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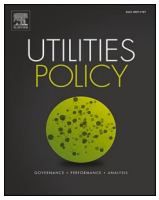

Full-length article

A strategic analysis of renewable energy communities in achieving sustainable development

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ABSTRACT

This study aims to identify the strengths, weaknesses, opportunities and threats associated with renewable energy communities (RECs) in Italy. The results, obtained through an incentivised online survey and an analytic hierarchy process, showed that economic saving on energy costs is the most relevant criterion for both consumers and expert stakeholders. Also, technical barriers and energy independence emerged as relevant in developing RECs. Consumers are more sensitive to the social opportunities behind RECs, while experts focus only on the economic aspects. The economic benefits, pragmatism, and effective management of human and physical resources within RECs can help achieve sustainable development.

1. Introduction

In 2015, the international community introduced the Sustainable Development Goals (SDGs) as a crucial component of the Agenda 2030 for Sustainable Development. The Renewable Energy Directive (RED II), enforced in December 2018, formally defined a renewable energy community (REC) for the first time. The European Commission (2022) emphasises energy communities in creating sustainable cities and underlines the importance of citizen participation in a clean energy transition. In the Italian context, a recent REC decree was released by the MASE (Ministry of the Environment and Energy Security), introducing new incentive mechanisms, including RECs and collective and personal self-consumption of energy from renewable sources. An organization that creates and distributes renewable energy independently generates and manages affordable green energy, and lowers CO_2 emissions and energy waste is known as a REC.

RECs can support the achievement of some sustainable goals, including SDG7 (Affordable and Green Energy), SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action) (Wuebben et al., 2020). The Clean Energy for All Europeans Package introduced these communities and the idea of collective self-consumption (CSC), which aimed to establish targets for improving renewable energy use and efficiency (Lowitzsch et al., 2020; Schiavo et al., 2022).

Recognising the prominent role played by prosumers in fostering the sustainable transition through both the direct consumption of self-produced energy (Onu et al., 2023) and more conscientious energy consumption behaviour (D'Adamo et al., 2024), the literature underscores the significance of collaboration that is inherent in the CSC and REC models. Such collaboration may involve individuals living in the same building or neighbourhood sharing electricity produced by a single plant (i.e., CSCs) or the establishment of a legal entity for energy produced from different plants supplying neighbouring individuals (i.e., RECs) (Frieden et al., 2020). Research has shown that RECs can yield environmental and economic benefits (Felice et al., 2022), and even greater advantages may be realised by implementing nearly zero-energy communities and buildings (Liu et al., 2022). However, it is also crucial to investigate social aspects in addition to the potential economic and environmental savings. Some works addressed the social sustainability issues in the context of energy poverty and injustice, considering the access of vulnerable groups to affordable energy prices (Hanke et al., 2021; Knox et al., 2022). Regarding the Italian case, Ceglia et al. (2022) underlined a range of 12–16% mitigation of energy poverty obtained through REC. From a critical point of view, it should also be noticed that the social aspects cannot be taken for granted since, in some cases, energy community members favor private profits over community issues (Vernay et al., 2023).

Given that RECs rely on cooperation, willingness to join is strongly

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Abbreviations

S1 =	Use of renewable sources as raw materials and promotion of a self-sufficiency mode
S2 =	Technological development
S3 =	Development of the local economy
S4 =	Active contribution of citizens to climate change mitigation or adaptation
S5 =	Economic savings on energy costs
W1 =	Technical barriers (e.g., bureaucratic slowness)
W2 =	Social and cultural barriers
W3 =	Organisational barriers (e.g., citizen difficulties in forming communities)
W4 =	Environmental barriers (e.g., landscape and land use constraints)
W5 =	Economic barriers (e.g., subsidies, taxes)
O1 =	Addressing climate change
O2 =	New models of sustainable business
O3 =	Increased industry investment
O4 =	Increased energy independence
O5 =	Forms of social aggregation
T1 =	Achievement of European objectives
T2 =	Lack of regulatory policy coordination
T3 =	Fragmentation of entities involved in the value chain
T4 =	Non-alignment of social interests
T5 =	Obstruction by 'big players in energy'

influenced by environmental concerns and social issues (Caferra et al., 2023). In addition, some authors have investigated the economic benefits of RECs and their contribution to achieving renewable energy targets (Haji Bashi et al., 2023). Studies have also shown that expanding the use of renewable energy resources (i.e., a key characteristic of RECs) may strongly impact household savings. This aspect has been highlighted recently, as electricity prices have risen significantly (Kurdi et al., 2022). Furthermore, research has shown that the economic benefits determined by RECs may reduce energy poverty when low-income households are involved (Cutore et al., 2023).

The analysis of RECs also demands attention to the political agenda. Economic considerations often take precedence over social or political objectives (Bauwens et al., 2022) and, in certain instances, political choices can wield more influence over market factors (Petrovich et al., 2021). The introduction of monetary incentives to support REC development is particularly crucial, as this may significantly impact the profitability of such investments (D'Adamo et al., 2023). Although the aspects mentioned above have been analysed in the literature, they have typically been analysed separately.

The role of social capital (cognitive, relational, structural) in participating in a sustainable energy community allows for the analysis of consumers' willingness to join a REC (Caferra et al., 2023). The present study complements this research as it considers the factors present in the SWOT quadrants of RECs in general. It aims to compare the perceptions of consumers and stakeholder groups (academics, politicians, industrialists and consultants). Using a SWOT analysis through an incentivised online survey and an analytic hierarchy process (AHP), we assessed the strengths, weaknesses, opportunities and threats associated with RECs in Italy, pursuing three research objectives (ROs).

- RO1: Assessing SWOT factors from the perspective of consumers.
- RO2: Assessing SWOT factors from the perspective of expert stakeholders.
- RO3: Comparison of consumers and stakeholder groups towards the development of RECs.

The remainder of the work is organised as follows: Section 2 describes the materials and methods employed for the data collection, Section 3 presents the main results, and Section 4 discusses the policy implications derived from the findings.

2. Materials and methods

This section begins by outlining the SWOT matrix's factors (Section 2.1). Subsequently, it presents the methodological approaches (Section 2.2). Specifically, the methodology included an online survey for RO1 (Section 2.3) and an AHP for RO2 (Section 2.4).

2.1. SWOT analysis

The methodological approach is based on a SWOT construction. SWOT analysis is a well-recognised and widely used methodology for assessing sustainability contexts (Igliński et al., 2022; Schmidt and Leitner, 2021), offering a clear framework for organising and evaluating gathered information. SWOT factors were constructed with an understanding of collecting the factors that can aid decision-making by building strategies based on strengths, eliminating weaknesses, exploiting opportunities, or even using them to counter threats (Yüksel and gdeviren, 2007). SWOT analysis summarizes the most relevant internal and external factors that may affect the organization's future, referred to as strategic factors (Kangas et al., 2003). External factors are sub-factors affecting a business's success but cannot be controlled by the organization as opportunities and threats, while internal factors are sub-factors affecting the success but can be controlled by the organization and classified as strengths and weaknesses.

Since we did not discover a consolidated SWOT to which we could refer, we identified factors from the literature and ongoing projects. The dataset was collected as part of a larger project to examine the impact of different social and economic dimensions on willingness to engage in an energy community (WEC) (Caferra et al., 2023).

A consistent number of criteria was established for each SWOT quadrant. The final choice of criteria was made through a collaborative process involving international experts (from academia and industry), who validated the SWOT criteria and their descriptions. Rigorous efforts were made to ensure the relevance and validity of these criteria, with expert opinions sought for validation. In particular, expert feedback ensured the comprehensive coverage of aspects such as renewable sources, technological development, economic savings, social aggregation and alignment with European goals.

The most challenging step in this process involved identifying an equal number of criteria for each quadrant (in order not to favor a priori one quadrant over the others) while minimising overlap. To this end, criteria were merged, where possible (e.g., S1 considered using renewable sources as natural resources and favoured a self-sufficient energy model). The analysis primarily aimed at determining the strengths, weaknesses, opportunities and threats associated with forming RECs. Each quadrant contained five criteria. Thus, the SWOT analysis explored 20 criteria (Table 1). We asked subjects to rank from 1 to 10 on the relevance of each criterion.

2.2. Methods

The study adopted a behavioural approach to study individuals' perceptions, attitudes and actions related to RECs. Our approach follows the taxonomy proposed in the literature (Sovacool et al., 2018) to investigate determinants and obstacles to forming RECs. Many criteria can be analysed numerically using different approaches. When the number of criteria is limited, an AHP can be employed, drawing on expert feedback to obtain diverse evaluations (Lode et al., 2021). This focused approach involves experts, while more accessible techniques should be considered for large-scale surveys. That is why, due to the specific focus on consumers (Lazdins et al., 2021) in the present study

Table 1
Distribution of criteria across the SWOT quadrants.

Strengths	S1	Use of renewable sources as raw materials and promotion of a self-sufficiency mode
	S2	Technological development
	S3	Development of the local economy
	S4	Active contribution of citizens to climate change mitigation or adaptation
	S5	Economic savings on energy costs
Weaknesses	W1	Technical barriers (e.g., bureaucratic slowness)
	W2	Social and cultural barriers
	W3	Organisational barriers (e.g., citizen difficulties in forming communities)
	W4	Environmental barriers (e.g., landscape and land use constraints)
	W5	Economic barriers (e.g., subsidies, taxes)
Opportunities	O1	Fight against climate change
	O2	New models of sustainable business
	O3	Increased industry investment
	O4	Increased energy independence
	O5	Forms of social aggregation
Threats	T1	Achievement of European objectives
	T2	Regulation: Lack of policy coordination
	T	Fragmentation of entities involved in the value chain
	T4	Non-alignment of social interests
	T5	Obstruction by 'big players in energy'

and considering the challenges involved in obtaining expert assessments through AHPs, a decision was taken to employ a questionnaire oriented towards a manageable SWOT analysis.

This method was deemed suitable for assessing broader categories of REC actors (Haji Bashi et al., 2023). Since RO1 aimed at understanding consumer opinions and perceptions regarding the SWOT, the collection of direct consumer data appeared most appropriate. Despite lacking a consistency ratio (CR - as with AHPs), the questionnaire method remains highly important and valid for understanding consumer opinions and perceptions. Furthermore, the SWOT-AHP approach is suitable for evaluating sustainable practices (Brudermann et al., 2015), drawing on expert opinions. Thus, it was used to investigate RO2.

2.3. Online survey

The preliminary questionnaire was drafted based on a comprehensive understanding of social analysis and energy communities. As explained in the previous section, we considered both existing literature and ongoing projects, asking also for the support of technical experts involved in the field. Subsequently, iterative feedback loops were employed to refine the questionnaire into its final version, with a panel of academics and industry professionals validating the draft survey and providing helpful recommendations for structural enhancements. Comprehensive information about energy communities was provided before they engaged with the questionnaire to ensure respondents had a contextual understanding of the concepts under investigation.

Data collection involved an online questionnaire distributed through the Prolific platform (www.Prolific.co). Prolific is an online survey platform designed for academic and commercial use, offering monetary rewards for questionnaire completion. It has been widely used in previous research (Palan and Schitter, 2018) and applied to Italian territory (Klaser et al., 2023; Mazzù et al., 2021). An alternative could be the Amazon Mechanical Turk platform (Colasante et al., 2022), and some studies provide further details on comparing these methods (Albert and Smilek, 2023).

The survey was distributed between March and April 2023, targeting a sample of Italian consumers. The decision to focus on Italy as the study area was motivated by ongoing political initiatives (including fiscal incentives) to promote the development of energy communities throughout the country. Despite the administrative challenges in setting up RECs, the literature emphasises the crucial role of incentivising policies in this endeavour (Musolino et al., 2023; Ruggieri et al., 2023; Trevisan et al., 2023).

The period of interest is in the aftermath of one of the most relevant and recent energy crises. This shock is a "natural" stimulus to raise citizen awareness and interest in energy-related themes, focusing on sustainable solutions. As demonstrated in the literature and the recent dramatic experience of the COVID-19 pandemic, crisis periods serve as laboratories to raise citizen participation and civic engagement (Malecki et al., 2021).

The dataset comprised 302 observations collected from Italian consumers who voluntarily participated in the research. All participants providing valid responses were remunerated with a fixed monetary reward of 2 euros to encourage participation.

Respondents ranked the relevance of each of the 20 items proposed in the different quadrants of the SWOT (Table 1) on a scale from 1 to 10.

2.4. AHP

SWOT analysis summarizes the most relevant internal and external factors that may affect the organization's future, referred to as strategic factors (Kangas et al., 2003). However, it does not allow us to determine the relative importance of the factors or the ability to assess the relevance of decision alternatives based on these factors (Kajanus et al., 2004). Kurttila et al. (2000) developed a hybrid method to eliminate the weaknesses in the measurement and evaluation steps of the SWOT analysis (Yüksel and gdeviren, 2007) by combining it with the AHP.

Through pairwise comparisons based on expert opinions, the AHP approach determines a list of priorities (Saaty, 2008). However, in the present study, the SWOT factors were already identified. Thus, the next step was to identify the experts, share the SWOT with the experts, collect their data and aggregate their judgments. For this purpose, experts were selected from solely the Italian territory in order to maintain consistency with the consumer analysis. Four stakeholder categories were considered: academics, politicians, industrialists and consultants – Table S1. Academics were selected based on their Scopus profiles and were required to demonstrate a minimum of 10 years of experience and expertise in energy management (Biancardi et al., 2023). Politicians were recruited from a seminar on energy issues attended by national and local representatives of different political parties. Finally, industry experts and consultants were chosen based on their LinkedIn profiles and experience in energy issues. Industrial profiles were required to demonstrate at least ten years of experience in the field, while consultant profiles were only required to demonstrate three years. Of note, 20% of the participating experts were female.

An email outlining the project objectives, a list of criteria and their descriptions, and a spreadsheet indicating the corresponding CR of the judgments made was sent to the experts to collect their priority rankings. Interviews were conducted between January and February 2024, with experts given the opportunity for online calls. However, all data collection for politicians was conducted in person.

To address the challenge of comparing 20 criteria, a method based on the initial computation of local priority—evaluating a limited set of criteria—was introduced for the subsequent calculation of global priority, aggregating all criteria. Local priority identified the specific relevance of each item within its macro-area, while global priority compared items across all macro-categories. This approach allowed for comparing a sizeable number of criteria, unlike a basic AHP. In more detail, three categories of priority analyses were conducted, as follows.

- "Local priority": four analyses considering 5 × 5 matrices and evaluating the importance of a single criterion within the same SWOT quadrant.
- "Category priority": a single analysis considering a 4 × 4 matrix and assessing the relevance of a single SWOT quadrant.
- "Global priority": the product of local and category priority, representing the significance of each SWOT factor.

Experts used a 9-point rating system (Saaty, 2008) for each matrix, ranging from 1 (equally preferred) to 9 (highly preferred), shown in Table S2. All SWOT factors were normalized to 1 as a result of the AHP, and the CR, which should not exceed 0.10, was computed to confirm the quality of the analysis.

3. Results

This section outlines the profile of the interviewed sample (Section 3.1) who provided numerical values for the SWOT criteria related to the consumer perspective (Section 3.2) (RO1). Subsequently, Section 3.3 presents the results from the expert stakeholders' perspective (RO2). Finally, Section 3.4 compares the findings (RO3).

3.1. Interviewed sample – consumer perspective

The consumer sample comprised 302 diverse individuals in age and gender (Fig. 1). The sample was youthful, with an average age of 31 years, and relatively balanced in gender (59% male). Approximately 60% of participants held at least a bachelor's degree. Nearly 44% of the sample resided in a small town, and about two-thirds lived in an apartment. Notably, the sample may differ from the reference population, as is typical of online survey research (Scherpenzeel, 2018). Sample selection was conducted using the Prolific platform to mitigate this issue.

There was a wide age distribution (Fig. 1(a)), with the largest group aged 25–34 years (48% of the sample), followed by young adults aged 18–24 years (22% of the sample). The age groups of 35–44 years and over 45 years constituted 17% and 13% of the sample, respectively. Furthermore, the gender distribution (Fig. 1(b)) revealed slight differences between men and women in various age groups. In particular, there was a majority of men (60%) in the sample, which was most pronounced in the age group of 25–34 years. In the supplementary material, we provide further analysis based on the demographic characteristics (Tables S3–S4).

3.2. SWOT analysis – consumer perspective

In the SWOT analysis, global and local priorities determined the relevance of different factors. This approach yields local and global rankings, providing a nuanced understanding of consumer priorities with insights for stakeholder decision-making regarding internal and external factors.

The methodological approaches used for the two ROs differ. For consumers, the value obtained was already global, and a local-global distinction was made only at the ranking level. In contrast, a local-global distinction was also made at the numerical level for the other stakeholder categories. Table 2, related to consumers (RO1), reports the average score for each item (first column); the local priority ranking (second column), referring to the item's priority within the same macro-category (i.e., strengths, weaknesses, opportunities, threats); and the global priority ranking (third column), referring to the average priority score of each item for all others.

The findings reveal that participants attributed greater importance to

Table 2
SWOT analysis of local and global priority rankings related to consumers (RO1).

SWOT factor		Global score	Local priority	Global priority
Strengths				
S1	Use of renewable sources as raw materials and promotion of a self-sufficiency mode	7.983	2	6
S2	Technological development	7.535	3	10
S3	Development of the local economy	7.030	5	16
S4	Active contribution of citizens to climate change mitigation or adaptation	7.300	4	14
S5	Economic savings on energy costs	8.566	1	1
Weaknesses				
W1	Technical barriers (e.g., bureaucratic slowness)	8.407	1	2
W2	Social and cultural barriers	6.872	4	18
W3	Organizational barriers (e.g., citizen difficulties in forming communities)	7.535	3	10
W4	Environmental barriers (e.g., landscape and land use constraints)	6.865	5	19
W5	Economic barriers (e.g., subsidies, taxes)	8.303	2	4
Opportunities				
O1	Fight against climate change	7.751	3	9
O2	New models of sustainable business	7.525	4	12
O3	Increased industry investment	7.855	2	7
O4	Increased energy independence	8.360	1	3
O5	Forms of social aggregation	6.620	5	20
Threats				
T1	Achievement of European objectives	7.013	5	17
T2	Regulation: Lack of policy coordination	8.037	1	5
T3	Fragmentation of entities involved in the value chain	7.290	4	15
T4	Non-alignment of social interests	7.500	3	13
T5	Obstruction by 'big players in energy'	7.810	2	8

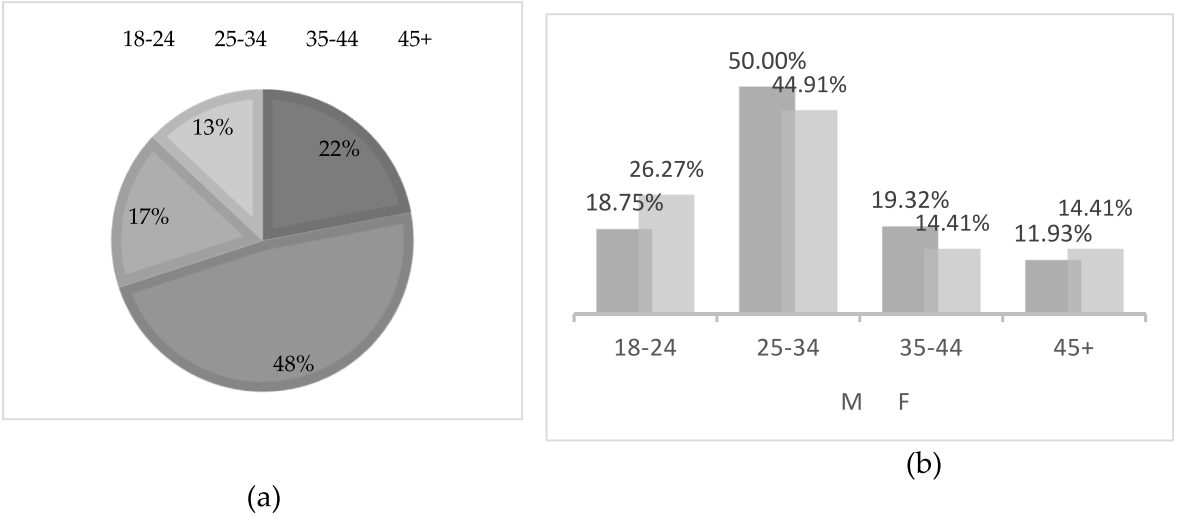

Fig. 1. Descriptive statistics: (a) sample distribution by age and (b) sample distribution by age and gender.

financial, technical and bureaucratic considerations in decisions related to RECs. Notably, environmental concerns exerted a comparatively lesser influence on decision-making. This finding suggests that economic savings may drive communities to seek renewable energy solutions while simultaneously addressing economic and technical hurdles. Coordinated policy regulation could contribute to overcoming bureaucratic and technical obstacles.

The five highest-ranking items (highlighted in grey in Table 2) can be interpreted as follows.

- Economic savings on energy costs (8.566). This criterion scored the highest, indicating the importance of financial savings attached to RECs. Indeed, RECs enable members to share renewable energy, leading to relevant savings on energy bills.
- Technical barriers (e.g., bureaucratic delays) (8.407). This high score highlights the importance of overcoming technical and bureaucratic challenges, suggesting that simplifying administrative and technical processes will facilitate adopting renewable energy solutions in RECs.
- Increased energy independence (8.360). RECs aim to reduce dependence on traditional energy sources and promote local renewable sources. This criterion reflects the goal of increased energy independence, contributing to sustainability.
- Economic barriers (8.303). Financial policies (i.e., subsidies and taxes) influence the accessibility of investments in renewable energy. This score indicates that consumers recognise the importance of favourable economic policies.
- Lack of policy coordination (8.037). Policy coherence and coordination are fundamental for RECs. This criterion emphasises the need for clear and coordinated government policies and regulations to support renewables in RECs.

These criteria reflect the challenges and opportunities RECs face, including economic savings, technical and bureaucratic barriers, energy independence, favourable financial policies and regulatory coherence. Addressing these aspects will be crucial for promoting the transition towards a more sustainable and participatory energy system.

Of note, the five lowest-ranked criteria were distributed throughout all quadrants. Indeed, a substantial balance between quadrants emerged, confirmed by the quadrant average values: strengths (7.683), weaknesses (7.596), opportunities (7.622) and threats (7.530). The breakdown of the highest-rated criteria provided further evidence supporting this observation. In this regard, the average values of criteria belonging to the same quadrant were evaluated as reference data, and approximately 83% of the sample indicated these values (for the remaining 17%, 5% preferred both positive quadrants, 4% preferred both negative quadrants and the remaining 8% were undecided). The proportions of the sample rating for each quadrant that was most relevant were as follows: strengths (23%), weaknesses (29%), opportunities (27%), and threats (21%). This finding calls for identifying short-term strategies aimed at reducing this consumer perception. Moreover, it should be emphasised that the ranking was led by a criterion within the strengths. A useful comparison is the numerical comparison of criteria within individual quadrants. As shown in Table 2, the differences between the values of the first and last criteria in each quadrant were relevant in three cases: strengths (1.536), weaknesses (1.542), and opportunities (1.740). However, the difference for the threats' quadrant was less pronounced (1.024).

From an inferential perspective, we merge all the positive factors (Strengths and Opportunities), and we compare this distribution with the one related to negative aspects (Weaknesses and Threats). A *t*-test reveals the statistical significance of the first group of factors (p-value = 0.09), evidencing the higher weights of positive issues.

3.3. SWOT/AHP analysis – expert stakeholders' perspective

The next step of the work compares the consumer analysis (RO1) results with those for other stakeholder categories (RO2). In this regard, the different assessments that emerged from the AHP were aggregated (Tables S5–24) after the CR verified the consistency of the judgments.

Regarding category priority (Fig. 2), for 15 experts, the sum of the positive categories outweighed that of the negative (a proportion test based on the share of experts weighing more positive and negative factors reports the statistical significance of this result). No academic provided a negative judgment of RECs, though a negative judgment was indeed demonstrated by one politician, two industrialists and two policymakers. Recalling that each expert was assigned the same relevance, strengths prevailed (with a score of 0.299), followed by opportunities (0.281). However, the difference between these categories was not statistically significant. In contrast, the gap between the top-ranked and the lowest-ranked categories (i.e., weaknesses at 0.256 and threats at 0.164) was significant. Notably, no expert rated threats as the most relevant category. Concerning the other categories, strengths were rated most relevant by eight experts, opportunities by seven experts and weaknesses by five experts.

We next examine the individual categories (Fig. 3). Starting with the category of strengths, 13 experts (all academics and four consultants) attributed the greatest relevance to criterion S5, which received a mean value of 0.327. Notably, the difference between this criterion and the second-ranked S1 (0.226) was significant. Four industrialists attributed the highest relevance to criterion S2. Regarding weaknesses, half of the experts (i.e., four academics and four industrialists) attributed the greatest relevance to criterion W1 (0.281). While the difference between this criterion and the second-ranked W5 (0.260) was insignificant, the three remaining criteria scored significantly lower.

Regarding opportunities, criterion O4 achieves the top position (0.278), followed by criterion O3 (0.228). Also, for this quadrant, a noteworthy finding emerged: four consultants favoured criterion O2, four industrialists favoured criterion O3, and seven experts (including four politicians) favoured criterion O4. Finally, for the threats quadrant, criterion T2 stood out with a score of 0.245 (rated the most relevant by six experts), followed by criterion T5 (0.228). All industrialists preferred criterion T3. Finally, no expert deemed criterion S4 or criterion O5 most relevant, and the differences between the first and last criteria within each quadrant were as follows: 0.193 for strengths, 0.163 for opportunities, 0.144 for weaknesses and 0.120 for threats.

Finally, global priority values were obtained for each criterion, representing the product of local and category priority (Table 3). Taking

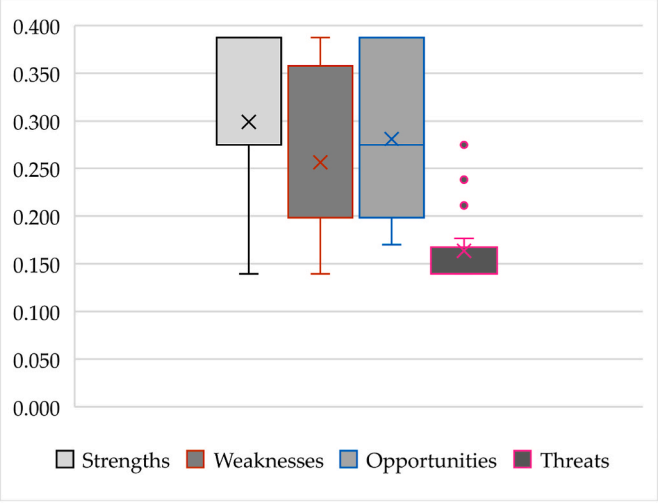

Fig. 2. Category priority.

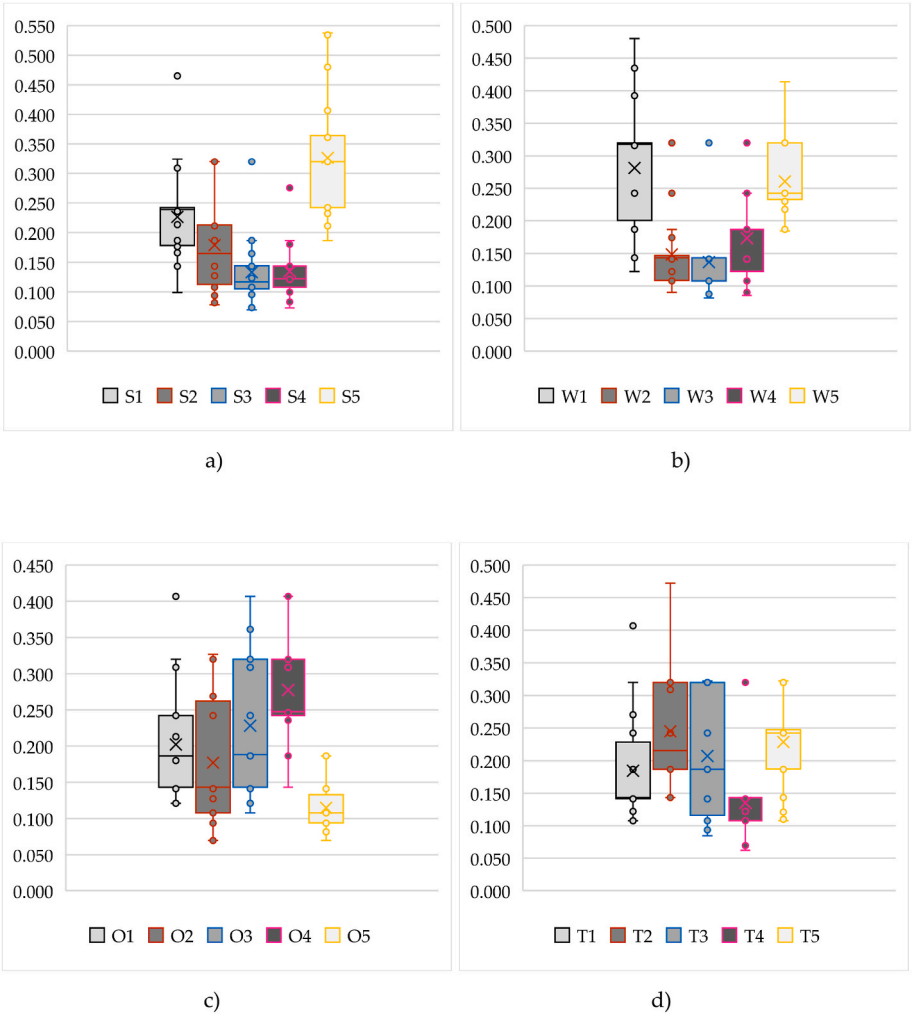

Fig. 3. Local priority. The sub-figures: a) Strengths, b) Weaknesses, c) Opportunities, and d) threats. X represents the average value.

criterion S1 as an example, the local weight of 0.226 was multiplied by the category strength of 0.299 to produce a global score of 0.068.

Compared to the previous one, this method is based on a pairwise comparison and does not evaluate individual criteria. Consequently, the weight associated with each category influenced the final result. Thus, a criterion with a high local score belonging to a highly relevant category would occupy a high position in the global priority ranking. Following this analysis, the five highest-ranking items (highlighted in grey in Table 3) were as follows.

- economic savings on energy costs (0.098);
- increased energy independence (0.078);
- technical barriers (0.072);
- use of renewable sources as raw materials and promotion of a self-sufficiency model (0.068); and
- economic barriers (0.067).

Thus, the economic sphere emerges as most relevant, suggesting its potentially positive role in countering inflationary phenomena that may affect both electricity bills and financial speculations on energy prices, especially in the case of ongoing energy crises. In addition, the experts attributed greater importance to energy independence, confirming the need for new self-sufficiency models, particularly those powered by renewable sources. However, negative consequences also emerged beyond these positives, associated with technical and economic barriers. Seven of the top ten positions were associated with positive factors (i.e., strengths and opportunities) and three with weaknesses (i.e., weaknesses and threats). Of note, the top-ranked threat appeared in 12th place due to the lower category priority and the smaller difference between the first and last criteria in this quadrant.

3.4. SWOT analysis: comparisons between expert stakeholders and consumers

The final step in the analysis involves comparing the rankings generated by the two methods, representing their position in the order of importance (RO3). Fig. 4 was constructed by taking the proposed ranking of consumers in Table 2 (see last column - global priority) and that of expert stakeholders in Table 3 (see last column - global priority). A direct numerical comparison was impossible due to the differing scales involved. While the 10-point value ranged from 1 to 10 in absolute value, the local-global approach based on the AHP normalized these scores to 1. The discrepancy in the results arose from variations in the panel of respondents and the methodological approaches used. The AHP, unlike the 10-point scale, enabled the consistency of the results to be assessed.

The results reveal differences between the rankings. In more detail, except for criterion S1, which maintained its top position in both rankings, the positions of all other criteria were subject to change. While both respondent categories emphasised economic factors, consumer perspectives varied, with some attributing greater relevance to positive factors over negative ones and others holding the opposite view. In

Table 3
SWOT analysis of local and global priority rankings – RO2.

SWOT factor		Local score	Global score	Local priority	Global priority
Strengths (0.299)					
S1	Use of renewable sources as raw materials and promotion of a self-sufficiency model	0.226	0.068	2	4
S2	Technological development	0.179	0.054	3	8
S3	Development of the local economy	0.133	0.040	5	13
S4	Active contribution of citizens to climate change mitigation or adaptation	0.135	0.040	4	11
S5	Economic savings on energy costs	0.327	0.098	1	1
Weaknesses (0.256)					
W1	Technical barriers (e.g., bureaucratic slowness)	0.281	0.072	1	3
W2	Social and cultural barriers	0.148	0.038	4	14
W3	Organizational barriers (e.g., citizen difficulties in forming communities)	0.137	0.035	5	16
W4	Environmental barriers (e.g., landscape and land use constraints)	0.173	0.044	3	10
W5	Economic barriers (e.g., subsidies, taxes)	0.260	0.067	2	5
Opportunities (0.281)					
O1	Fight against climate change	0.202	0.057	3	7
O2	New models of sustainable business	0.177	0.050	4	9
O3	Increased industry investment	0.228	0.064	2	6
O4	Increased energy independence	0.278	0.078	1	2
O5	Forms of social aggregation	0.115	0.032	5	18
Threats (0.164)					
T1	Achievement of European objectives	0.184	0.030	4	19
T2	Regulation: Lack of policy coordination	0.245	0.040	1	12
T3	Fragmentation of entities involved in the value chain	0.207	0.034	3	17
T4	Non-alignment of social interests	0.135	0.022	5	20
T5	Obstruction by 'big players in energy'	0.228	0.037	2	15

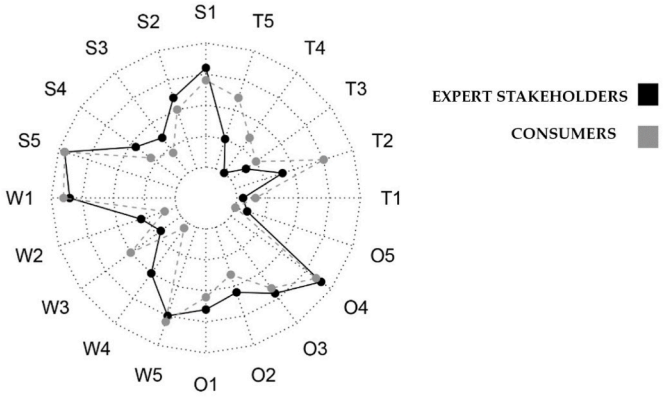

Fig. 4. The comparison of Global rankings of ROs.

particular, the weaknesses quadrant was most frequently prioritised. Conversely, academics and politicians prioritised opportunities among the expert stakeholders, while consultants and industry experts favoured strengths.

A focus on the top five criteria, W1, W5 and O4 features consistently across both rankings. However, criterion S1 appeared in the top five of the RO2 ranking, whereas in the RO1 ranking, it occupied the sixth position. This discrepancy may be attributed to the differing relevance of the strengths category. Similarly, the category priority attributed to threats likely explains the drop of criterion T2 from its top-five status in RO1 to its significantly lower (by seven positions) status in R2. Criteria T4 and T5 also decreased by seven positions. Thus, under the local-global approach, variations in category priority significantly impacted all criteria within the threats' quadrant. Furthermore, criterion W3 dropped six positions, while criterion W4 increased by nine. This shift may be due to the local priority scores, leading W3 and W4 to exchange the third and fifth positions between the rankings.

The above-described analyses underscore the absence of an expert category representing consumers' associations. However, this omission deliberately highlighted the disparity in rankings between consumers and other stakeholder categories.

Further analysis can be based on a subjects' clustering related to their sensitivity to the three pillars of sustainability (economic, social, and environmental). This type of analysis is secondary because the SWOT was not primarily aimed at identifying and isolating the different components. Therefore, different points in the quadrants simultaneously contain different aspects of sustainability. However, some questions isolate each pillar, and further considerations can be made. Specifically, we consider the following classification for economic, environmental, and social aspects.

- *Economic Aspects:* S5, W5, O3, T5. Regarding strengths and weaknesses, they directly refer to economic incentives. Regarding opportunities, the question refers to industrial investments, uniquely identifying the economic component. Regarding threats, the reference to Big Players considers economic aspects related to low competitiveness and oligopolies or collusion within the market.
- *Social Aspects:* S4, W2, O5, T4. In this case, reference is made to civic engagement, cultural factors, and the costs and opportunities of social coordination.
- *Environmental Aspects:* S1, W4, O1, T1. These items identify the environmental and green transition components linked to the construction of energy communities.

Based on this, we can observe within each of the four quadrants (Strengths, Weaknesses, Opportunities, and Threats) which of the three pillars (Environmental, Social, and Economic) have a greater weight and score among the different stakeholder groups (Consumers and Expert Stakeholders).

Fig. 5 reports the shares of subjects giving greater weight to each of the three pillars. As mentioned earlier, expert stakeholders are intensely focused on economic aspects, almost ignoring or underweighting the social aspects in terms of limitations and opportunities related to this type of policy. On the contrary, we find a more balanced consideration among consumers, where social aspects also seem to have a greater weight. A proportion test on social aspects confirms the statistical significance of the different views between consumers and expert stakeholders.

4. Discussion and policy implications

Energy communities represent a promising new social model for the ecological transition (D'Adamo et al., 2023), prioritising community over private interests. However, their development relies on several prerequisites. This study clarifies the mix of relevant factors in promoting WEC and ranking their importance. The literature underscores the role of economics in encouraging prosumerism (D'Adamo et al., 2022; Petrichenko et al., 2022). However, some studies have suggested that personal and social norms and awareness hold equal relevance (Niamir et al., 2020). The present work highlights that cost savings are the primary driver for consumers to participate in a REC (Felice et al.,

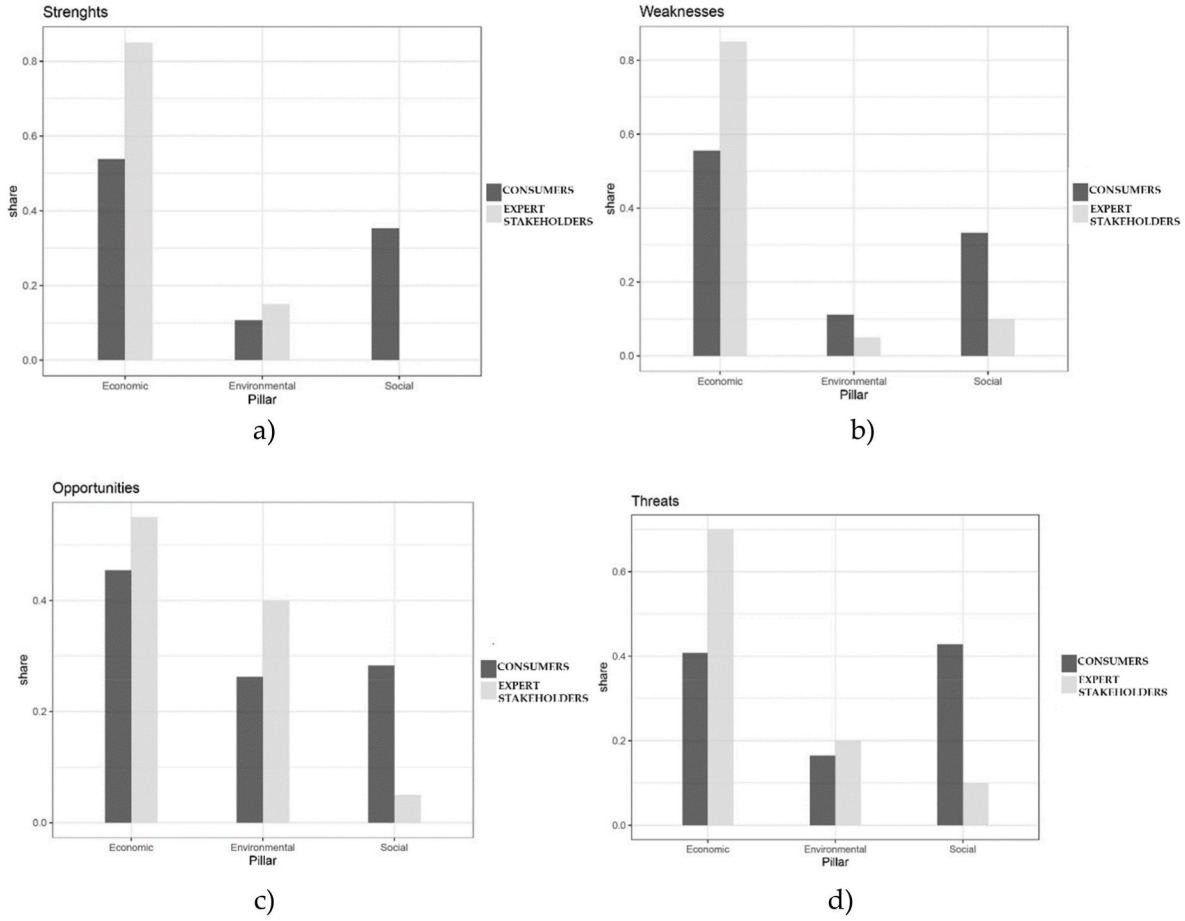

Fig. 5. Strengths, weaknesses, opportunities, and threats rank economic, environmental and social pillars.

2022), emphasising the importance of policies encouraging renewables in this context. Thus, renewable plants, combined with forward-looking green policies, may support sustainability goals and offer economic advantages, facilitating greater competitiveness with fossil fuels (Bianco et al., 2019; Shuai et al., 2022).

The alignment with several SDGs (Wuebben et al., 2020) underscores the relevance of RECs to the European green transition. However, a communication challenge is evident, as citizens may fail to grasp the increased competitiveness due to a lingering emphasis on economic weakness. This knowledge gap may be rooted in national approaches in which the energy sector is perceived as more reliant on government actions than market forces (Colasante et al., 2022). In general, political risks are thought to outweigh market risks (Petrovich et al., 2021), and technical shortcomings also represent a significant concern (Haji Bashi et al., 2023; Inês et al., 2020).

The unresolved issue of complete disconnection from the grid (considering the intermittency of renewable sources, variability in energy demand, and limitations in storage technology, as well as the high cost of standalone infrastructure, vulnerability to power outages, and regulatory barriers) also raises questions about the benefits for prosumers, potential revenue declines for electricity companies and the feasibility of decentralised and autonomous systems. Thus, RECs should not only be viewed as legal entities for incorporation into a distinct socio-legal institution (Heldeweg and Saintier, 2020) but also entities necessitating innovative business models. A broad transition to RECs will require storage systems for periods of solar non-production (Bartolini et al., 2020; Sarfarazi et al., 2023). Is our society ready for such a socio-economic transformation in the electricity sector? What political approach would facilitate this transition? These questions call for further contributions from the scientific community. However, before addressing these challenges, issues related to risk sharing and benefit distribution in the development of RECs should be addressed (Dorahaki et al., 2023; Volpato et al., 2022). Seeking compromises may render the system less stable (Gjorgievski et al., 2021). Thus, to encourage the development of RECs, an equitable distribution of benefits should be proposed among prosumers, consumers and generally all stakeholders involved (D'Adamo et al., 2024). The development of RECs should also be designed to support the fight against energy poverty, as in some cases, members of energy communities may be more interested in private profits than in community issues (Caferra et al., 2023; Ceglia et al., 2022; Parreño-Rodriguez et al., 2023).

The SWOT applied to the energy context allows decision-makers to identify actions and strategies to achieve the goal (Nascimento et al., 2023), which may be represented by the renewable energy potential of each country (Elavarasan et al., 2020) or the specific characteristics of the context of analysis. In this direction, some authors have dwelt on the different legal forms that may characterize the models, although they are all geared toward encouraging a collective investment by citizens (Herenčić et al., 2023) or the prosumer perspective is evaluated (Siksnelyte-Butkiene et al., 2023). A SWOT applied to RECs shows the advantages associated with a municipality-led initiative (Efthymiou et al., 2022). As mentioned in Section 1, this work proposes a general SWOT applied to a REC.

The present findings, complementing those of a prior analysis (Caferra et al., 2023), underscore that civic norms within households and structural interactions within neighbourhoods are the social contexts in which RECs evolve. Fig. 6 proposes the joint results of this research project, which, through analyses involving different categories of stakeholders, highlighted the aspects salient to the diffusion of RECs.

Energy communities represent an excellent opportunity to promote

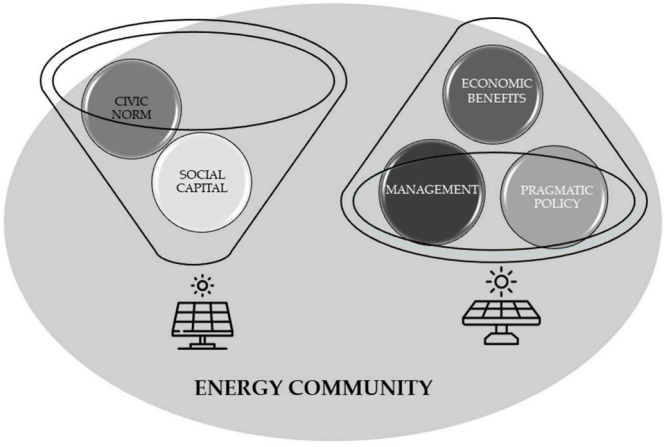

Fig. 6. The pillars of the development of a REC.

sustainable transition, yet this approach seems to demand high social coordination. Among the various proposals made, Citizens are highly sensitive to this aspect; after economic considerations, social factors appear to take precedence over environmental ones. Consequently, the pillars presented in Fig. 6 highlight the role of social coordination as a crucial factor in promoting the social stability of RECs. On the right side of the figure, the need for stakeholders to identify suitable policies and promote appropriate economic incentives is evident. The analysis indicates that the expert group is mainly focused on these points. It is essential to align the vision and interests of the energy communities with those of the groups involved in their formation: maintaining the right economic incentives while fostering social sustainability and reducing coordination costs. Therefore, efforts should focus not only on economic aspects but also on the social fabric.

Moreover, the present study outlines that economic motivations can function as social enablers. Highlighting the economic benefits of incentives for RECs to promote renewable self-consumers, the results underscore the importance of awareness-raising policies. Sustainability hinges on the realisation of not only the environmental and economic dimensions of renewables but also their social dimension. Thus, sustainable education is necessary for developing sustainable communities (Biancardi et al., 2023). RECs can support energy independence (a political priority for energy-dependent countries) and energy security. While some market players in the fossil fuel sector resist ecosystem transformation, citizens and the scientific community must chart the path forward. A pragmatic, problem-solving approach – informed by analyses demonstrating renewables as an alternative to fossil fuels without subsidies and supported by policies and technological innovations fostering a low-carbon society – may prevail over an ideological one. Effective management of resources within a REC is crucial for optimising the decentralised model, both technically and economically and socially. The increasing presence of renewable self-consumers necessitates a participatory approach, fostering the realisation of sustainable communities. Developing RECs in the city and suburbs may serve as a stabilising element against speculation and inflation, ensuring clean and affordable electricity.

5. Conclusions

The present work emphasises the pivotal role played by the ecological transition in shaping a sustainable future, highlighting RECs as instrumental in this transformative process. The ecological transition demands a shift in energy systems and a cultural change that sees local communities becoming active protagonists.

The high importance attributed to the criterion of economic savings on energy costs suggests that individuals may be motivated to participate in renewable energy projects when they perceive a direct economic advantage. Additional criteria deemed relevant were technical and bureaucratic barriers, which were perceived to impede project realisation, along with uncertain and short-lived incentive policies. However, the issue of energy independence has gained significant relevance, possibly linked to the idea of sustainable communities based on available raw materials and self-sufficiency models.

Consumer respondents failed to identify environmental concerns as a significant priority, and other stakeholder categories assigned relatively low relevance to organisational concerns. However, these aspects should not be underestimated for a REC to succeed. The results showed that experts paid more attention to the positive SWOT quadrants, while consumers were more divided between the positive and negative categories.

The work has some limitations. The first is the lack of analysis on the effect of participants' income and the conduct of cluster analysis. Further research could involve a field experiment to evaluate deviations in consumer choice from those reported in an online survey. In addition, an investigation of actual experiences with complete disconnection from the network, bureaucratic procedures and the distribution of benefits could be valuable. Future analyses should be situated in contexts where RECs are present while differentiating between various application settings (e.g., small versus large cities).

Pragmatic policies, economic benefits and the optimised management of human and physical resources are essential for establishing stable energy communities. RECs may serve as the cornerstone of sustainable communities, given that energy is an essential resource influencing consumer habits.

CRediT authorship contribution statement

Rocco Caferra: Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization. **Annarita Colasante:** Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization. **Idiano D'Adamo:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Data curation, Conceptualization. **Gülşah Yilan:** Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization. **Davide Lancialonga:** Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization.

Declaration of competing interest

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

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jup.2024.101810.

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