante such
80 as soil cover index (Migliorini et al., 2018), pesticide use (Meul et al., 2008), or phosphorus and
81 potassium use (Roesch et al., 2017).

82 Some assessment methods have been designed specifically for urban agriculture, but mainly focus on
83 evaluating the environmental impacts of urban agriculture or the ecosystem services provided (Dorr et
84 al., 2021; Langemeyer et al., 2015; Lin et al., 2015; Petit-Boix and Apul, 2018; Wang and Pryor,
85 2019), without considering social and economic aspects. Studies on the assessment of all dimensions
86 of sustainability focus on evaluating benefits (Altman et al., 2014; Mackenzie and Davies, 2019;
87 Teitel-Payne et al., 2016) and on a farm's contribution to urban sustainability (Tapia et al., 2021), but
88 not the sustainability of the farm itself, when the internal sustainability of PIUA projects is an
89 important assessment topic for sponsors and project leaders (Clerino and Fargue-Lelièvre, 2020).

90 Since the overall sustainability of PIUA projects cannot be assessed using established tools or
91 methods, the actors implement their own practices to do so. Several studies have shown that grassroots
92 actors are a source of innovation by building new knowledge and practices (Dolinska and d'Aquino,
93 2016; Leitgeb et al., 2011; Tambo and Wuenscher, 2017), that can be disseminated and benefit to
94 other stakeholders (Gupta et al., 2019; Salembier et al., 2021; Wu and Zhang, 2013). We thus posit
95 that PIUA stakeholders have developed innovative practices to assess the sustainability of their
96 projects. Sanyé-Mengual et al. (2018), studying the conceptualization of sustainability from the

97 stakeholders' perspective, identified sustainability elements belonging to the three classic
 98 sustainability dimensions (environmental, social and economic). Nevertheless, they did not explore the
 99 details of the assessment practices, criteria or indicators used. Our study aims to investigate the
 100 stakeholders' assessment practices, to identify their original features concerning sustainability
 101 assessment of PIUA. We first focus on the sustainability dimensions considered, with a special interest
 102 for those that differ from the classic triptych "environmental, social and economic dimensions". Then
 103 we study the nature of criteria and indicators used, and the way stakeholders use them.

104 2. Material and method

105 To explore stakeholders' practices regarding the sustainability assessment of PIUA projects, we
 106 performed a "diagnosis of uses" (Cerf et al., 2012). A diagnosis of uses is an approach designed by
 107 ergonomists and agronomists, aiming at identifying issues faced by stakeholders when they implement
 108 a specific activity and the way they use diverse tools to cope with these issues. It is then a preliminary
 109 stage of the design of a new and more efficient tool. The diagnosis of uses relies on data collection
 110 from various potential users of the new tool. In our case, the diagnosis of uses applies to the
 111 sustainability assessment of PIUA projects: it aims at highlighting the diversity of criteria and
 112 indicators used by different stakeholders, in order to enrich the design of an assessment tool adapted to
 113 the diversity of stakeholders' working situations. This diagnosis covered 19 case studies in which
 114 PIUA projects were evaluated. Some case studies (12 among 19) deal with a single project which has
 115 been evaluated by sponsors when they decided to finance it, or when project leaders were elaborating
 116 the project proposal. In other case studies (7 among 19), sponsors and experts assess sustainability of
 117 several projects, when calls for proposals cover different projects' sites. Among the 19 case studies,
 118 three cover the whole French territory, thirteen the Ile-de-France region, where most of the French
 119 PIUA projects are implemented, one the Pays de la Loire region, one the Haut-de-France region and
 120 one the Centre-Val de Loire region. Case studies were analysed based on semi-structured interviews,
 121 desktop review of official documents relating to selection processes and internal analysis framework
 122 of projects. The details of the 19 case studies are presented in Table 1.

123 *Table 1 : Description of the 19 case studies, according to whether it concerns one or several projects,*
 124 *the location of the crops, the cultivation techniques, the projects' selection process and the source of*
 125 *data*

| ID | Single or multiple projects | Crops location | Cultivation techniques | Projects selection process | Source of data | |
|-----|-----------------------------|---------------------------|------------------------|---------------------------------|--|---------------------|
| | | | | | Interviews | Documents analysis |
| CS1 | Single | Rooftop and ground -based | Raised beds | Calls for applications | Interview 1: sponsor (urban planning company) | Official document 1 |
| CS2 | Multiple | Multiple | Multiple | Call for expression of interest | Interview 2: sponsor (urban planning public agency) Interview 3: expert (consulting firm) | Official document 2 |

| | | | | | | |
|------|----------|---------------------------|-----------------------------|---------------------------------|---|--|
| CS3 | Single | Ground-based | Soil-based | Call for proposals | Interview 4: expert (urban agriculture company) | Official document 3 Internal assessment framework 1 |
| CS4 | Multiple | Multiple | Multiple | Call for proposals | Interview 5: sponsor (public company) | Official document 4 |
| CS5 | Single | Rooftop | Multiple | Call for proposals | Interview 6: sponsor (local authority) | Official document 5 |
| CS6 | Single | Indoor | Raised beds | Closed competition | Interview 7: sponsor (local authority) Interview 8: project leader (architectural firm) | Official document 6 Internal assessment framework 2 |
| CS7 | Single | Rooftop | Raised beds | Mutual agreement | Interview 9: project leader (civil society organization) | / |
| CS8 | Multiple | Multiple | Multiple | Funding request | Interview 10: sponsor (public bank) | Official document 7 |
| CS9 | Multiple | Multiple | Multiple | Funding request | Interview 11: sponsor (private foundation) | / |
| CS10 | Single | Ground-based | Soil-based | Calls for applications | Interview 12: sponsor (local authority) | Official document 8 |
| CS11 | Single | Indoor | Hydroponics | Mutual agreement | Interview 13: sponsor (food retailer private company) | / |
| CS12 | Single | Rooftop and ground -based | Soil-based and raised beds | Call for proposals | Interview 14: expert (urban agriculture company) Interview 15: project leader (architectural firm) | Official document 9 |
| CS13 | Single | Rooftop and ground -based | Hydroponics and raised beds | Calls for applications | Interview 14: expert (urban agriculture company) Interview 16: sponsor (local authority) Interview 17: sponsor (social housing services) | / |
| CS14 | Single | Indoor | Raised beds | Call for proposals | Interview 6: sponsor (local authority) Interview 18: sponsor (social housing services) Interview 19: expert (public institution) | Official document 10 |
| CS15 | Multiple | Multiple | Multiple | Call for proposals | Interview 6: sponsor (local authority) Interview 19: expert (public institution) | Official document 10 |
| CS16 | Multiple | Multiple | Multiple | Call for expression of interest | Interview 20: sponsor (local authority) | Official document 11 |
| CS17 | Single | Ground-based | Soil-based and raised beds | Call for proposals | Interview 21: project leader (urban agriculture company) | / |
| CS18 | Single | Ground-based | Raised beds | Call for expression of interest | Interview 2: sponsor (urban planning public agency) Interview 3: expert (consulting firm) Interview 22: project leader (property developer) | Official document 2 |
| CS19 | Multiple | Multiple | Multiple | Call for proposals | / | Official document 9 |

126

127

128 In order to capture the diversity of assessment practices, the sample of case studies was selected to
129 represent:

- 130 - The **range of actors** involved in PIUA projects. The sponsors providing land and funding for
131 these projects may be public or private. We interviewed local authorities, a public company, a
132 public bank, urban planners, a private foundation, a food retailer, and social housing services.
133 The project leaders also vary. We interviewed a property developer, a civil society
134 organization, an urban agriculture company, and architectural firms. Finally, we met different
135 experts mobilized by the sponsors for their expertise: consulting firms, companies specialized
136 in urban agriculture, and a public regional authority for food and agriculture.
- 137 - The **diversity of PIUA projects**. PIUA projects vary depending on their location and their
138 cropping system. Of the 19 cases studied, the location of the crops was known at the time of
139 the assessment in 12 cases: two of the cases provided for rooftop cultivation, four for ground-
140 based crops, three for both rooftop and ground based crops, and three for indoor farming. The
141 cropping systems were unknown at the time of the project assessment in 8 cases, soil-based in
142 two cases, raised beds in five cases, hydroponics in one case, and combined different
143 cultivation supports in three cases.
- 144 - The **diversity of project selection processes**: sponsors can adopt a variety of processes to
145 select a PIUA project. Of the 19 cases we studied, three used calls for expression of interest,
146 three used calls for applications, eight used calls for proposals, two used mutual agreement
147 processes, and two used requests for funding. Finally, one of the processes involved a closed
148 competition. The different processes entail different levels of expectation from sponsors
149 regarding the project proposals submitted by project leaders. With calls for expression of
150 interest, applicants are free to propose a wide range of PIUA projects; the project proposal
151 does not necessarily have to be a final version. Calls for applications are geared towards
152 selecting a project to develop a particular space; here again, a wide range of PIUA projects are
153 possible. Calls for projects generally target more precise needs than calls for expression of
154 interest and calls for applications: the project proposal must fit a specified framework. Closed
155 competition allows public actors to select PIUA projects based on expectations that are very
156 well defined upstream. All these processes involve competitive project proposal bidding. Two
157 processes allow for selection without competition: mutual agreement processes, where the
158 sponsor and the project leader agree on the PIUA project together, and requests for funding,
159 where the project leader submits a project to a sponsor, who decides to support it or not,
160 without comparing it to other project proposals.

161 We studied the 19 cases by analysing three types of data:

- 162 - **Semi-structured interviews** with a range of sponsors, experts and PIUA project leaders. A
163 total of 22 interviews were conducted. Some interviews covered different case studies, when a
164 sponsor, expert or project leader was involved in different case studies. For 18 of the 19 cases
165 studies, at least one interview was held: one interview for 11 of the cases, two interviews for
166 four of the cases, and three interviews in three cases, when a diversity of stakeholders was
167 involved. Interviews were held during a live meeting or through telephone for two of them.
168 During the interviews, questions were asked about the history of the PIUA projects, their
169 objectives and characteristics, the stakeholders involved in the selection processes, how the
170 project proposals were evaluated, by who and based on which criteria or indicators. All
171 interviews were recorded and summarized.
- 172 - **Official documents relating to selection processes:** these are specifications and regulations
173 for selection procedures that are published and publicly available. We studied a total of 11
174 official documents, which provided data for 14 of the 19 case studies. Some documents gave
175 information for two case studies related to the same call for proposals. We extracted from
176 these documents information about the project's objectives, some of their characteristics, but
177 also about the selection processes, how they were put in place, the stakeholders involved and
178 some of the criteria and indicators used to assess project proposals and select awardees.
- 179 - **Project proposal analysis frameworks** supporting the selection of winning proposals as part
180 of calls for projects, when they could be retrieved. We were able to access two analytical
181 frameworks, which provided information on two of the 19 cases studies. These frameworks,
182 which do not always exist, are confidential and difficult to access. They reflect the internal
183 discussions of a selection committee and are generally not shared outside this committee. We
184 extracted, from these documents, criteria and indicators used to compare project proposals
185 during selection processes.

186 Based on the interviews and documents desk review, we systematically recorded in an Excel database
187 every item that allowed the assessment of PIUA projects for each case study. We classified these items
188 as themes, sub-themes, criteria or indicators underpinning the assessment of PIUA projects:

- 189 - **Themes and sub-themes** encompass several criteria, such as *Contribution to global*
190 *sustainability* and *Contribution to access to quality local food*;
- 191 - **Criteria** are variables that make up sustainability and serve as a basis for formulating
192 assessments (Lairez et al., 2015), such as *Local consumption of products*, and can comprise
193 several indicators;
- 194 - **Indicators** are quantitative or qualitative variables used to estimate criteria (Lairez et al.,
195 2015), such as *Share of the production sold locally* or *Local sale of the production*

196 Then we organized the theme, criteria and indicators recorded. Among the themes and criteria, some
 197 were identical or close. For instance, we recorded from two different documents the following draft
 198 criteria: *Significant skills of the project leader* and *Project matching with the skills of the candidate*. In
 199 this case, we considered that the two draft criteria were similar and merged them under the final
 200 criterion *Relevant skills of the project leader*. Where criteria did not fit any of the recorded themes, an
 201 overarching theme was formulated. For instance, for the criteria *Preservation of old buildings*, *Use of*
 202 *age-old agricultural know-how* and *Perpetuation of the agricultural use of the land*, a theme
 203 *Contribution to heritage preservation* was formulated. Likewise, where indicators recorded could not
 204 be grouped under a recorded criterion, an umbrella criterion was formulated. After the classification of
 205 the items recorded, we obtained 10 different themes, 67 final criteria and 138 indicators.

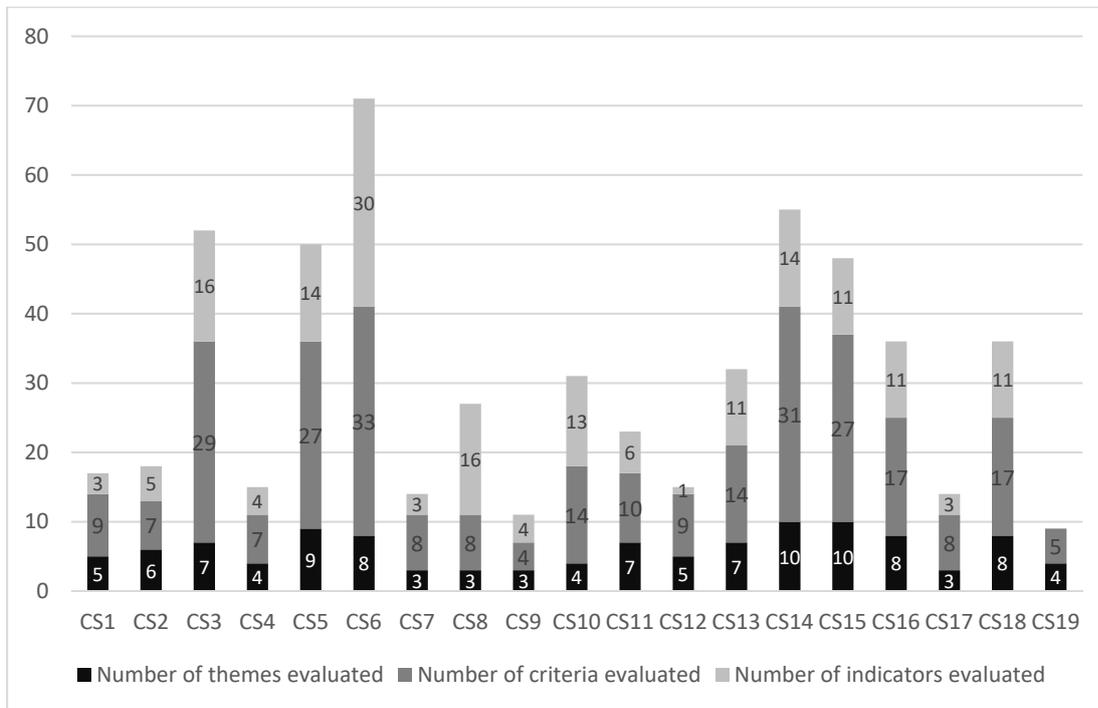
206 We analysed the diversity of the different themes, criteria and indicators used; but also, their frequency
 207 of use (occurrences) among the 19 case studies, knowing that different case studies may use the same
 208 criteria or indicators.

209 A statistical analysis based on a Hierarchical Clustering (HC) was also carried out to categorize the
 210 case studies according to the number of themes, criteria and indicators they applied. The HC was
 211 performed using XLSTAT software.

212

213 **3. Results and discussion**

214 **3.1. Diversity of assessment structure among case studies**



215

216 *Figure 2 : Number of different themes, criteria and indicators used by each case study (CS)*

217 We observed a wide disparity in the number of themes, criteria and indicators used per case study as
218 presented in Figure 2. Some case studies assess a small amount of sustainability themes (with a
219 minimum of three themes assessed for CS7, CS8, CS9 and CS17), whereas CS14 and CS15 consider
220 up to 10 sustainability themes. An average of 15 criteria were used per case, with a minimum of 4
221 criteria for CS9 and a maximum of 33 for CS6. While some projects were evaluated based on a very
222 small number of themes and criteria, others were analysed in great depth, suggesting that the
223 evaluators' expectations can vary widely. At last, for some case studies, we identified a large number
224 of indicators (with a maximum of 30 for CS6) whereas no indicators were identified for CS19,
225 suggesting that indicators may be implicit or confidential.

226 For instance for CS7 corresponding to a farm implemented by a local association in a school,
227 sustainability assessment was based on 1) the theme *Coherence and technical robustness* assessed by
228 criteria *Respect and personal fulfilment of employees* and *Sustainability of contracts for the staff*; 2)
229 the theme *Contribution to local sustainability* assessed by criteria *Fostering of neighbourhood life*,
230 *Suitable activities proposed on the farm for vulnerable populations* and *Job creation*; and 3) the theme
231 *Contribution to global sustainability* assessed by criteria *Preservation of biodiversity*, *Hosting of*
232 *school groups* and *Organization of workshops*. Three indicators were identified for CS7: *Creation of*
233 *jobs with permanent contracts* (used to estimate two different criteria: *Sustainability of contracts for*
234 *the staff* and *Job creation*), *Hosting of pupils during school time, after school and during vacations*
235 (used to assess the criteria *Hosting of school groups*) and *Conducting workshops on nature with a*
236 *science teacher* (used to assess the criteria *Organization of workshops*).

237 **3.2. Original features of the sustainability dimensions and themes for PIUA projects**

238 We identified 10 different themes of sustainability, and gathered those under four dimensions of
239 sustainability (Figure 3).



240

241 *Figure 3: Occurrences of criteria used by the 19 case studies according to their related sustainability*
 242 *dimension (in black) and sustainability theme (in grey). The number of occurrences for each*
 243 *dimension equals the sum of occurrences of the themes below.*

244 **3.2.1. Nature of the sustainability dimensions and themes assessed by stakeholders**

245 The first dimension encompasses themes pertaining to the external sustainability of a project. This
 246 concept of external sustainability applied to urban agriculture was defined by Aubry et al. (2012),
 247 based upon the territorial sustainability of agriculture, that refers to the contribution of agriculture to
 248 the sustainable development of its territory. In an urban context, external sustainability is linked to the
 249 multifunctionality of PIUA and gathers the services provided by PIUA projects to the city. In our
 250 study, external sustainability relies on themes such as (i) project's contribution to sustainability at a
 251 local level (city, neighbourhood), (ii) at a global scale (issues relevant at the country or world scale,
 252 such as biodiversity or heritage preservation), and (ii) project's contribution to the sponsor's
 253 sustainability (positive contribution to its image or to its economic added value for instance).

254 The second dimension comprises themes and criteria relating to the internal sustainability of a project.
 255 In agriculture, internal sustainability can be defined as the internal goals that a farmer wants to achieve
 256 (Zahm et al., 2018). In an urban context, internal sustainability relies on different themes such as the
 257 project's technical coherence, its economic robustness, and the management of regulatory aspects
 258 (respecting the regulations in force, knowledge of the necessary authorizations).

259 The third dimension of sustainability relates to themes and criteria used for assessing the innovative
 260 nature of a project. New issues are emerging around urban agriculture, such as limited and non-
 261 traditional access to land (i.e. rooftop or underground farms, precarious lease), use of urban soils and

262 alternative growing media (i.e. soil pollution management, use of coffee ground as substrate), the
263 specific legal and political environment, the functions which are not strictly productive or the
264 involvement of non-traditional farmers (Pfeiffer et al., 2015). All these distinct features encourage the
265 development of innovative practices, particularly important to adapt to specific urban challenges
266 (Schans et al., 2014). Innovative projects are thus ones that offer levers to overcome these challenges
267 and ensure their sustainability, but novelties applied in urban agriculture also enhance the social,
268 ecological and economic impacts of practicing agriculture within urban areas, holding the potential to
269 contribute to sustainability (Opitz et al., 2016b). To evaluate the innovative nature of a project, our
270 results suggested to rely on two elements: 1) project's originality, whether the project involves an
271 innovation, by introducing new concepts (such as new technology or new form of organization); or by
272 representing a novelty when a similar project has not been seen before ; 2) project's participation in
273 the evolution of knowledge, by generating new knowledge through experimentation, or by
274 disseminating new knowledge through workshops, trainings. This configuration echoes the CK design
275 theory (Hatchuel and Weil, 2009) that consider innovative design as an expansion of both concepts
276 and knowledge.

277 The fourth and final dimension of sustainability encompasses themes and criteria for assessing the
278 credibility of a project leader, i.e. evaluating the robustness of the project's governance and the
279 adequacy of the project leader and partners' profiles (references, training and motivations). These
280 criteria serve to ascertain whether the project leader is able to ensure the implementation of the project
281 and the achievement of its objectives (set in the project proposal). Such criteria are considered as
282 particularly relevant by stakeholders interviewed, as many project leaders do not come from the
283 farming world, and a lack of training in agriculture is perceived as a risk for the sustainability of
284 projects, as described by Sanyé-Mengual et al., 2018.

285 ***3.2.2. Frequency of assessment of the sustainability dimensions***

286 Figure 3 highlights that most criteria used by the 19 case studies refer to external and internal
287 sustainability (229 occurrences of criteria assessing external and internal sustainability). Case studies
288 use more criteria associated with external sustainability than with internal sustainability (141
289 occurrences for criteria assessing external sustainability versus 88 occurrences for criteria assessing
290 internal sustainability), pointing that in PIUA projects considerable attention is paid to the project's
291 contribution to sustainability at broader levels, and especially at local level, on the scale of the
292 neighbourhood, city or region in which the farm is based.

293 The criteria pertaining to the credibility of the project leader or the innovative nature of the project are
294 less used than the ones related to internal and external sustainability (28 occurrences for criteria related
295 to the credibility of the project leader and 27 occurrences for criteria related to the innovative nature of
296 the project) but are far from anecdotal in the assessment of PIUA project sustainability. Few previous

297 studies attest to interest in integrating innovation : one study highlights that innovation is an important
 298 dimension for defining sustainable urban agriculture (Sanyé-Mengual et al., 2019), and the IDEA tool
 299 displays a sustainability objective based on the production and sharing of knowledge to assess
 300 sustainability of rural farms (Zahm et al., 2018). However none of them include the credibility of the
 301 project leader, whereas Chopin et al., (2021) stressed that governance aspects and the characteristics of
 302 the project leader ought to be included in the sustainability analysis of farming projects.

303 **3.3. Diversity of criteria for evaluating the sustainability of PIUA projects**

304 The four dimensions of sustainability are organized into themes covering 67 different criteria. Some
 305 themes are divided in sub-themes to ease the reading, within the external and internal sustainability
 306 dimensions. As presented in Table 2, we analysed the nature of the 67 different criteria and observed
 307 the occurrence of each criterion among the 19 case studies to highlight which criteria are mostly used
 308 by PIUA stakeholders.

309 *Table 2: Criteria organized per dimensions and themes, and their occurrence among the 19 case*
 310 *studies (a) criteria related to external sustainability, (b) criteria related to internal sustainability, (c)*
 311 *criteria related to the innovative nature of the project, (d) criteria related to the credibility of the*
 312 *project leader*

| EXTERNAL SUSTAINABILITY OF THE PROJECT | | | |
|---|---|---|---|
| Themes | Sub-themes | Criteria | Occurrences of each criterion among case studies (/19) |
| Total = 3 | Total = 11 | Total = 35 | Total = 138 |
| Contribution to local sustainability | Ability to integrate into the neighbourhood | Limitation of disturbances for neighbours | 3 |
| | | Aesthetic quality of the farm | 7 |
| | | Accessibility of the farm | 5 |
| | | Take-up of the project by locals | 6 |
| | Contribution to local development | Connection with local actors | 8 |
| | | Job creation | 6 |
| | | Contribution to the attractiveness of the neighbourhood | 6 |
| | | Improvement of locals' living environment | 7 |
| | Contribution to the inclusion of vulnerable populations | Creation of vocational rehabilitation jobs | 3 |
| | | Accessibility for people with reduced mobility | 1 |
| | | Suitable activities proposed on the farm | 2 |
| | Contribution to access to quality local food | Diversified food production | 5 |
| | | Freshness and nutritional quality of produce | 5 |
| | | Sanitary quality of the produce | 4 |
| | | Complementarity with the rural farms of the area | 4 |
| | | Local consumption of products | 7 |
| Fostering of social ties | Fostering of neighbourhood life | 2 | |
| | Promotion of social diversity | 1 | |
| | | Contribution to stormwater abatement | 4 |

| | | | |
|--|--|--|---|
| | Ability to provide ecosystem services | Contribution to the reduction of the urban heat island effect | 1 |
| Contribution to global sustainability | Contribution to heritage preservation | Preservation of old buildings | 1 |
| | | Use of age-old agricultural know-how | 1 |
| | | Perpetuation of the agricultural use of the land | 1 |
| | Protection of the environment | Limiting soil and water pollution (reduced use of pesticides or nitrogenous fertilization) | 5 |
| | | Preservation of biodiversity | 6 |
| | Practices linked to the circular economy | Monitoring and limiting of resource consumption | 8 |
| | | Recycling and waste recovery | 6 |
| | Participation in environmental and food education | Hosting of school groups | 3 |
| | | Organization of workshops | 5 |
| | Bringing consumers and producers closer together | Visible production process | 1 |
| | | Ability to raise awareness of market gardeners' work | 1 |
| Contact between growers and consumers | | 3 | |
| Contribution to the sustainability of the sponsor | Economic added value for the sponsor | 2 | |
| | Image impact for the sponsor | 2 | |
| | Integration of the project into the sponsor's strategy | 9 | |

313 (a)

| INTERNAL SUSTAINABILITY | | | |
|--|---|---|--|
| Themes | Sub-themes | Criteria | Occurrences of the criterion among case studies (/19) |
| Total = 3 | Total = 6 | Total = 22 | Total = 88 |
| Coherence and technical robustness | Realistic nature of technical proposals | Realistic cropping systems and yields | 7 |
| | | Compliance with architectural requirements | 3 |
| | | Adequate means to expected results | 3 |
| | | Synergies of the different activities developed on the farm | 1 |
| | | Reference to the principles of permaculture | 1 |
| | Ethical staff management | Sustainability of contracts for the staff (permanent contracts rather than internships or short term contracts) | 2 |
| | | Respect and personal fulfilment of employees | 3 |
| | | Limitation of arduous work | 2 |
| | Land risk management | Capacity to move to another location, mobile facilities | 1 |
| | | Land tenure compatible with urban agriculture | 2 |
| | Adaptation to the characteristics of the site | Essential premises planned (storage area, public hosting area, sanitations, etc.) | 4 |
| | | Adaptation of the project to a rooftop location | 1 |
| | | Taking into account necessary works | 2 |
| Consistency and economic robustness | Robustness of the financing plan | Amount of investments compared to financing capacity | 12 |
| | | Amount and distribution of capital | 2 |
| | | Aid and subsidies obtained or expected | 4 |
| | Economic viability | Turnover and expected results | 7 |

| | | |
|---|--|----|
| | Cost control (operating costs, staff wages) | 7 |
| | Diversification of income sources multifunctionality | 6 |
| | Robustness of the marketing plan (identified customers, selling prices, labels) | 11 |
| Management of regulatory aspects | Compliance with urban agriculture regulations | 4 |
| | Management of the appraisal processes and authorizations | 3 |

314 (b)

| INNOVATIVE NATURE OF THE PROJECT | | |
|--|---|--|
| Themes | Criteria | Occurrences of the criterion among case studies (/19) |
| Total = 2 | Total = 5 | Total = 27 |
| Participation in the evolution of knowledge | Ability to generate new knowledge – implementation of an experimental device | 4 |
| | Ability to disseminate new knowledge | 6 |
| | Replicability of the project | 5 |
| Originality of the project | Project involving an innovation | 11 |
| | Novelty of the project | 1 |

315 (c)

| CREDIBILITY OF THE PROJECT LEADER | | |
|---|--|--|
| Themes | Criteria | Occurrences of the criterion among case studies (/19) |
| Total = 2 | Total = 5 | Total = 28 |
| Robustness of the project's governance | Composition of the project leader's team and partners | 4 |
| | Role and responsibilities of the team and partners | 5 |
| Adequacy of the project leader's profile | Quality and consistency of references of the project leader's team and partners | 11 |
| | Relevant skills of the project leader | 6 |
| | Project leaders' motivation | 2 |

316 (d)

317 3.3.1. Nature of the sustainability criteria used by stakeholders

318 The external sustainability dimension is the richest, with 3 themes and 11 sub-themes covering 35
319 different criteria. The internal sustainability dimension comprises 3 themes, 6 sub-themes and 22
320 different criteria, the innovative dimension 2 themes and 5 different criteria, and the dimension of the
321 project leader's credibility also counts 2 themes and 5 different criteria (Table 2).

322 First, we observed that some criteria are similar to the criteria found in existing assessment tools. For
323 instance, the criteria *Monitoring and limiting of resources consumption* and *Preservation of*
324 *biodiversity* are similar to the criteria *Use of inputs* and *Biodiversity* found in MOTIF tool (Meul et al.,
325 2008). The criterion *Limiting soil and water pollution* and the theme *Contribution to heritage*

326 *preservation* are similar to the indicators *Reduce impact on human health and ecosystems* and
327 *Preservation of local heritage* found in IDEA tool (Zahm et al., 2018). Then, criteria related to the
328 consistency and economic robustness such as *Aid and Subsidies obtained or expected* or *Turnover and*
329 *expected results* are also similar to criteria found in IDEA tool.

330 We also note original criteria compared to those generally found in methods for evaluating the
331 sustainability of rural farms (Grenz et al., 2009; Schader et al., 2016; López-Ridaura et al., 2002; Meul
332 et al., 2008; Scialabba et al., 2014).

333 Some criteria assess the risk, for the farm, of being refused by the neighbourhood: *Limitation of*
334 *disturbances for neighbours*, *Aesthetic quality of the farm* and *Take-up of the project by locals*. Indeed,
335 bad smells or noise due to agricultural activities can increase the risk that neighbours reject the project;
336 conversely, involving inhabitants in the farm's activities can decrease this risk. Previous studies
337 identified the risk of the farm being refused by the neighbourhood (Desrousseaux and Stahl, 2014;
338 Specht et al., 2016), but no corresponding criteria was included in existing assessment methods.

339 We identified other criteria specific to the risks linked to an urban location such as *Capacity to move*
340 *to another location*, *Land tenure compatible with urban agriculture* and *Adaptation of the project to a*
341 *rooftop location*. For instance, in CS18, land is provided under a short-time lease before the start of a
342 construction project, so the ability of the farm to move to another location is an important criterion. In
343 the case of a rooftop location like in CS5, specific attention is made to the safety measures put in place
344 or the bearing capacity of the roof. These criteria allow to assess how the project will mitigate the risks
345 related to precarious or unsuitable nature of the land available to set up agricultural activities that were
346 pointed out by Sanyé-Mengual et al., 2018.

347 Conversely, other criteria highlight benefits specific to intra-urban settings, such as a *Contribution to*
348 *the attractiveness of the neighbourhood*, *Improvement of locals' living environment*, or *Fostering of*
349 *neighbourhood life* and the capacity to provide ecosystem services, such as *Contribution to*
350 *stormwater abatement* or *Contribution to the reduction of the urban heat island effect*. Moreover, by
351 avoiding long transportation time and by selling perishable products shortly after harvest, intra-urban
352 agriculture makes fresh fruits and vegetables available to city dwellers, like in CS11 where the
353 production is located within a supermarket. We identified the criterion *Freshness and nutritional*
354 *quality of produce* to assess the benefits of growing food as close to the consumer as possible, benefits
355 that were pointed out in the literature (Opitz et al., 2016a).

356 The integration of the theme *Contribution to the inclusion of vulnerable populations* and the related
357 criteria confirms that intra-urban agriculture is a real support to develop activities with social benefits,
358 that might be integrated to the primary goals of the farm, and not only considered as co-benefits of the
359 production activity. This is the case for instance in CS1 where the farm is co-designed with a local
360 association which provides shelter to homeless people in order to include them in the farm activities.

361 The ecosystem of actors specific to PIUA also justified the addition of original criteria. *Integration of*
362 *the project into the sponsor's strategy* underlines that PIUA projects are also guided by objectives
363 specific to the actors supporting their development. Contributing to the sponsors' strategy can justify
364 why a sponsor allocates resources to the project (subsidies or land), and is also relevant when
365 evaluators need to justify project selection to their hierarchy. *Compliance with urban agriculture*
366 *regulations* is also a criterion linked to the specific nature of PIUA stakeholders. These regulations are
367 most often derived from classical agricultural regulations, with which sponsors and project leaders
368 with few ties to the farming world are sometimes unfamiliar.

369 Our study suggests to consider innovation as a sustainability dimension relying on five criteria related
370 to the evolution of knowledge (*Ability to generate new knowledge*, *Ability to disseminate new*
371 *knowledge*, and *Replicability of the project*), and the originality of the project (*Project involving an*
372 *innovation* and *Novelty of the project*). These criteria are consistent with some criteria proposed by Le
373 Masson et al., (2010) to assess an innovative design process: by evaluating the *Ability to generate new*
374 *knowledge* and the *Ability to disseminate new knowledge*, we assess the Value of knowledge generated
375 by the projects, and by evaluating the *Replicability of the project*, we assess the Robustness of the
376 concepts and knowledge generated. These criteria are particularly important in PIUA as the sector is
377 fairly young. Indeed, PIUA often requires the implementation of new technologies about which very
378 little is known (Orsini et al., 2020; Specht et al., 2013). Consequently, existing projects are actively
379 involved in creating and capitalizing on knowledge on various issues linked to urban agriculture.
380 Some existing tools include a sustainability criterion related to the ability of the farm to adopt a new
381 technology (López-Ridaura et al., 2002), which does not consider social innovation or capacity to
382 create and share knowledge, or a criterion related to the participation in innovation networks (Zahm et
383 al., 2018), which does not consider the originality of a project or its ability to replicate.

384 Finally, we identified the criterion *Complementarity with the rural farms of the area*, which reflects
385 the sponsors' desire to develop spatial and functional complementarities between rural and urban
386 agricultures, such as selling rural farm's products on an urban farm to offer a more diverse range of
387 products to the consumer. This criteria is relevant as there is a need to consider the complementarity of
388 urban and rural agriculture in land-use planning as pointed out by Valente et al., (2014).

389 **3.3.2. Frequency of use of the sustainability criteria by stakeholders**

390 Looking at the occurrences of criteria in Table 2, we can see that the themes mostly assessed among
391 those related to local sustainability are *Connection with local actors* (8 case studies on 19),
392 *Improvement of locals' living environment* (used by 7 case studies on 19), *Aesthetic quality of the farm*
393 (7 case studies on 19), and *Local consumption of products* (7 case studies on 19). The regular use of
394 these criteria emphasizes the links between a farm and its surroundings, highlighting that PIUA takes
395 place on an ultra-local level, on the scale of a city or even a neighbourhood. Regarding the

396 contribution to global sustainability, the most used criteria are *Monitoring and limiting of resource*
397 *consumption* (used by 8 case studies on 19), *Preservation of biodiversity* (6 case studies on 19) and
398 *Recycling and waste recovery* (6 case studies on 19), highlighting that a PIUA project must consider,
399 for numerous stakeholders, environmental issues. The last criterion of the external sustainability
400 dimension which is mostly used is *Integration of the project in the sponsor's strategy*, used by 9 case
401 studies on 19, which confirms that PIUA projects are part of overall strategies, territorial or even
402 national, when they are for instance supported by local authorities or national public stakeholders.

403 For internal sustainability, the most used criteria are *Amount of investments compared to financing*
404 *capacity* (used by 12 case studies on 19) and *Robustness of the marketing plan* (11 case studies on 19).
405 The use of these economic criteria by most of the case studies confirms the importance of economic
406 viability and robustness of the financing plan for PIUA projects, no matter what the crops location or
407 cultivation techniques are as the criterion *Amount of investments and financing capacity* is used among
408 others by CS3 (crops ground-based and cultivation soil-based), CS13 (crops located on rooftop and
409 ground-based, cultivation with hydroponics and raised-beds), and CS14 (crops located indoor,
410 cultivating in raised-beds). The realistic nature of the technical proposals, evaluated by 7 case studies
411 on 19 with the criterion *Realistic cropping systems and yields*, confirms that evaluators wish to
412 anticipate the risks that high investments represent, especially as urban farmers are often not coming
413 from the agricultural sector and might lack agricultural skills.

414 Within the dimension related to the innovative nature of the project, the criterion *Project involving an*
415 *innovation* is used by 11 case studies on 19, confirming the important link between PIUA and
416 innovation, again no matter what the crops location or cultivation techniques are, as the criterion is
417 used when crops are located on rooftops (CS5), indoor (CS6, CS14), or ground-based (CS18) ; and
418 when the cultivation techniques are hydroponics (CS11), soil-based (CS12) or raised beds (CS6,
419 CSS14, CS18) .

420 Within the dimension related to the credibility of the project leader, the most used criterion is *Quality*
421 *and consistency of references of the project leader's team and partners*, used by 11 case studies,
422 which can balance the risk induced by innovation. The project might implement a new cultivation
423 technique or involve a social innovation which represent a risk if few feedbacks of similar projects are
424 available; however relevant and consistent references of the project leader might mitigate this risk.

425 ***3.4. The qualitative nature of the sustainability indicators identified***

426 Our analysis identified 138 different indicators used by at least one of the 19 case studies. Some
427 indicators are used by different case studies (such as *Farm site open to the public*, or *Response to a*
428 *political will*) even most of them are unique and use by only one case study. Some indicators are used
429 by a case study to assess different criteria (such as the indicator *Creation of jobs with permanent*
430 *contracts* used by CS7 to assess both criteria *Sustainability of contracts for the staff* and *Job creation*).

431 Table 3 presents several indicators, their related criteria and their source, selected to exemplify the
 432 diversity of indicators encountered.

433 *Table 3: Overview of the diversity of sustainability indicators identified*

| Indicators | Sustainability criteria estimated by the indicators | Source |
|--|---|--|
| <i>Produce 4-5 tons a year of leafy greens</i> | Realistic crop plan and yields | Interview, CS11: <i>“We have to produce 4-5 tons a year, you can’t make a loss, we have to at least ensure the profitability of the products we replace and if possible make a little extra margin.”</i> |
| <i>Have natural lighting</i> | Limitation of arduous work | Document, CS6: <i>“Visual comfort: the spaces occupied have natural lighting”</i> |
| <i>Implement workshops to test farm’s activities</i> | Take-up of the project by locals | Interview, CS18: <i>“We preferred to test things through workshops [...] with the city’s non-profit organizations [...] to see whether there were any advantages for the inhabitants.”</i> |
| <i>Production and consumption within a 20km radius</i> | Local consumption of produce | Document, CS6: <i>“Fruit and vegetables produced and consumed within a 20km radius”</i> |
| <i>Project leader justifying training in the agricultural field and market gardening in particular</i> | Relevant skills of the project leader | Document, CS3: <i>“Training in the agricultural field and market gardening in particular”</i> |
| <i>Project leader from the private sector</i> | Project involving an innovation | Interview, CS6: <i>“The private sector is more dynamic, it’s the one that creates jobs [...] it would be innovative because there would be the whole aspect of supporting people reintegrating society. Today, most of the time this is handled by non-profits or organizations that are trained to do that”</i> |

434

435 We identified indicators of different nature, quantitative indicators and qualitative indicators: of the
 436 138 indicators, only 31 are quantitative indicators whereas 107 are qualitative. Quantitative indicators
 437 thus account for just 22% of the indicators recorded.

438 Table 4 analyses how qualitative and quantitative indicators are spread between the different
 439 sustainability dimensions and themes, to estimate which kind of indicators are the most used to assess
 440 which theme of sustainability. Note that some indicators are used by different case studies or used by a
 441 same case study to assess different themes or criteria: therefore, the number of occurrences – 184 - is
 442 higher than the number of indicators – 138.

443 *Table 4: Occurrences of indicators used by the 19 case studies according to their related*
 444 *sustainability dimension and theme*

| Dimensions | Themes | Occurrences among all the indicators used | Occurrences among the qualitative indicators used | Occurrences among the quantitative indicators used |
|--|---|--|--|---|
| External sustainability | Contribution to local sustainability | 27 | 25 | 2 |
| | Contribution to global sustainability | 31 | 31 | 0 |
| | Contribution to the sustainability of the sponsor | 10 | 10 | 0 |
| Internal sustainability | Coherence and technical robustness | 28 | 22 | 6 |
| | Consistency and economic robustness | 52 | 27 | 25 |
| | Management of regulatory aspects | 8 | 8 | 0 |
| Innovative nature of the project | Participation in the evolution of knowledge | 7 | 6 | 1 |
| | Originality of the project | 10 | 10 | 0 |
| Credibility of the project leader | Governance robustness | 4 | 4 | 0 |
| | Adequacy of project leaders' profile | 7 | 7 | 0 |
| Total | | 184 | 150 | 34 |

445
 446 Table 4 shows 25 occurrences of the theme *Consistency and economic robustness* among the 34
 447 occurrences of quantitative indicators, underlining that quantitative indicators are mostly used to
 448 assess economic criteria. However, 27 occurrences of qualitative indicators are also recorded to assess
 449 this theme, confirming that qualitative indicators represent an alternative to assess economic criteria,
 450 such as *Diversification of the sources of income* or *Farmer paid as city agent*. In addition, qualitative
 451 indicators are used to assess a wide diversity of theme, unlike quantitative ones, such as *Contribution*
 452 *to global sustainability* (31 occurrences), *Contribution to local sustainability* (25 occurrences), or
 453 *Coherence and technical robustness* (22 occurrences).

454 In practice, PIUA actors thus tend to use more qualitative than quantitative indicators to assess the
 455 sustainability of projects. Qualitative indicators, especially those reported as “present” or “absent”,
 456 informed by “yes” or “no”, and that do not include thresholds, are easier to establish and to articulate.

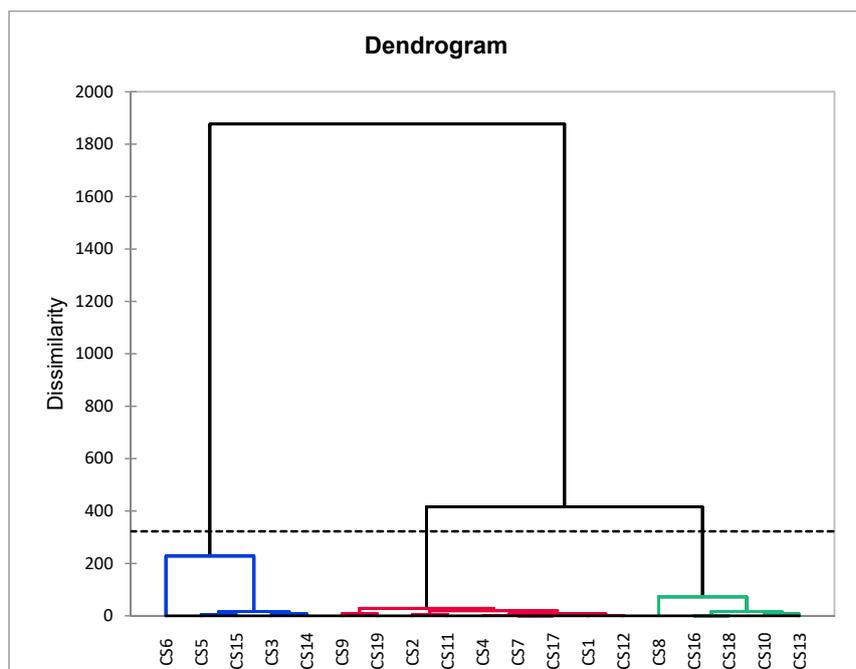
457 It is therefore unsurprising that in the absence of a consensual assessment method proposed by
458 scientists, PIUA actors have developed qualitative indicators themselves.

459 This trend is not systematically observed in the literature, or at least to a lesser extent. Only 25% of the
460 indicators used in the Five Borough Farm tool are qualitative (Altman et al., 2014), against 55% in the
461 FADEAR tool (FADEAR, 2013) and 62% in the IDEA method (Zahm et al., 2018). However, our
462 results support the conclusions of some studies which stress that qualitative indicators are essential for
463 evaluating sustainability, alongside quantitative indicators, as they allow for better inclusion of
464 stakeholders' values and practices impacting their capability to implement sustainability (Scerri and
465 James, 2010). Likewise, they align with the finding that qualitative methods are in the majority for the
466 assessment of the socio-cultural benefits of urban agriculture (Ilieva et al., 2021).

467 ***3.5. Identification of three groups of cases studies according to assessment practices***

468 The last stage of analysis focused on the links between case studies and themes, criteria and indicators
469 used for assessment. In other words, we wanted to know whether certain assessment situations led to
470 the use of specific themes, criteria and indicators.

471 A Hierarchical Clustering divided the case studies into three groups, each group including case studies
472 with similar trends in the number of themes, criteria and indicators used as presented in Figure 4.
473 Group 1 includes five case studies (CS3, CS5, CS6, CS14 and CS15), Group 2 gathers nine case
474 studies (CS1, CS2, CS4, CS7, CS9, CS11, CS12, CS17 and CS19) and Group 3 includes five case
475 studies (CS8, CS10, CS13, CS16 and CS18).



476
477 *Figure 4: Dendrogram of the Hierarchical Clustering – Group 1 in blue, Group 2 in red, Group 3 in*
478 *green.*

479 The characteristics of the groups are presented in Table 5.

480 *Table 5: Features of the three groups of case studies identified by a Hierarchical Clustering,*
 481 *according to (a) the average number of criteria and indicators used, and (b) the average occurrences*
 482 *of criteria per case study according to their related sustainability dimensions and theme*

| | Group1 | Group 2 | Group 3 |
|-----------------------------------|--------|---------|---------|
| Average number of criteria used | 29.4 | 7.4 | 14.0 |
| Average number of indicators used | 17.0 | 3.2 | 12.4 |

483 (a)

| Dimensions | Themes | Average occurrences of criteria per case study | | |
|-----------------------------------|---|--|---------|---------|
| | | Group 1 | Group 2 | Group 3 |
| External sustainability | Contribution to local sustainability | 8.4 | 2.9 | 3.8 |
| | Contribution to global sustainability | 4.6 | 1.1 | 1.6 |
| | Contribution to the sustainability of the sponsor | 1.2 | 0.3 | 0.8 |
| Internal sustainability | Coherence and technical robustness | 5 | 0.4 | 0.6 |
| | Consistency and economic robustness | 3.8 | 1.2 | 3.8 |
| | Management of regulatory aspects | 1.4 | 0 | 0 |
| Innovative nature of the project | Participation in the evolution of knowledge | 1.4 | 0.2 | 1.2 |
| | Originality of the project | 0.8 | 0.4 | 0.8 |
| Credibility of the project leader | Governance robustness | 1 | 0.1 | 0.6 |
| | Adequacy of project leaders' profile | 1.8 | 0.7 | 0.8 |

484 (b)

485 Group 1 includes 5 case studies, using the highest number of themes, criteria and indicators to assess
 486 their projects. This group uses in average 29 criteria to assess sustainability, underlining that the
 487 evaluators of Group 1 have a precise idea of the kind of project they expect. Indeed, within this group,
 488 the selection processes are calls for projects and closed competition, processes used when evaluators
 489 already know precisely the PIUA project they want to implement. Group 1 uses the most indicators
 490 (17 in average per case study), several criteria related to *Coherence and technical robustness* (5 in
 491 average) and is the only group to use criteria related to *Management of regulatory aspects*, suggesting
 492 that the evaluators have advanced knowledge about technical and legal related issues. This is
 493 confirmed as all the case studies of Group 1 call in external expertise in urban agriculture, either
 494 during the selection process, or both before and during the selection process.

495 The second group includes 9 case studies, using the lowest average number of criteria and indicators
 496 (7 criteria used in average per case study and 3 indicators). Among the 9 case studies, 7 did not call
 497 any external expertise in urban agriculture, which can explain the low number of criteria and
 498 indicators used. In this group, 4 case studies ended up in several projects and 5 in a unique project; and
 499 the group includes the 2 case studies where projects are implemented through a mutual agreement

500 between sponsors and project leader. Therefore, the low number of criteria might not only be linked to
501 the lack of expertise in PIUA, but can be a deliberate strategy: some case studies might use few criteria
502 as they concern different sites of implementation, or as they will create the criteria during the process
503 of project elaboration. Case studies of Group 3 uses most of their criteria to assess external
504 sustainability and more precisely *Contribution to local sustainability* (2.9 occurrences representing
505 39% of the occurrences for this group, Table 5) and *Contribution to global sustainability* (1.1
506 occurrence representing 15% of the occurrences for this group), underlining that these topics are of
507 primary concern for evaluators even when the project is not defined, and may be their first motivation
508 to implement a PIUA project.

509 Group 3 includes 5 case studies, using an intermediary number of criteria and indicators compared to
510 Group 1 and Group 2 (average of 14 criteria and 12 indicators used by case studies). Four of the five
511 case studies of Group 3 involved external expertise in PIUA either during or before and during the
512 selection process of projects, explaining why this group uses more criteria and indicators than Group
513 2. Case studies of Group 3 also implemented selection procedures such as call for expression for
514 interest and calls for applications, which are selection processes that allow a wide variety of project
515 proposals and are generally launched when the project idea is not totally mature. This can explain why
516 the number of criteria and indicators used is lower than in Group 1. The case studies of Group 3 focus
517 on *Consistency and economic robustness* (average of 3.8 criteria representing 27% of the occurrences)
518 suggesting that economic aspects are a major concern for evaluators.

519 The three groups use different kinds and amounts of criteria and indicators to assess PIUA projects. A
520 first hypothesis to explain it could be the co-evolution of the project and the assessment process: the
521 process of assessing PIUA projects is not fixed in time, but evolves alongside the project. The way in
522 which the sustainability of a PIUA project is assessed changes as the project progresses, adapting to
523 the evolution of the project. The clearer the project idea is, the more accurate and specific the criteria
524 to assess it can be. This is the result of a dialogue between stakeholders involved (sponsors, project
525 leaders and experts), and represents a process of mutual learning between them. Thanks to discussions,
526 they refine the characteristics of the project itself, the way it is perceived as sustainable, and of the
527 criteria to assess it. In our study, Group 2 could represent the first stage of evolution, based on project
528 ideas and few criteria, then Group 3 the second stage of evolution, when the project idea is a bit more
529 mature and criteria more diverse, and Group 1 the third stage where project proposals are defined in
530 details and criteria to assess them precisely designed. The need to adapt the assessment method to the
531 project cycle has already been highlighted in the context of the assessment of the innovation's social
532 impact (Molecke and Pache, 2019). McConville and Mihelcic (2007) have also developed a matrix to
533 assess water and sanitation project sustainability combining sustainability factors and project life-cycle
534 stages. However, no existing method to assess farm sustainability suggests different sets of criteria
535 according to the project development stage (Grenz et al., 2009; Schader et al., 2016; Scialabba et al.,

536 2014; Zahm et al., 2018), whereas the need to develop a temporal dynamic assessment of farm
537 sustainability has been described (Chopin et al., 2021).

538 A second hypothesis to explain the disparities between the three groups regarding the number and type
539 of criteria used could be that evaluators adapt the design of criteria to their use. In some situations, a
540 large number of criteria and indicators is needed to explain why a project should be selected, when an
541 evaluator needs to convince a supervisor or a local politician. A diversity of criteria can also be needed
542 when the design of a project is the result of a collective process involving stakeholders who may have
543 different objectives. Both situations are represented in Group 1 where the case studies involve local
544 authorities as sponsors with different partners and external expertise, suggesting that the decisions to
545 design and select PIUA projects involved various actors and needed to be well justified as it involved
546 public investments. In other cases, few criteria and indicators are needed, as the evaluators do not want
547 to design the project in details, but want to allow another stakeholder to do it without too many
548 constraints and to foster innovation to receive original project proposals. A small number of criteria
549 can also be formulated when the decision to select a project does not need to be thoroughly argued or
550 when project criteria will be the result of a collective learning: this is the case when a project is
551 selected by a single actor or based on mutual agreement between different stakeholders. Both
552 situations are present in Group 2 where external expertise rarely called upon and mutual agreement
553 used, highlighting more individual and intuitive decisions than in Group 1, which needs less
554 justification.

555 Our study is part of a project aiming at designing a specific tool to assess the sustainability of PIUA.
556 As discussed by Cerf et al. (2012), when a new tool is designed, acknowledging diversity among the
557 uses implies to introduce flexibility into the tool. In our case, the three groups of case studies
558 identified confirmed a diversity of assessment practices (using more or less criteria and indicators,
559 focusing on different sustainability themes) and suggests a diversity of uses for the assessment tool to
560 be designed. Flexibility means that the assessment tool will provide information relevant for a
561 diversity of decision contexts (for different stages of project development) and operating methods
562 (whether the assessment is made collectively or not, to support the design of a project, justify its
563 selection, assess its potential impacts etc.). Many studies pointed out the low level of use of decision
564 support tools due to the gap between the way designers elaborated the tool and the way users make
565 decisions (Díez et al., 2009; McCown, 2002; McIntosh et al., 2007), therefore our study enriches the
566 understanding of users' assessment practices, that should be taken into account for the design of a
567 flexible tool to assess sustainability of PIUA projects.

568 **4. Conclusion**

569 The rapid development of PIUA projects is generating the need to assess their sustainability.
570 Stakeholders such as sponsors, project leaders and PIUA experts have developed their own assessment

571 practices. This study examined these practices with a view to shedding light on the original features of
572 the assessment of PIUA projects' sustainability as implemented by the actors involved. The analysis of
573 19 case studies allowed us to identify four dimensions of sustainability used to assess PIUA projects:
574 external sustainability, internal sustainability, credibility of the project leader, and innovative nature of
575 the project – the last two of which are original in the context of sustainability assessment in
576 agriculture. We also identified 67 assessment criteria, some of these being particularly original,
577 compared to the classical methods of assessment of agriculture: for instance, a project's contribution
578 to the appeal of its neighbourhood, its complementarity with the rural farms in the area, or the
579 freshness of its produce. Finally, we showed that assessment practices differ among case studies by
580 identifying three groups of case studies, some using a large number of criteria and indicators, other
581 only a few, and focusing on different sustainability themes. This diversity of practices seems to be
582 linked to an evolution of assessment practices over time, and to the variety of assessment situations.
583 The sustainability assessment practices of PIUA stakeholders are proving to be a source of innovation,
584 to feed urban agriculture sustainability assessment; and our conclusions confirm the need for an
585 assessment tool where criteria and indicators used can vary according to the project stage and the
586 assessment situation. We are aware that the set of criteria and indicators identified based on 19 case
587 studies is not comprehensive, however it can be a basis to design a tool for assessing the sustainability
588 of PIUA projects, which will be completed by supplementary criteria identified by local stakeholders
589 as relevant for their specific situation. In this perspective, the assessment tool should be very flexible,
590 both to sort the relevant criteria and to complete the list of criteria, matching with the diversity of
591 stakeholders' practices and expectations.

592

593 **Declarations**

594

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603 **Conflicts of interest**

604 The authors declare that they have no conflict of interest.

605 **Ethics approval**

606 This study involved interviews with human participants. It didn't include any health-related
607 experiment or private data questions, thus it is not concerned by the Helsinki declaration on medical
608 research ethical questions.

609 **Consent to participate**

610 Informed consent to participate was obtained from all participants included in the study.

611 **Consent for publication**

612 Informed consent for publication of the results was obtained from all participants included in the
613 study. The data published about the case studies were anonymized for their publication.

614 **Availability of data and material**

615 The datasets generated during and/or analysed during the current study are available from the
616 corresponding author on reasonable request.

617 **Code availability**

618 Not applicable.

619 **Authors' contribution**

620 Conceptualization and methodology P.C., A.F.L and J.M.M. Data collection, analysis, writing P.C.
621 Review and supervision A.F.L and J.M.M.

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