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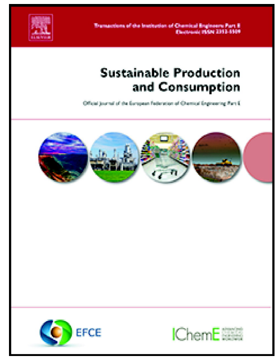
Journal Pre-proof



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PII: S2352-5509(22)00343-8

DOI: https://doi.org/10.1016/j.spc.2022.12.022

Reference: SPC 1224

To appear in:

Received date: 6 September 2022

Revised date: 7 December 2022

Accepted date: 26 December 2022

A sustainability scoring system to assess food initiatives in City Regions

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Abstract

The City Region Food Systems approach has been proposed to achieve food system resilience and nutrition security while promoting the urgent ecological transition within urban and peri-urban areas, especially after the COVID-19 pandemic. However, the great diversity of the initiatives composing City Region Food Systems in Europe poses barriers to the assessment of their integrated sustainability. Hence, the present work is developed within the EU-H2020 project Food System in European Cities (FoodE), to build a consistent sustainability scoring system that allows comparative evaluation of City Region Food System Initiatives. Adopting a Life Cycle Thinking approach, it advances on existing knowledge and past projects, taking advantage of a participatory process, with stakeholders from multidisciplinary expertise. As a result, the research designs, and tests on 100 case studies a simplified and ready-to-use scoring mechanism based on a quali-quantitative appraisal survey tool, delivering a final sustainability score on a 1-5 points scale, to get insights on the social, economic, and environmental impacts. As in line with the needs of the UN Sustainable Development Goals, the outcome represents a step forward for the sustainable development and social innovation of food communities in cities and regions, providing a practical and empirical lens for improved planning and governance.

Keywords

City Region Food System Initiatives; Sustainability Performance; Scoring Mechanism; Multi-Stakeholder Approach; Life Cycle Thinking.

1. Introduction

Sustainability has increasingly become central to global, regional, and national agendas. Through the Sustainable Development Goals (SDGs) a shared set of guiding elements has been operationalised to make tangible progress at multiple levels (UN, 2015). Sustainable food systems defined as systems that 'deliver food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised' (FAO, 2018) are today recognized key segments in the transition to meet these goals (Sachs et al., 2019).

Despite meaningful commitments in achieving just food systems, as a result of the globalization process food and nutrition security in European cities and regions are being increasingly challenged by economic, ecologic, and health-related crises (FAO/IFAD/UNICEF/WFP/WHO, 2021; Hu et al., 2020; FAO, 2020). The recent COVID-19 pandemic has exacerbated vulnerabilities (O'Meara et al., 2022), while the current Ukraine war is intensifying the food crisis and accessibility to primary goods (McGreevy et al., 2022). More than ever, increased efforts are needed to transform the food system in a way the economic aspirations are considered together with social and environmental ones (Ivo de Carvalho et al., 2022; Fanzo et al., 2021). This urgency asks for both new paradigms able to overcome strict neoclassical interpretations of food system dynamics and new operative assessment to monitor advancements of food system with a comprehensive outlook (McGreevy et al., 2022).

Over the last decades, multiple approaches to reflect on food system sustainability have flourished. The bioregion paradigm, defined by Harris et al. (2016) as a geographical space characterized by local eco-system interactions, highlighted the opportunity for human populations to leave their steady-state economies (Evanoff, 2017) by promoting ecologically sensitive agricultural practices (Gilbert et al., 2009) to control their domestic resources (Evanoff, 2017). In the same way, the foodsheds framework strengthened the relation between producers and consumers in terms of geographical delimitation (Arthur et al., 2022), helping to analyse global changes through the lens of the food system (McCabe 2010). Basing on the foodshed delimitation, several assessment models have been developed to explore indicators for improving self-sufficiency in cities and regions (Sylla et al., 2022; Vicente et al., 2021; Zasada et al., 2019). The proposed assessments discussed the capacity of local food systems in meeting human dietary needs, but without considering social and economic aspects in the framework of the analysis. A step forward in the sustainability assessment was proposed by the framework of Agroecology-Based Local Agri-Food systems which identify four categories to evaluate food initiatives, i.e., environmental health, economic viability, social equity and right (González De Molina and Lopez-Garcia, 2021). Still, operative methodologies to measure it are falling short. On the agroecology principle also the bio district approach emerged, defining territories as farming systems, where natural resources are sustainable managed by local stakeholders following agroecology and organic farming principles (Passaro and Randelli, 2022). Despite their specificities, the abovementioned concepts fail to consider the complexity and diversity of the relationships between (and among) people and places, beyond food flows (Blay-Palmer et al. 2018).

Across the several approaches and operative definitions of sustainable food systems (Blay-Palmer et al., 2018; Born & Purcell, 2006; Ericksen, 2008), one of the most proposed approaches to advance in this direction is the City Region Food System (CRFS). It is defined by the Food and Agriculture Organization of the United Nations (FAO) and the Resource Centre for Urban Agriculture and Food Security (RUAF) as *'an approach aimed to foster the development of resilient and sustainable food systems within urban centres, peri-urban and rural areas surrounding cities by strengthening rural-urban linkages'* (FAO & RUAF, 2015). As a result of the globalisation process, city-regions represent major places of agglomeration of goods, while at the level of social dynamics, stakeholder groups lobby for their rights, beyond the economic growth (Arthur et al., 2022). Envisioning a single network of all the urban, peri-urban and rural linkages of food consumers, producers, suppliers and processors operating in a given city-region, the CRFS approach is largely recognized for shaping a sustainable environment able to provide accessible, affordable, safe and nutritious food (FAO & RUAF, 2015).

In this respect, CRFS performances are assessed through several indicators for six areas of intervention, namely social, economic and environmental sustainability, urban-rural integration, governance and resilience (Carey & Dubbeling, 2017), which have been applied for evaluating different city-regions at global scale (Chappell et al., 2016; Forster and Escudero 2014). Nevertheless, literature does not yet offer consistent evidence of a sustainability performance of CRFS that combines Life Cycle Assessment (LCA), Life Cycle Costing (LCC) and Social Life Cycle Assessment (S-LCA) methodologies, only providing partial or alternative integrations. For example, Stillitano et al. (2021) stated that most case studies implement a stand-alone LCA to specifically evaluate the benefits and impacts of circular economy strategies in the context of agri-food activities. Few studies combined LCA with the LCC approach, and none dealt with S-LCA. Single attempts proposed to integrate LCA and LCC approaches to specifically address a sustainability evaluation of a CRFS (Sanye-Mengual et al., 2018). However, the environmental and economic impact categories considered did not provide a comprehensive assessment analysis, as they focused on specific aspects. Furthermore, some multi-criteria assessment methods were designed to assess the sustainability of farms, but the literature has pointed out that these tools are largely unsuitable for multifunctional CRFS initiatives since they focus on agricultural activities and production and fail to consider non-agricultural activities (Barbier and Lopez-Ridaura, 2010). Some assessment methods have been designed specifically for urban agriculture, but the focus is mostly on the environmental pillar (Langemeyer et al., 2015; Lin et al., 2015; Petit-Boix and Apul, 2018; Wang and Pryor, 2019), disregarding social and economic consequences. Others have been designed without the stakeholders' involvement (Corvo et al., 2021) or not testing it to case studies (Ivo de Carvalho et al., 2022).

Moreover, despite the validity of those approaches in identifying areas of intervention at a territorial scale (Armendáriz et al., 2016; Blay-Palmer et al., 2018), most of them were built on data gathered at city-region level, and not at the initiative level. Especially, they did not discriminate against punctual variances within a food system and could not account for individual stakeholders or local variances (e.g., different districts or enterprises). Additionally, they included indicators that could hardly be measured at this level, like most of the Sustainability Assessment of Food and Agriculture (SAFA) indicators (FAO, 2013) or those developed by urbanists, implemented at the city level or at best at borough level (Teitel-Payne et al., 2016; Altman et al., 2014). Furthermore, the few sustainability assessment frameworks developed at the initiative level were anyhow either looking only at one or two pillars of sustainability or a sector or specific crop and not at the CRFS itself (Dorr et al., 2021; Stillitano et al., 2021) (see also Supplementary Material (SM) Table A).

As a result, the literature highlighted the need for a comprehensive and systemic approach that can ensure: 1) operationalisation of the assessment at the initiative level, and 2) an adequate representation of different sustainability dimensions, including social, economic, and environmental aspects (Trachsel et al., 2018).

Hence, the present work discloses the research carried out within the FoodE project on the development and testing of an assessment scoring framework designed on Life Cycle Thinking (LCT) and builds on previous knowledge and co-design processes, to analyse the sustainability of CRFS Initiatives (CRFSI) through a single synthetic, comprehensive and coherent mechanism. As such, the simplified scoring framework is not intended to substitute a full LCA, LCC, and S-LCA assessment, but rather to be used as a scoping mechanism in the design phase of an extensive study, or as an auto scoring tool for non LCT practitioners, or as an understanding of the sustainability performances of city region environment across a different period (Deng, Peng, and Tang 2019).

2. Methods

2.1 Theoretical background

Starting from the CRFS definition described by the FAO & RUAF (2015), 600+ European initiatives were scouted and selected by the FoodE project to better identify the most relevant characteristics of CRFSI, in terms of the type of organization, food-related operations, workforce, size, and relations with customers and society. The identified key features allowed to characterise European CRFSI through their key activities, relevant external and internal partnerships, impact areas, innovation strategies and collaborative attitudes. Therefore, CRFSI can be defined as profit or non-profit entities involved in the food system in strong connection with their territorial context and being in one or more of the following activities: agriculture & fishing, food processing (e.g., transformation of agricultural products into food), food distribution (e.g., wholesale, retail, community supported agriculture), food service and consumption (e.g., catering, cooking, restauration), food waste management, education and services. Their workforce is often composed of less than 10 employees, with volunteers involved in several cases. They are located in, or nearby cities or consumption centres and they bond mutual relationships with their final users, enabling the creation of rural-urban linkages. This working definition has been used as a unit for the sustainability scoring system development.

2.2 Scoring system development

Since CRFSI are characterized by a wide diversity of functions, products, and processes, the scoring system was designed to cover and assess a wide variety of activities. The requirements for the scoring system are both to allow a rapid quali-quantitative appraisal for the evaluation of CRFSI, and to develop it both for the use by experienced practitioners and by non- practitioners for a generic analysis and understanding.

Despite the fact the initial scope of the scoring system is focused on the European area, it stands to be applied globally, taking into consideration several local characteristics for further tailoring and data interpretation. This means local characteristics need to be broadly explored when applying the sustainability scoring system.

The backbone of FoodE methodology for the CRFSI scoring mechanism builds on three main aspects: a Life Cycle Thinking (LCT) approach, the existent knowledge and co-design processes with practitioners from different knowledge backgrounds.

The former is adopted to include all three sustainability pillars in an integrated manner (Petit-Boix et al., 2017, Sanyé-Mengual, 2015). The second is based on key national and international projects on CRFS developed in recent years and the available peer-reviewed literature. The latter is based on the previous methodological experience in co-creation processes (Manríquez-Altamirano et al., 2021; López-Forniés et al., 2017; Sierra-Pérez et al., 2016), and internal and external consultation processes followed to improve the sustainability scoring system.

Overall, the novelty of the present FoodE methodological development consists first in the modelling of the LCT approach on CRFSI, then in its scoring mechanisms which provide a final sustainability result, and finally in its feasibility both for LCT and non-LCT practitioners in replicating the scoring mechanism. Furthermore, as highlighted by other scientific researches, the sustainability scoring system can support city region urban policy makers and food initiatives in taking effective interventions to improve the sustainability performance of their food system (Maliene et al., 2022). The following sections describe in detail the three aspects of the methodology.

Life Cycle Thinking approach

LCT constitutes the first conceptual foundation of the sustainability scoring system (Petit-Boix et al., 2017). The evaluation of food system sustainability within city-regions implies embracing the multiplicity and complexity of supply chains, impact pathways, and affected stakeholders in different areas. This challenge can be addressed only by going beyond the global, de-localized production approach and related processes and including all sustainability pillars: social impact (e.g., labour, health, innovation); economic impact (e.g., costs, net present value, value added); environmental impact (e.g., carbon footprint, land use, water scarcity). The three pillars of sustainability are not exclusive and can be mutually reinforcing. Furthermore, promoting the territorial proximity of food supply chains represents a key element in meeting the CRFS definition and its sustainability.

Overall, the social pillar focuses on the process of creating sustainable, successful places that promote well-being, by understanding what people need from the places they live and work at (Taslis et al., 2022; UNEP 2020). The economic pillar represents a broad interpretation of ecological economics where environmental and ecological variables and issues are basic but part of a multidimensional perspective (Peña & Rovira-Val, 2020; Estevan et al., 2018; ISO, 2017). Finally, the environmental pillar concerns the human impact on nature, its ecological processes and ecosystem services provided (Hauschild et al., 2017; ISO, 2006; SETAC, 1991). These three pillars serve as a common ground for numerous sustainability standards and certification systems in recent years, in particular in the food industry (Notarnicola et al., 2017), and were used as the basis to select a set of impact categories and KPIs for the scoring mechanism.

Previous Knowledge

To focus on relevant hotspots only, impact categories and KPIs were screened based on previous knowledge. Among key projects and initiatives operated in the recent past by FoodE partners, the ones with a relevant contribution towards an integrated methodology for a sustainability assessment of food systems segments were selected. The full list of selected projects is presented in SM Table B, along with the covered pillars and the general methodology.

Some of the research projects used a more standardised methods for their indicators choice while other studies focused on the development of new indicators, especially regarding the S-LCA, for example when it came to the assessment of innovation in urban agriculture. In general, while the evaluation of environmental impacts through LCA is already standardised, its integration with other methods to include economic and social impacts of food production systems has been tackled in a variety of ways, and it calls for a more integrated approach, to be eventually generalised for CRFSI.

To integrate previous projects, a literature review of the integrated Life Cycle Sustainability Assessment (LCSA) of CRFS was also carried out using the keywords '*life cycle sustainability assessment**' and '*food**' on the Scopus database to derive an overview of current knowledge, possible indicators, and assessment methods. SM Table A summarizes the relevant works along with information on pillars, general approaches, and methodologies.

This literature was used in combination with knowledge from previous projects to derive an overview of existing tools and indicators that constitute the base of the sustainability scoring system. The initial design step included the most common of these indicators to then start an iterative participatory consultation for the final sustainability scoring system development.

Co-design process

The involvement of a variety of stakeholders had a key role to support the development of the integrated assessment methodology and was deemed necessary to deliver a consistent mechanism, translating the complexity of sustainability to clear and manageable metrics.

To this aim, coherently with the Citizen Science and Responsible Research & Innovation principles (Robinson et al., 2018) a participatory approach was adopted to co-design the scoring mechanism. The participatory consultation was conducted in four main steps and included multiple hierarchical levels. An opportunistic approach was applied to co-create indicators and set-up the scoring system (Winjberg, 2000) involving various experts in the field of food system sustainability. Then, the principle of completeness was applied (Geibler et al. 2006) in the co-design session aimed to inform and consult stakeholders. This latter approach was fundamental to find a balance between the analysis capacity that LCA tools could provide to actors and the ease of understand the results (Renouf et al. 2018). To ensure inputs from all stakeholders online and offline methodologies were used. Interactions between the different participants were elicited through focus group discussions (Belzile et al. 2012) carried out in small groups and led by design developers. It was crucial to achieve user participation in design and gather all relevant information (Yanki et al. 2008). Besides that, online tools such as Mentimeter were used to collect inputs from participants during and after the participatory activities (Zhang et al. 2018).

A first consultation step, aiming at involving the FoodE actors, was organised during the recurrent FoodE General Assembly (GA), composed by 23 partners with a wide diversity of perspectives and expertise on food systems. The GA included professors, researchers and students, food businesses, CRFSI, NGOs, professionals and municipal actors dealing with food policies.

Primarily, the first FoodE GA meeting (February 2020) served to kick-off preliminary discussion on the CRFSI definition and its sustainability dimensions. A live survey was launched and all attendees (around 68 staff members from the FoodE consortium partners) were involved in a participatory discussion. This initial activity was used to set the scene and create a common vocabulary on food system sustainability. In particular, participants were asked what adjectives could describe the CRFSI with which a word cloud was created based on the word frequency. After compiling the database of CRFSI in Europe, half a year later during the third FoodE GA meeting (July 2020) a second online session was organised. It consisted in a simplified participatory review to get feedback on the most effective Key Performance Indicators (KPIs) to be used when measuring sustainability and on the relative selected questions needed to investigate them. The KPIs were selected on the basis of a literature review to identify key indicators for environmental, social and economic analysis. The project partners were asked to rank the KPIs according to the City Region Food System framework defined in the first participatory activity. The results were used to design the KPIs and the relative questions.

A second consultation step on the sustainability of CRFSI was developed during the FoodE Winter School (February 2021), an online event organised by FoodE with the participation of around 50 individuals (both within and outside the FoodE consortium). The winter school was elaborated on purpose to simultaneously obtain awareness creation and stimulate participatory co-design for the assessment indicators. The involved arena included young and senior researchers, students, and professors, interested in the food system sustainability evaluation. A total of 18 organisations from 7 different countries (Spain, Italy, France, Germany, Netherlands, United Kingdom and Norway) were involved in the FoodE Winter School either as participants, speakers or organizers. Within the workshop, participants were involved in two afternoon sessions on the environmental and on the integrated economic-social assessment, respectively. The different working groups were set up to share expertise in a mixed way across the different discussion tables to ensure multidisciplinary knowledge sharing. This activity was used to test the sustainability scoring system on different CRFSI thus stimulating participants to offer their views and experiences. The feedback was collected with a focus group discussion with the participants of the workshops and then output used to achieve the final version of the mechanism.

The third consultation step assessed the relevance of the KPIs, and the availability of the data explored in the survey by involving the member of the stakeholder board established in the different FoodE related regions. The scoring system was carried out by means of a Likert scale from 0 to 5 and the questions with the lowest score were modified or deleted to improve the response rate and the clearness of the methodology. The stakeholder board is composed by a variety of 102 geographically distributed bodies across Europe, including NGO, schools, CRFSI, public administrators (PAs) and policy makers, citizens and researchers to support the definition of the priorities at local level. The detailed composition of the FoodE stakeholder board participants is showed in Table 1.

Table 1 - FoodE stakeholder board composition

Country	PAs	Schools	CRFSI	Civil Society	Researchers	Total
France	2	2	2	2	2	10
Italy	1	8	5	4	1	19
Netherlands	0	2	3	0	1	6
Norway	1	1	1	0	0	3
Romania	0	2	6	0	1	9
Slovenia	1	2	1	1	0	5
Spain	8	19	3	5	3	38
Germany	2	1	0	3	3	9

Other	0	0	3	0	0	3
Total	15	37	24	15	11	102

The final consultation phase involved only experts and consisted in a final round of participatory revisions from around 15 well-recognised researchers working specifically on the sustainability of the agri-food sector. Starting from the finalized survey, a methodological refinement was advanced. Professionals from fisheries, growing systems and animal husbandries were asked to verify whether the system structure was appropriate for respondents and if the required information was likely to be measured and shared by the respondents. Discussions were organised online, both on a bilateral basis and as a mixed working group and results were used to revise the survey.

The final feature of the approach was the validation of the sustainability scoring system. This phase aimed at ensuring its applicability and at validating the data collection protocol. Also in this case, the involvement of relevant experts and stakeholders played a crucial role. Experts and researchers addressed in the co-design and participatory consultation provided various feedback on the efficacy, the detailedness and the clearness of questions. Five selected CRFSI owners were involved in testing the final survey. They were asked to answer the various questions and then to provide feedback on comprehensibility, duration, and ease of response.

2.3 Testing

The indicators have been then tested on 100 case studies in 10 European countries involved in the European project H2020 of FoodE. The scope of this specific phase was to identify potential strengths, opportunities, and weaknesses of the sustainability scoring system rather than to assess the performances of a representative sample across Europe. Hence, for the data collection, data from each CRFSI was collected through the dissemination of an online survey on Qualtrics. A complete description of the survey is included in SM Table C. Data collection took place from July 2021 to December 2021.

The results of the testing have been analysed and processed individually. A Microsoft Excel Spreadsheet Editor was first used to process collected data from Qualtrics into a spreadsheet. In a second step, R programming language for statistical computing and graphical representation was used to run calculations and process and visualize data.

3. Results and Discussion

3.1 Sustainability scoring system

The Sustainability scoring system resulting from the described process is detailed below. All three pillars resulting in Impact Categories (IC), KPIs and description and unit of measurement are described in Table 2.

For the social pillar, the focus of the IC is on i) the job opportunity at CRFSI level, ii) the embedment in the community, and iii) the quality and safety of their food. For SocIC1 the number of jobs, compensation, workforce composition, training, and gender equality factors are considered. In particular, as for the job compensation, intended as the average gross monthly salary, the ranges included are related to the average salaries of the European Union in 2020 (Eurostat, 2022; Eurostat 2021). For SocIC2, the direct social impact is closely related to the engagement of certain demography and it is measured in the number and type of events organised or even community training opportunities. Finally, SocIC3 are included ranging from food perception factors (e.g., appearance, texture, and flavour) to external food attributes (e.g., price, animal welfare degree).

For the economic pillar, the focus of the IC is on i) the general profitability and business's future outlook, ii) the embeddedness of CRFSI within the local economy, and iii) the customer and users profile. The EcoIC1 includes profit margins, revenue diversification (e.g., product revenue, activity revenue or other forms of income such as public or private funding) and business's future outlook. The The EcoIC2 is proxied by assessing the locally sourced supply and labour, as well as fair practices towards suppliers. The EcoIC3 is analysed to evaluate citizens' and consumers' fidelity, relationships, and habits.

Finally, the environmental pillar the focus of the IC is on i) the food production supply, ii) resource use efficiency, iii) waste management & circularity and, iv) transport. The EnvIC1 entails elements such as the typology of technology used for crop production, the animal feed provenance, the typology of fishing gears, the inclusion of agricultural biodiversity measures, and food characteristics. The EnvIC2 refers to the use of different resources, such as water, electricity and heating. The EnvIC3 is composed by waste production and measures to reduce or reuse waste. Finally, the EnvIC4 is related to food logistic from suppliers and to consumers.

Table 2 – Social, economic and environmental Impact Categories, Key Performance Indicators with the code, the description and unit of measure

Social					
Impact category	**Code**	**KPI**	**Code**	**Description**	**Unit**
Job (quantity, quality, diversity)	SocIC1	Waged jobs	SocKPI1	The number of employees that receive a salary	N of full time and part time paid employees
		Contract typology	SocKPI2	The prevalent typology of contracts within the organisation	Degree of fixed term/temporary contracts
		Average gross monthly salary	SocKPI3	The average monthly gross wage received by employees.	€/employee
		Workplace Trainings	SocKPI4	The frequency of workplace trainings per employee	Hours/ year/employee
		Gender equality	SocKPI5	Share of female waged employees over the total number of employees	%
Community outreach, engagement & education	SocIC2	Frequency of events	SocKPI6	Frequency of events organised by the initiative for the local community.	frequency /year
		Disadvantaged people	SocKPI7	Activities for the disadvantaged people of local community	Y/N
		Connection with local producers	SocKPI8	Management of food coming from local producers.	Y/N
		Volunteering activities	SocKPI9	Involvement of community people in volunteering activities	Y/N
Food quality	SocIC3	Product characteristics	SocKPI10	Taste, freshness, healthiness and nutritional quality, availability, affordability and fair price, animal welfare, food safety, food chain fairness, variety of food offered, being local, environmental sustainability	Importance degree
Economic					
Impact category	**Code**	**KPI**	**Code**	**Description**	**Unit**
Organisation profitability and outlook	EcoIC1	Annual net profit margin	EcoKPI1	Annual net profit margin in positive or negative percentage	%/year
		Income diversification	EcoKPI2	The revenue produced by product sales, organised activities, and funding received from the public and private institutes	%/year
		Business future	EcoKPI3	Expectancy on the change of the business for the upcoming 3 years relative to product sales, other revenues, profits and number of customers/clients/users	Degree of change
Local economic	EcoIC2	Provenance of employees	EcoKPI4	Area of provenance of the waged employees	Administrative levels

development		Locally sourced supply	EcoKPI5	Supplies sourced locally (from suppliers within a distance of maximum 50 km from your venue)	%
		Suppliers' practices	EcoKPI6	The presence of specific fair practices toward suppliers	Y/N
Customer and users	EcoIC 3	Customers/ Users acquisition	EcoKPI7	New customers or users per year	Degree level
		Customers/users return	EcoKPI8	Quantity of customers coming back after the first time	Degree level
		Customer/user expenditure	EcoKPI9	Expenditure increases of each customer/user	Degree level
		Customers/users return reason	EcoKPI10	Quantity of customers/users coming back because recommended by others	Degree level
		Online selling	EcoKP11	Presence of online selling channels	Y/N
Environmental					
Impact category	**Code**	**KPI**	**Code**	**Description**	**Unit**
Food production/ supply	EnvIC 1	Technology used for crops	EnvKPI1	The technology used for the crops produced, managed or sold	Typologies
		Animal fed provenance	EnvKPI2	The distance of the meat feed produced, managed or sold	Distance degree
		Fishing Gear types	EnvKPI3	Gear types used for the fish produces, managed or sold	Typologies
		Ancient cultivar or local breed	EnvKPI4	Cultivation, management or sell of ancient cultivar and local breed	Y/N
		Characteristics of the products	EnvKPI5	The preferences on some specific characteristics of the food produced, managed or sold	Importance degree
Resource use efficiency	EnvIC 2	Water saving practices	EnvKPI6	Importance of water saving practices	Importance degree
		Electricity sources	EnvKPI7	Typology of electricity used	Renewability degree
		Heating sources	EnvKPI8	Typology of heating used	Renewability degree
Waste management & circularity	EnvIC 3	Waste recycling	EnvKPI9	Amount of recycled waste according to each waste typology	%
		Sustainability commitment	EnvKPI 10	The commitment towards the adoption of a set of practices regarding energy, water, organic waste, materials and packaging	Commitment degree
		Packaging and materials recyclability and compostability	EnvKPI 11	The usage of composable and recyclable packaging and materials.	Recyclability and compostability degree
		Packaging and materials reusability	EnvKPI 12	The usage of reusable packaging and materials.	Reusability degree
Transport	EnvIC 4	Distance from clients/ customers	EnvKPI13	The distance between the initiative and key clients/customers	km
		Type of transport to clients/ customers	EnvKPI14	The type of transport used between the initiative and key suppliers.	Degree of Fossil fuel employment
		Type of transport of supplies	EnvKPI15	The type of transport used between the initiative and their supplies.	Degree of Fossil fuel employment

3.2 Testing

To move each KPIs into metrics for the online scorable survey, these were translated into three types of questions (see SM Table C):

1. Binary question (yes/no), where the no option corresponds to the lower sustainable solution (1 point), and the yes option to the most sustainable one (5 points).
2. 5-points Likert scale with 5 options as answers. The options correspond to a score going from the least sustainable solution (1 point) to the most sustainable solution (5 points). In one of these questions (Q2.4), the '*I don't know* was included as a third one on the scale, with a score of 3 points. This is because, for that kind of question, the lack of related information was considered an indicator of not optimal monitoring of the process and hence of an average CRFSI performance.
3. Set of open questions, whose answer range couldn't be defined after the testing in a consistent way. The choice was established during the co-design approach to leave to the testing phase the responsibility of establishing the quantitative ranges that would lead to Likert-type scoring. These questions are Q1.1, Q1.4. Q2.1. The scored mechanism rationale behind these questions is developed given the percentiles of the cumulate answers considered in the testing phase. It means that answers in the first percentile are meant to be assigned with a score of 1 and answers in the fifth percentile meant to be assigned a score of 5 with the central values following the same reasoning.
4. Other questions (namely Q3.1), in which the respondent was given a list of 11 sustainability strategies from which he/she could choose. The scoring was then based on the number of strategies selected (e.g., 1 to 2 was assigned 1 point, 3 to 4 was assigned 2 points).

Given the necessity to build a scoring system applicable to a large set of CRFSI, active in very different segments of the food supply chain, we foresaw the possibility of two questions being not applicable to a CRFSI. In that case, the choice to include the '*I do not produce, manage or sell'* option as a central value in the scoring scale was taken. These questions are Q3.2, Q3.3.

Additionally, for each sustainability pillar, an additional blank space was included to allow CRFSI respondents in discussing additional points recognized as important and helping the contextualization of results.

The overall sustainability scoring system is then obtained by aggregating the different points.

To guarantee a parallel weight to all KPIs, impact categories, and sustainability pillars, the points of each question are weighted accordingly to the number of questions in the relative KPIs. In turn, the points of each KPIs are weighted accordingly to the number of KPIs in the relative sustainability pillar.

In doing so, each pillar results in a final score between 1-5 which is then aggregated with the remaining sustainability pillars to compose the final single sustainability score for each CRFSI (always from 1-5).

Based on the scoring mechanism, the highest scores (5) correspond to the best sustainability performances, whereas the lowest values (1) are associated with the lowest integration of sustainable choices. Results need to be interpreted both on individual KPIs, on each sustainability pillar, and on the overall integrated sustainability degree level. The sole analysis of the single score is highly discouraged, as it is intended only as a synthetic measure and for dissemination purposes.

The distribution of surveyed 100 CRFSI for testing is described in Figure 1.

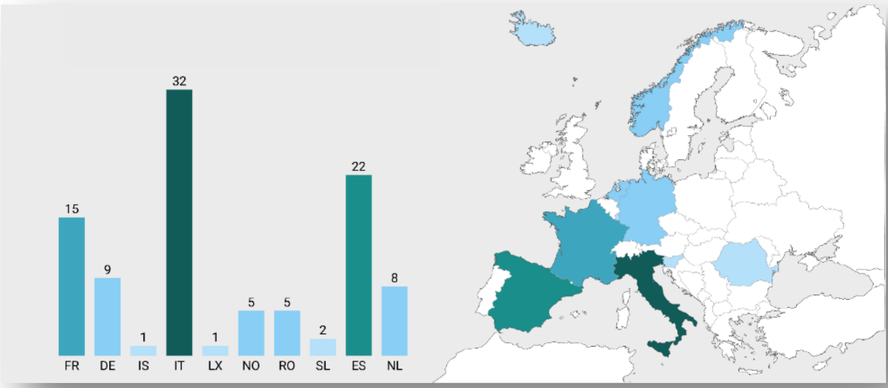

Figure 1 – Geographical distribution of the 100 surveyed City Region Food System Initiatives (CRFSI) across Europe (colour should be used for this figure in print)

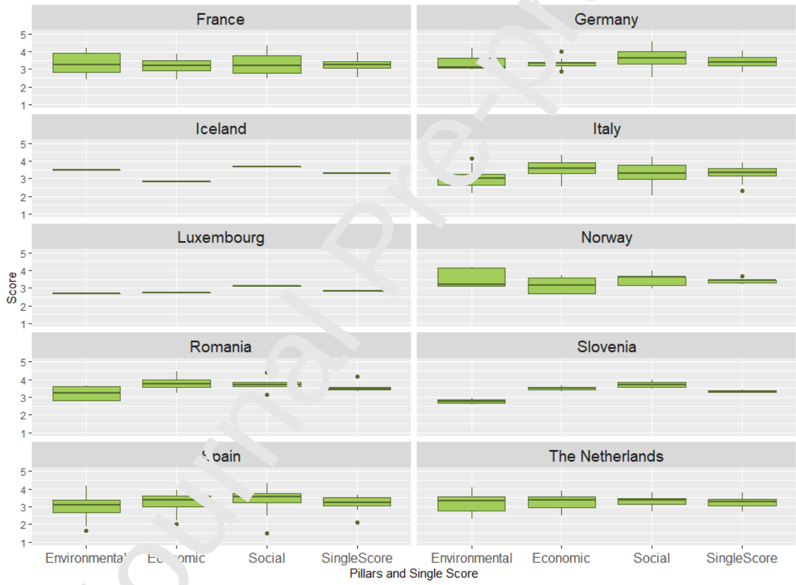

Figure 2 - Pillars and single score for the surveyed City Region Food System Initiatives CRFSI accordingly to Countries (n=100)

Figure 2 and Figure 3 show the total sustainability score and the score per pillar of the 100 CRFSI tested, on average and in different countries.

Overall, the single average score among the three sustainability pillars is 3.30±0.36. Considering the 1-5

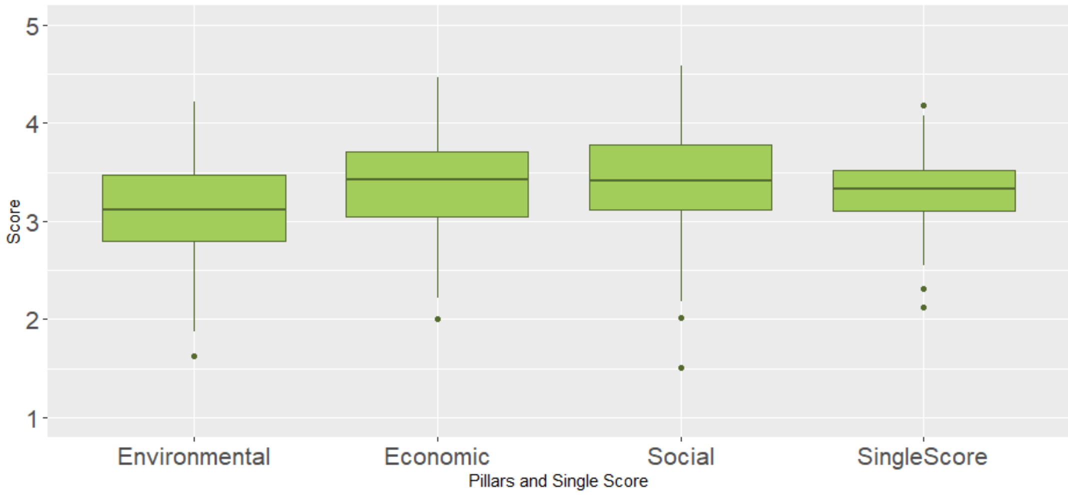

Figure 3 - Pillars and Single score for the surveyed CRFSI (n=100)

scale, this means that the sustainability of CRFSI is on average above the medium level, with only a few outliers having low performances (e.g., 2.18 and 2.31). The scoring results of pillars and single score is quite consistent across different countries, with Germany, Romania, and Norway having a slightly higher than average score. The environmental scoring (3.15±0.10) is on average lower than the economic and social one (3.37±0.09 and 3.39±0.11). In this case, differences among countries are more evident (see Fig. 2), probably due to the diverse typologies of CRFSI involved and the number of responding CRFSI for each EU country.

Social Dimension

Figure 4 shows the average scores for the 3 Impact Categories (IC) of the social pillar. The highest score is related to the *'food quality'* (soclC3) having a value 4.10±0.15. This is followed by the social category *'job'* (quantity, quality, and diversity) (soclC1) (3.07±0.15), and by the '*Community outreach, engagement & education'* (soclC2) (3.00±0.21) even though the values are quite close.

The comparison of three IC (Figure 4) in the box plot shows that IC *'Job'* (soclC1) and *'Community outreach, engagement & education'* (soclC2) are similar on average even though the latter presents a higher level of diversity on the answers. However, the SocIC2 results are more heterogeneously distributed across the median, probably due to the very different settings of the tested CRFSI. The above-average results of this pillar is attributed to IC '*Food quality'* (SocIC3), which also presents the lower answers variability. Such result is explained by the relevance of the food quality concept (Sadilek, 2018) that led consumers/users to a overall consensus on the importance of it.

In general for the social IC, as the Standard Deviation (SD) shows (0.57) concerning its average (3.39), it can be observed that the answers do not present a high level of variability.

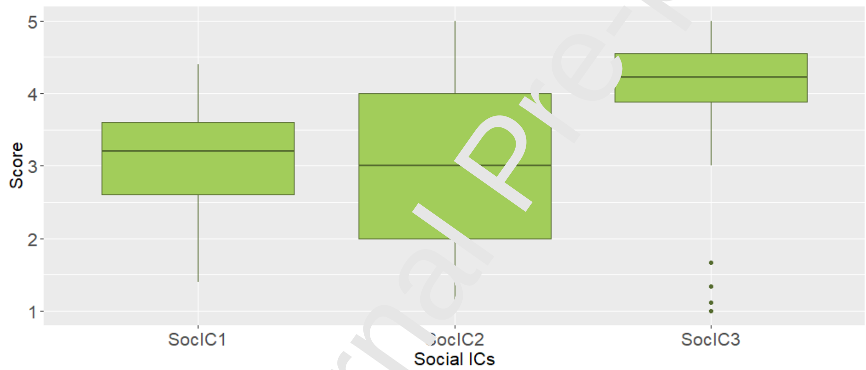

Figure 4 - Social Impact Categories (IC) scoring for the surveyed CRFSI (n=100)

When analysing scores related to KPIs (Figure 5) for each social ICs, it is possible to get a more detailed understanding of the specific drivers of impact in each category. The highest average score is related to *'Product characteristics'* – 4.10±0.15 (SocKPI10), which is the only KPI in the IC *'Food quality*' (soclC3). This result highlights that for CRFSI owners the most important characteristic of their products is the item of *'Taste and freshness'* with an average score of 4.56±0.18. Furthermore, it is important to highlight that '*Local*' and '*Environmental sustainability*' items are the second most important information that CRFSI owners want to communicate to their customer segment with the same average score of 4.40±0.15.

While the second most important social KPI is SocKPI5 *'Gender equality'* – 3.57±0.33, related to the IC

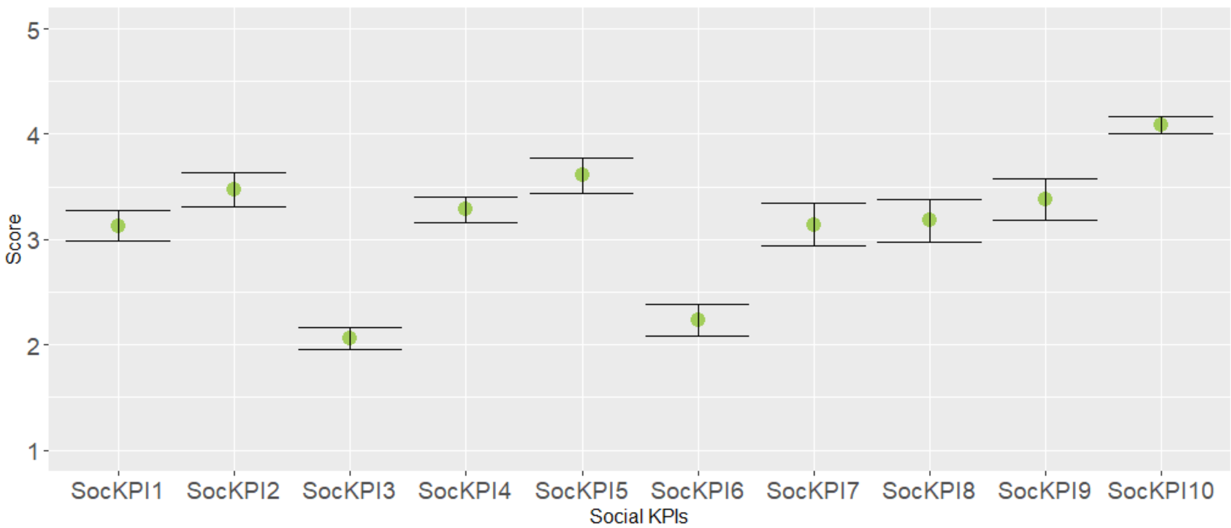

Figure 5 - Social Key Performance Indicators (KPIs) scoring for the surveyed CRFSI (n=100)

'Job quality' (soclC1). This result shows the proactive approach of CRFSI on the management of gender equality in the workplace. It must be noted that gender balance is proxied by the share of women in the workplace, without considering nonbinary individuals as well as qualitative or income-related aspects of gender balance.

However, the low score of SocKPI3 *'Average gross monthly salary'* – 2.05±0.20 means that CRFSI provide a relatively consistent job opportunity to both women and men, with permanent positions, trainings, but with a relatively low salary.

While concerning the IC *'Community outreach, engagement & education'* (soclC2), it is possible to argue that higher scores are derived from SocKPI9 *'Volunteers' activities'*– 3.42±0.38, and *'Disadvantaged people'* (SocKPI7 – 3.18±0.39), and the SocKPI8 *'Connection with local producers'* – 3.18±0.39. Interesting to analyse is the SocKPI6 *'Organization of outreach events'* – 2.22±0.28 which show a low score result and it is clearly affected by the limitations imposed for the spread of Covid-19.

Economic Dimension

Figure 6 shows the average scores for the 3 IC of the economic pillar which presents the lowest variability across indicators. The highest score is related to the '*Local economic development*' (EcolC2) with a value of 3.51±0.19. This is followed by the '*Organization profitability and outlook*' (EcolC1) (3.31±0.14), and then by the '*Customers and users*' (EcolC3) (3.29±0.12).

The box plot in Figure 6 shows that all three IC are similar on average even though EcolC2 presents a higher level of diversity in the answers. Given the great diversity of CRFSI, the definition and evaluation of the local dimension for CRFSI might differ significantly (Forster et al., 2015). There is not a common standard definition for short distances in food supply chains, especially for the diversity of CRFSI (Belletti & Marescotti, 2020). As a consequence, the set distance of 50 km for the EcoKPI5 'Locally sourced supply' results (e.g., fishery related CRFSI) do have different significance depending on the location of each CRFS. However, it can be noted that in general, for the economic IC, the answers do not present a high level of variability (3.37 ±0.47).

Figure 6 - Economic Impact Categories (IC) scoring for the surveyed CRFSI (n=100)

When analysing scores related to KPIs for the economic ICs (Figure 7), it is possible to get a deeper understanding of the specific drivers of impact. The highest average score is related to EcoKPI3 '*Business future*' – 3.82±0.13, which is one of the three KPIs for '*Organization profitability and outlook*' (EcolC1). A deeper overview of this economic KPI highlights that for CRFSI owners the most important change in their Business in the next three years will be the '*Number of customers/clients/users*' with an average score of 4.04±0.16. In addition, also the other items '*Product sales*', '*Other revenues*', and '*Profits*' have a high average score (3.90±0,18; 3.65±0,16; 3.67 ±0,16). It means that most of the CRFSI owners are quite optimistic about the future even with the spread of the COVID-19 pandemic.

Most CRFSI assessed their outlook quite positively in terms of sales, revenues, profits, and customers. A medium score of EcoKPI1 '*Annual net profit margin*' – 3.21±0.25 is reported, while a slightly lower than average value for EcoKPI2 '*Diversification of income*' – 2.92±0.29 is registered.

As mentioned, ties to local economies are demonstrated by the consistently high scores in all EcoKPI4-6 for the EcoIC2 (‘*Provenance of employees’, ‘Locally sourced supply’, ‘Suppliers’ practices*’), in particular when it comes to the adoption of fair practices towards suppliers.

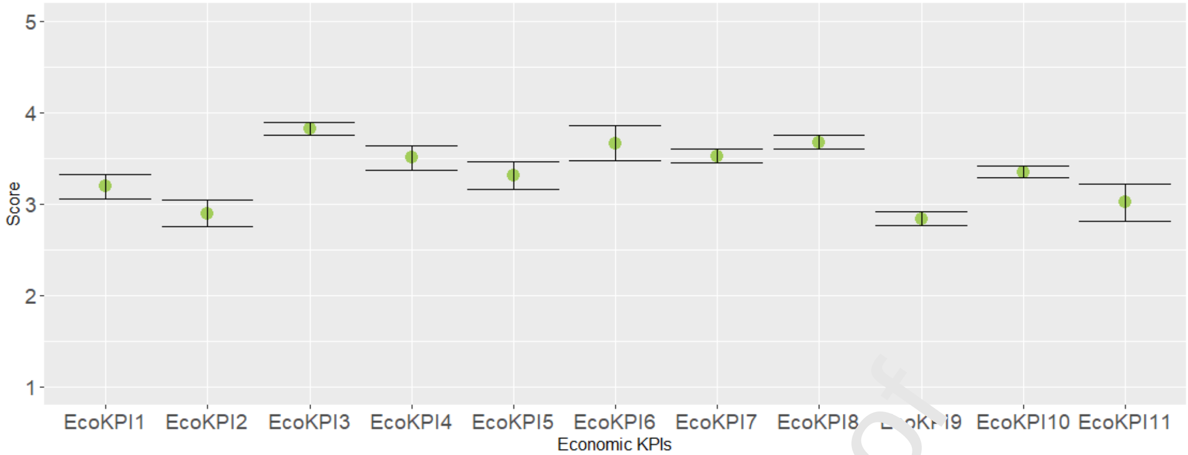

Figure 7 - Economic Key Performance Indicators (KPIs) scoring for the surveyed CRFSI (n=100)

The positive outlook in terms of customers (EcoIC3) is confirmed by the scores related to EcoKPI7 ‘*Customers/users’ acquisition*’ – 3.53±0.15, and EcoKPI8 ‘*Return rates*’ – 3.67±0.15 thanks to the positive effect of the word of mouth (see EcoKPI10 ‘*Customers/users return reason*’). However, their expenditure does not tend to increase (see EcoKPI9 ‘*Customer/user expenditure*’). Finally, as far as online selling is regarded, the average score suggests that such a channel typology is adopted only by 50% of CRFSI.

Environmental Dimension

Figure 8 shows the average scores for the 4 IC of the environmental pillar. The highest score is related to *‘Waste management and circularity’* (EnvIC3) having a value of 3.76±0.68. This is followed by the environmental category *‘Resource use efficiency’* (EnvIC1) (3.21±1.01), and ‘*Food production/supply*’ (EnvIC2) (2.99±0.62) and ‘*Transport*’ (2.63±1.22) (EnvIC4), having the lowest score with the greatest SD. The comparison of the four environmental IC (Figure 9) in the box plot shows that EnvIC1 and EnvIC2 are similar on average even though the latter presents a higher level of diversity on the answers (1.01 compared to 0.62). When we look at the environmental single pillar score (3.15±0.53), the SD shows lower value than the one obtained in the four environmental IC.

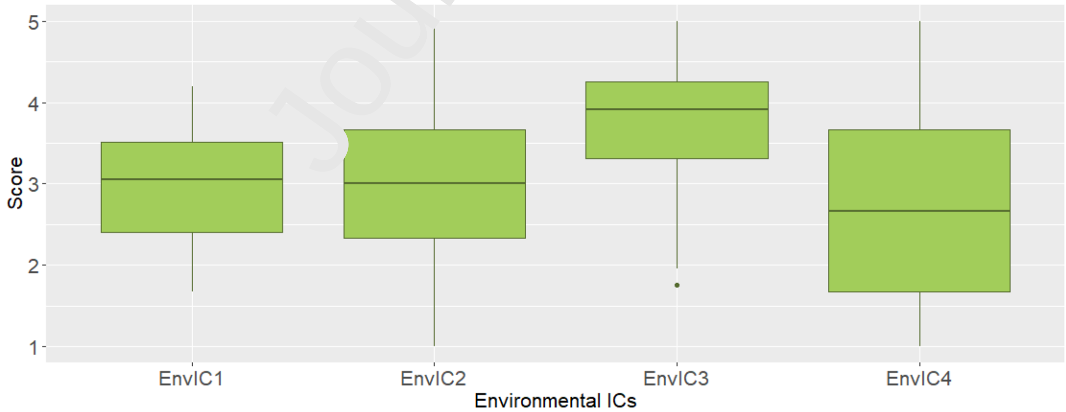

Figure 8 - Environmental Impact Categories (IC) scoring for the surveyed CRFSI (n=100)

When analysing scores related to environmental KPIs in Figure 9, it is possible to get a deeper understanding of the specific drivers of impact. The highest average score is related to EnvKPI6 ‘*Water saving practices’* – 4.11±1.16, which is one of the three KPIs for ‘*Resource use efficiency*’ (EnvIC2). This score is more than 1 point above the other two KPIs of EnvIC2, i.e., EnvKPI7 ‘*Electricity sources*’ – 2.67±1.40, and EnvKPI8 ‘*Heating sources*’ – 2.85±1.63. These two latter KPIs are among the lowest scores across the environmental KPIs. Such a result reveals that CRFSI still use more fossil fuel energy resources than renewable ones. However as highlighted by Gielen et al. (2019) the adoption of more energy efficient infrastructures and

equipment can be more effective than using renewable energies. Such a topic has been already investigated also by the work of Amory Lovins (2019) in which the authors show the huge impact that energy saving technologies had on overall energy consumption in the last 30 years as compared to the adaptation of renewables energies (Michael P Totten. 2020).
The other environmental scores above 4 are obtained by EnvKPI5 '*Characteristics of the products*' – 4.07±1.07, and EnvKPI9 '*Waste recycling* '– 4.07±1.07.

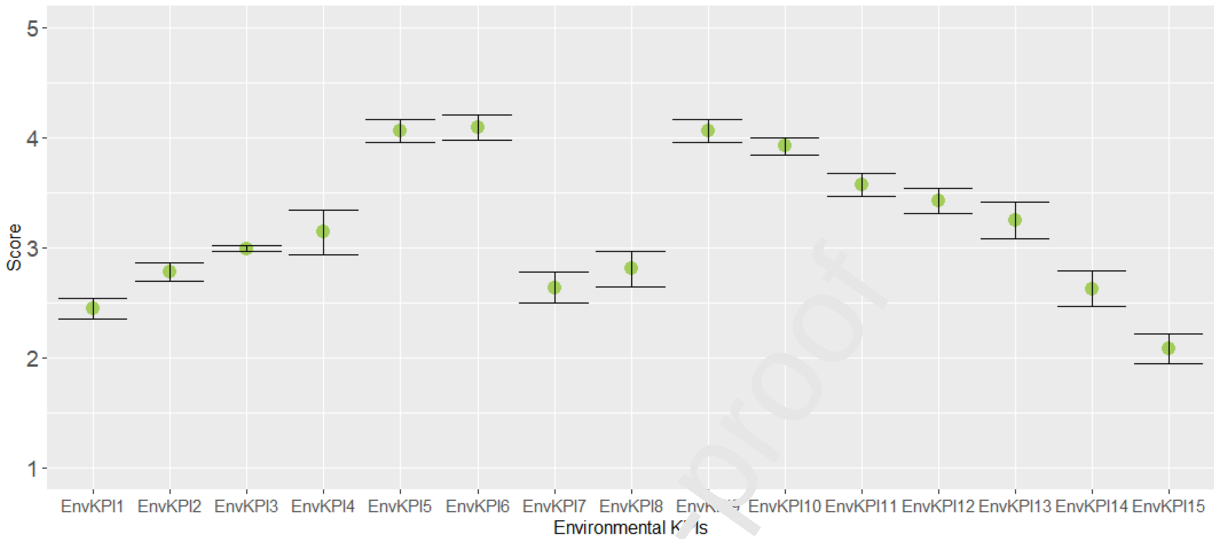

Figure 9 - Environmental Key Performance Indicators (KPIs) scoring for the surveyed CRFSI (n=100)

On the IC '*Food production/supply*' (EnvIC1), the EnvKPI1 '*Technology used for crops'* – 1.98±1.16 is one of the lowest-scoring indicators for the environmental pillar. This score was obtained from the sum of the possible technology strategies implemented by the CRFSI. The greater the number of strategies, the higher the score. However, since the CRFSI represent various sectors of the food supply chain and they are small and medium size activities by definition, the result reveals the difficulty in adopting multiple technological strategies at once. Furthermore, the EnvKPI1 is included in the IC '*Food production/supply*' (EnvIC1) in which KPIs scores are close between them but with a very different variability. See the EnvKPI2 '*Animal fed provenance* – 2.78±0.84, the EnvKPI3 '*Fishing gear types*' – 2.99±0.26, the EnvKPI4 '*Ancient cultivar or local breed* – 3.14±2.01, and the EnvKPI5 '*Characteristics of the products*' – 4.23±1.43. The close value of EnvKPI2 to 3 is due to the frequency of '*I do not produce manage or sell any dairy and/or eggs and/or fish*' answers in the survey sample. However, more than 20% of the CRFSI replied with a specific distance to the question, thus yielding an SD close to 0.80. The choice of kilometre distance set in the scoring system might have influenced the result. This result can both express the evidence that initiatives purchase from long-distance suppliers and/or that distances between buyers and suppliers should be better investigated on the basis of the geographical context. In the case of EnvKPI3 the value is extremely close to 3 due to the fact that almost all answers in the sample were '*I do not produce, manage or sell any fish*' or '*I don't know*', with only 4 answers with specific gear types. This is related to the low representativity of fisheries in the sample, and thus yields a value close to 3 and a low variability of answers.
The second lowest scored indicator is the EnvKPI15 '*Type of transport of supplies'* – 2.06±1.37 in the the IC '*Transport*' (EnvIC4). Considering that CRFSI are located within certain urban-rural areas, it means that transport still occurs using fossil fuel means of travels. While in this EnvIC4 the best-scoring is EnvKPI13 '*Distance from clients/customers* – 3.23±1.64, understandable given that the survey was focused on initiatives level included in the CRFS. Finally, the relatively medium score obtain by the IC '*Waste management and circularity*' (EnvIC4) is also seen in its KPIs with values close to 4 in EnvKPI9 '*Waste recycling* – 4.07±1.07', and the EnvKPI10 '*Sustainability Commitment* – 3.94±0.79', and values close to 3.5 in the EnvKPI11 '*Packaging and materials recyclability and compostability* – 3.58±1.03' and the EnvKPI12 '*Packaging and materials reusability* – 3.44±1.15'.

3.4 Limitations and future research needs

At the core of the CRFS approach there is the need to improve short-range food systems and strengthen rural, peri-urban, and urban linkages based on local production, low dependency on food imports and long-distance food trade (Jennings et al., 2015). As already outlined by Manning et al. (2016), scoring mechanisms can support food systems improvements in monitoring the abovementioned advancements. On this background the work proposed a sustainability scoring system where multiple indicators on the social, economic and environmental dimensions are integrated into a single score. Such integration offers an opportunity to obtain a sustainability performance overview which considers trade-offs between pillars and indicate the most sustainable evaluation option as suggested by Bunge et al. (2022).

The most relevant answers provided in the blank spaces of the online survey were also considered relevant for the discussion of the sustainability scoring system and reported in the SM Table D. Since the scoring system was designed to be as inclusive as possible for different CRFSI dealing with different steps of the food chain (e.g., food production, transportation, distribution, services) and different food typologies (e.g., meat, dairy, vegetables, fruits), some CRFSI faced challenges in answering one or more questions. Specific examples are provided by additional remarks 1-10, in SM Table D. This kind of challenge applies for instance to non-profit initiatives which tend to adopt different financial structures (Cestari et al., 2021) and informal mechanism (Medici et al., 2021). Relatively to other specific models of production, such as Community Supported Agriculture or Solidarity Purchased Groups, they might entail fixed subscriptions for members or customers (Medici et al., 2021) and a constant money collection from this financial source (see additional remarks 5-7 in SM Table D).

An additional point of interest is towards family-owned initiatives. Some of them obtained lower scoring values for the '*Job*' IC given the fact they don't employ anyone outside their family members. In some cases, they also work for self-sufficiency only (see additional remarks 11-13 in SM Table D).

It is also worth noticing that some terms used for the sustainability assessment might have been interpreted differently by each CRFSI. Some examples of how this might have influenced the CRFSI answers are provided in remarks 14-16 of SM Table D. Such a concern suggests that providing the respondents with standardized vocabulary explanation might have helped in standardising the answers meaning. Something similar emerged for the fishery related CRFSI. In EnvKPI3 ('*fishing gear type*'), the large share of the '*I do not produce, manage or sell''* or '*I don't know*' answers might be related to the formulation of the question related to fishing gears, which was interpreted differently from the fishers involved.

The lifespan of each CRFSI could have also influenced the final sustainability scoring. Examples refer to the workplace training or frequency of events which might be harder to organize in newly settled CRFSI. Or still, very young initiatives might have obtained lower sustainability scores in '*Organisation profitability and outlook'* IC because the initial years of activities can be particularly critical from a financial perspective (Bartz and Winkler, 2016) and because it is quite hard to forecast the business future they expect (Lisa-Marie Semke, 2020). In parallel, the total expenditure increase of customers and their return rate might also be quite difficult to be estimated at the very early stage of activity (Terpstra and Verbeeten, 2014) (see remarks 19-21 in SM Table D).

An additional point of attention refers to the fact that people answering the survey can influence the results (Stocké, 2006). In particular, as also highlighted in the additional remarks (SM Table D, Additional remarks 22,23), when the individual is not fully aware of the CRFSI functioning he or she might risk including biased data. Hence, making sure to address the adequate CRFSI stakeholder is a key preliminary issue for the quality of the assessment.

Relatively to the scoring system design, some impact categories were excluded based on prioritisation by stakeholders engaged, to ensure a reduced data intensiveness and guarantee the comparability of the results. As an example, animal welfare is considered just from a customer or user perspective while it is not investigated in terms of production systems. Similarly, stakeholders' trust is captured only through consumers. We recommend future context-based application to further explore those factors. Lastly, the cultural dimension was included in the scoring system through several KPIs disseminated in the pillars (e.g., *'Gender equality'*, *'Ancient cultivar or local breed'*, *'Products characteristics'),* rather than through an ad-hoc pillar. Still, as already highlighted by Pizzirani et al. (2014), further efforts are needed to investigate the role of culture in sustainability assessments. Basing on these considerations, when applications of the sustainability scoring system are conducted in different contexts, stakeholders are encouraged to review and tailor KPIs basing on local characteristics.

4. Conclusions

Given the need of understanding and improving the sustainability performances of the food system in cities and regions from a multidisciplinary outlook, the present work aims to move in this direction.

Based on the Life Cycle Thinking methodology, on the knowledge acquired from previous works and projects and on the extensive participatory approach with representatives from CRFSI, industry, government, universities, and research institutes, a sustainability scoring system for City-Region Food System Initiatives is developed. It is composed by 10 social, 11 economic and 15 environmental KPIs is one of the first of its kind to integrate the social, economic, and environmental pillars in a holistic, transparent, and accessible manner, resulting in a single sustainability scoring.

To identify potential strengths, and weaknesses, the scoring system was then tested in more than 100 case studies in ten European countries. When testing it, from a general perspective, the single sustainability average score among the three pillars (3.30 out of 5 ±0.07) of the selected CRFSI highlights a superior level from the average for the sustainability scoring. Results are characterized by a large degree of comparability across scales, and food sectors confirming the key role of the present mechanism in offering a unique innovative step for the European CRFSI evaluation. Overall, the social dimension seems to be the most high-scoring pillar for CRFSI (3.39±0.11), followed by the economic dimension (3.37±0.09) and the environmental one (3.15±0.10). However, such scores slightly vary concerning the different geographical areas investigated.

With the present work, the CRFSI stakeholders are offered an operational scoring system that guides them through the sustainability assessment process, providing science-based support for policy planning and decision making in the city and region food system domain. Within the FoodE project, this work will also contribute to support processes of business model innovations in the FoodE pilots and FoodE label certification standard, for the integrated sustainability of products. Moreover, the scoring system will be implemented in the FoodE App, to help CRFSI evaluating their sustainability performance and increase their visibility in the CRFS context. Further refinements of the sustainability scoring system will be advisable, with the contributions of stakeholders and researchers, tailoring it to capture additional CRFSI specificities, without endangering the comparability of results. Additionally, future development can strengthen its matching with the United Nations Sustainable Development Goals supporting its progress tracking by a quantitative tool.

Declarations of interest: none

Acknowledgments: The authors thank all partners in the FoodE consortium for their collaboration.

Funding: This work was supported by the funding from the European Union's Horizon 2020 research and innovation programme [grant agreement No 862663]. The publication reflects the author's views. The Research Executive Agency (REA) is not liable for any use that may be made of the information contained therein.

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