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A systematic review of indicators and metrics

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Measuring the social impact of City-region food system initiatives (CRFSIs): A systematic review of indicators and metrics

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ABSTRACT

City-region food system initiatives (CRFSIs) are crucial for sustainable urban development, as they bridge the gap between local producers and consumers, adapt and restructure city-regions, and improve urban food security. Although in political and scientific discourses, CRFSIs are generally associated with positive effects across all sustainability dimensions, research has begun to measure their actual impact. While many studies address their environmental and economic impacts, it is widely argued that social impacts are 'fuzzier' and more difficult to measure. This paper challenges the notion that social impacts are immeasurable by presenting social indicators and metrics in four social dimensions (education, health, community development and economy).

For this purpose, a systematic literature review covering the period 2010–2020 was conducted via the PRISMA method. The analysis of $n = 234$ papers confirmed that social impacts are measurable through various indicators, including quantitative metrics (e.g., kg, €) and qualitative measures (e.g., Likert scales). Health-related indicators were present in 47 % of all analyzed papers. Across the 597 identified indicators, 249 indicators were health-related, followed by indicators related to education (151), economic aspects (105), and community development (92). This review highlights the strong correlations between these different social impact dimensions. It serves as a valuable resource for quantifying social impacts and enabling researchers to assess social sustainability of CRFSIs in the future.

1. Introduction

Owing to the increasing number of inhabitants in cities worldwide and the endeavor to create sustainable urban environments, the topic of sustainable urban food provision is moving to the forefront of social and political debates. In this context, the development of City-region food systems (CRFSs) has become progressively relevant, as conventional agriculture puts increasing pressure on the Earth's natural resources (FAO, 2023). CRFSs are defined as "complex networks of actors, processes and relationships to do with food production, processing, marketing, and consumption that exist in a given geographical region that includes a more or less concentrated urban center and its surrounding peri-urban and rural hinterland; a regional landscape across which flows of people, goods and ecosystem services are managed" (Forster et al., 2015). CRFS initiatives (CRFSIs) are increasing worldwide. They can range from community gardens to local farmers' markets and are spatially related to a particular urban area connected to its surrounding rural areas. They have various impacts, from both an environmental perspective and a social perspective (Millard et al., 2022). Social impacts can concern not only community cooperation and cohesion but also more individual needs, such as impacts on the health of individuals directly or indirectly involved in CRFSIs (Ilieva et al., 2022; Kirby et al., 2021).

Previous research has already demonstrated the significant impact of

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CRFSIs, such as the positive effects of urban agriculture on mental health and human well-being (Gregis et al., 2021; Malberg Dyk et al., 2019). Manual labor and a sense of responsibility for plant growth have been shown to reduce stress (Laquatra et al., 2018) and increase the quality of life in different population segments (Teo et al., 2019). Furthermore, the presence of a CRFSI can significantly increase food accessibility and affordability, as the community actively participates in cultivation-related activities (Albaladejo-García et al., 2021; Cirone et al., 2023). Healthy food accessibility and intake increase owing to both geographical proximity (Jilcott et al., 2011; McGuirt et al., 2018) and cooking skills (Saxe-Custack et al., 2021), as well as the affordability of healthy and locally produced food (Godoy et al., 2017). Involvement in a CRFSI has been shown to have a positive effect on people's diets by increasing fiber intake and reducing the consumption of sugar- and fat-dense products (Raj et al., 2016). Importantly, studies have shown that CRFSIs empower disadvantaged populations, such as children (Plaka & Skanavis, 2016) or low-income households (Aktary et al., 2020). Facilitating healthier dietary changes, e.g., through improved access to fresh fruits and vegetables via market vouchers, could increase consumption by up to 1.4 servings/1000 kcal (ibid.; Herman et al., 2008) and thereby prevent obesity and associated health problems

CRFSIs can play an important role in promoting community well-being among the actors involved. They have the potential to strengthen social cohesion through engagement and educational activities (Cirone et al., 2023) and can serve as a platform for improving the quality of life (Säumel et al., 2022). In addition, CRFSIs promote cooperation, participatory governance, and decision-making across the urban−rural continuum (FAO, 2023). They also provide opportunities for capacity building through multiple long-term cooperation mechanisms (Fei et al., 2023), particularly in raising public awareness of food as a foundation for sustainability.

In economic terms, CRFSIs can create advantages for both producers and consumers. For producers, they grant increased market access by promoting direct sales opportunities such as farmers' markets, community-supported agriculture (CSA), and local food hubs. This access allows producers to bypass intermediaries and retain a larger portion of their profits (Uematsu & Mishra, 2011). For organic farms, the direct marketing strategy (DMS) can lead to an increase in gross sales of 3.39 % compared with organic farms without DMS (Detre et al., 2011). Eliminating intermediaries also allows consumers to reduce the cost of food by buying directly from producers (Elepu & Mazzocco, 2010). When cost reduction is not possible, consumers are often willing to pay premium prices for fresh and local products, leading to higher returns for farmers (Bavorova et al., 2016; Berg & Preston, 2017). By buying locally produced food, consumers contribute to job creation in the whole food supply chain. Local markets are also less affected by global price fluctuations, thus reducing price volatility and offering farmers more predictable prices for their produce. Overall, CRFSIs strengthen local economic stability, as spending on local food tends to stay within the region, thereby stimulating its resilience to global shocks or market disruptions (Mihailović et al., 2020). Overall, CRFSIs can create a more balanced, resilient, and locally integrated food economy, benefiting both producers by increasing market opportunities and profitability and consumers by improving access to fresh, affordable, and sustainable food (Abel & Faust, 2022).

Moreover, CRFSIs can impact education by providing an opportunity to teach citizens about food production and sustainability. Through participation in CRFS-related activities, citizens can acquire tools to become more aware of consumers with increasing knowledge of sustainable and healthy nutrition (Travaline & Hunold, 2010; Pourjavid et al., 2020). Participation in a CRFSI is increasingly used as a teaching tool in schools, which is becoming particularly relevant in urban areas where access to natural areas can be limited (Rogers et al., 2020). Pupils and students who participate in these activities exhibit a higher level of self-esteem and more positive attitude toward science (Patchen et al., 2017; Malberg Dyg & Wistoft, 2018). These types of educational programs also have an impact on students', and more generally, citizens' well-being and on their product choices (Grebitus et al., 2017; Brennan et al., 2021). For example, the Nourish intervention in Project Daire (Brennan et al., 2021) shows that there can be a significant reduction in behavioral problems (by -0.82 points) and improved nutritional knowledge (e.g., by +0.15 points in food labeling) in children through interventions focused on CRFSIs.

General literature reviews such as that by Säumel et al. (2022) analyze existing policies and strategies to promote CRFSIs, such as regulatory frameworks or urban planning guidelines, but neglect the systematic recording of indicators to measure social impacts. At the same time, narrowly focused reviews dominate, which examine only individual dimensions, e.g., health impacts, such as the reduction in childhood obesity (Rahman et al., 2011) or the interactions between health and soil ecosystem services (Schram-Bijkerk et al., 2018). While such studies provide valuable insights into specific aspects, such as the role of urban gardens in physical activity, stress reduction and social cohesion, there is a lack of systematic integration of all four areas of health, education, community development and economics. In addition, many reviews are limited to specific CRFSIs, such as aquaponics (Greenfeld et al., 2018) and food pantries (An et al., 2019; Long et al., 2019), or focus on specific population groups, such as children (Rahman et al., 2011), vulnerable groups (Malberg Dyg et al., 2020) or low-income populations (Poulsen et al., 2015). Although some studies, such as Kunpeuk et al. (2020), address the diverse social impacts of CRFSIs, they do not systematically record indicators that could enable these effects to be measured. Other reviews, such as Verger et al. (2019), consider metrics but limit them to individual aspects, such as food security and dietary diversity, without including economic or community-related effects. Although studies such as that of Warren et al. (2015) analyze the relationships between urban agriculture and food security and between dietary diversity and nutritional status, they remain limited to these individual dimensions and do not integrate an overarching assessment framework for CRFSIs. Even approaches that adopt a multidimensional perspective, such as Hunter et al. (2019), who analyze the environmental, health, welfare, social and equity impacts of urban green spaces, do not take economic and educational dimensions into account and focus primarily on interventions.

However, the benefits are difficult to quantify. Three primary challenges hinder progress: (1) the absence of consensus on social impact frameworks, (2) inconsistent methodologies (e.g., varying indicator definitions, data collection protocols), and (3) fragmented or inadequate databases for social metrics. These issues create barriers to rigorous scholarly analysis and practical implementation, limiting the ability to compare findings or scale solutions. This situation not only complicates scholarly discussions on the topic but also hampers the practical application of methods for measuring social impacts. The outlined challenges highlight the urgent need to analyze measurement frameworks for CRFSIs and prompt us to pose the following core research questions:

1. To what extent can the social impacts of a CRFSI be measured, and what methodological challenges exist? (Measurability)
2. Which indicators and metrics exist for assessing a CRFSI's social sustainability? (Indicators & Metrics)
3. To what extent can the social impacts of a CRFSI be identified and analyzed beyond the health dimension? (Multidimensional Assessment)

Our review addresses the identified research gaps by systematically analyzing existing measurement approaches across all four dimensions—health, education, community development, and the economy. By integrating a comprehensive range of indicators, we establish a scientific foundation that captures the full complexity of CRFSIs. Unlike previous studies, our overarching analysis critically evaluates the practical applicability of existing metrics while identifying robust, generalizable indicators. This work directly challenges claims about the immeasurability of social impacts by demonstrating how qualitative and quantitative approaches—from participatory community assessments to standardized economic metrics—can systematically capture social impacts. By defining measurable indicators, we provide actionable evidence to refute skepticism about the validity of social impact assessments. The identification of these standardized metrics is essential not only to advance the understanding of the role of CRFSIs in sustainable food systems but also to empower policy-makers in prioritizing initiatives that holistically address health, equity, and environmental resilience.

2. Method: literature review

2.1. Data collection

The data collection was carried out by four research teams via the Preferred Reporting Items for Systematic review and Meta-Analyses (PRISMA) method. This systematic literature review intended to map the social dimensions of CRFSIs and to create a list of indicators and metrics for measuring their social impact (Page & McKenzie et al., 2021). In the context of this paper, indicators are understood as measurable variables that serve to record certain states, trends or changes in a specific area (Walz, 2000). Metrics are subordinate to indicators. They are specific units or data points that can be used to objectively measure and quantify success or general development (Collins, 2024). The PRISMA method is based on a 4-phase flow diagram to filter examined papers according to the specific research purpose (Selçuk, 2019; see Fig. 1).

In addition to the 4-phase flow diagram, the 27-item checklist is essential to this method. These items relate to specific parts of the paper. For example, according to this checklist, the title can be used to assess the relevance of the paper for the purpose of the review (PRISMA statements, 2023, http://prisma-statement.org/).

To standardize the data collection, we jointly developed a protocol for conducting the literature review. To fully cover the social impacts of CRFSIs, the team was divided into four subgroups, which allowed the four social impact dimensions of this research to be systematically covered:

1. Educational impacts
2. Health impacts
3. Community development impacts
4. Economic impacts

Papers were retrieved from the scientific databases Web of Science and Scopus in 2021. In preparation, an initial list of 28 X-keywords and 40 Y-keywords was created (see the Supplementary Material; Annex B). The keyword search considered various CRFSI types (X) (e.g., urban agriculture) with different social impacts (Y) (e.g., food access). The initial keyword list was tested in the four subgroups and refined through an iterative process. After this pretest phase, which took place between November 2020 and January 2021, the list was finalized. If a combination of X and Y yielded over 100 results, an additional search term was used to refine the datasets.

English-language and peer-reviewed articles from 2010–2020 were collected and systematically reviewed. Only empirical papers reporting tangible social impacts with indicators and metrics were included in the final analysis. Duplicates between Scopus and Web of Science were removed through automated and manual checks. The baseline data from these papers, including years, first author, DOI, database source, country analyzed and identified indicators and metrics, were entered into an Excel spreadsheet. The selected papers were stored in the shared online literature database Zotero to archive a complete collection and to access these papers during the analyses.

The PRISMA process started with $n = 17{,}759$ papers, which were significantly reduced through the screening phases (see Fig. 1).

After screening for titles, keywords and abstracts, the pool of papers was reduced to $n = 1301$. Of these, 616 papers were eliminated at the eligibility step, decreasing the number of selected papers to $n = 685$ papers. After the full text of the remaining papers were read, the number of papers was further reduced to $n = 279$. The main reason that papers were excluded at this stage was that they did not present a clear methodology with tangible indicators and metrics. Finally, 45 papers were removed after the full text of the papers was reviewed in detail, which led to a final sample of $n = 234$ papers that were included in the analysis (see the Supplementary Materials; Annex A).

2.2. Data analysis

The analysis included several parameters. In addition to the extraction of the applied indicators and metrics, it included the distribution of papers across the four dimensions, their quantitative distribution and chronological classification by year of publication, and their geographical distribution by continent. It also categorized the methods used,

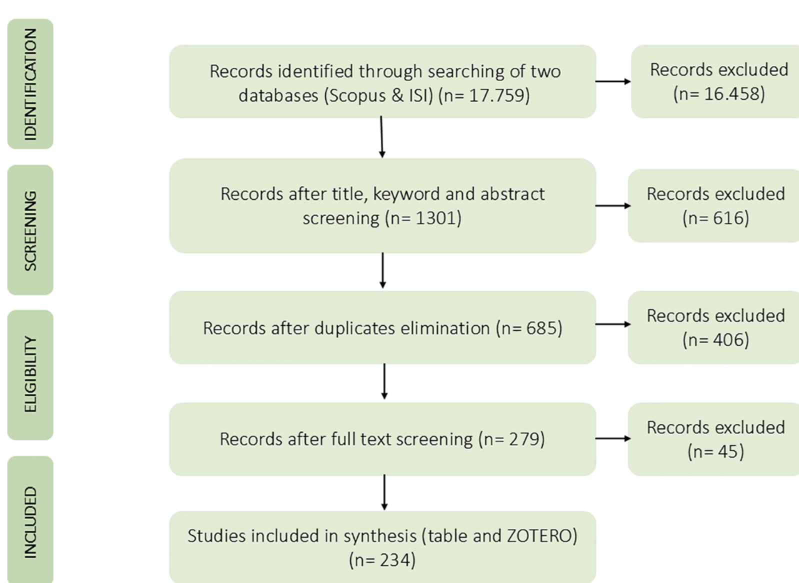

Fig. 1. 4-Phase diagram of the PRISMA method applied for this review.

distinguishing between quantitative, qualitative, mixed methods, interventions, medical studies, life cycle assessment (LCA) and spatial analysis.

Quantitative methods focus on data collection and statistical analysis, whereas qualitative methods examine subjective experiences and opinions (Barella et al., 2024; Busetto et al., 2020). In addition, mixed methods, which combine these approaches, are distinguished. Furthermore, interventions and medical studies are presented as separate methodological categories. Interventions, which are planned actions to identify problems or implement changes (Melnyk & Morrison-Beedy, 2012), are analyzed separately owing to their aim of actively influencing systems to engender positive effects. By analyzing interventions in the context of the social impact of CRFSs, it is possible to show how targeted interventions can influence local food systems and social structures. In addition to general interventions (such as educational interventions), medical studies are treated as a separate methodological category focusing on patient-oriented studies to evaluate treatments and interventions in medicine and health care (Cuschieri, 2019). Thus, these two types of interventions are considered separately in this paper. The LCA method systematically analyses the potential environmental impacts of products or services throughout their life cycle (Hauschild et al., 2018). Finally, spatial analysis is regarded as a different type of methodology (Paramasivan & Venkatramanan, 2019).

An inductive approach was chosen to inform indicator categories (Mayring, 2014). By developing categories based on the data, a total of 23 different indicator categories were formed as follows: [User group]; [Diet/consumption]; [Food waste]; [Income]; [Economic yield]; [Investment performance]; [Food security]; [Neighborhood food environment]; [Distance connection]; [Frequency at outlets visits]; [Costs]; [Accessibility]; [Revenues]; [Physical activity]; [Participation & cooperation]; [Consumer purchase attitude]; [Economic efficiency]; [Educational impact/skill development]; [Social benefit/bonding]; [Health/well-being]; [Knowledge/awareness]; [Stakeholder attitude]; and [Others]

3. Results

3.1. General overview: quantity of publications

The result of the PRISMA method after the entire process is a total of 234 papers containing indicators and metrics on the social impacts of CRFSIs (see Table 1).

As described in Section 2.1, there was a significant reduction in the number of papers across the four dimensions. The *education* dimension started with $n = 8486$ papers and was reduced to $n = 48$ through the review process. The *health* dimension also showed a significant reduction, from $n = 7503$ to $n = 117$. However, this reduction is smaller than that in the *education* dimension. For the *community development* dimension, $n = 1299$ papers were identified, which then decreased to $n = 40$ after the phases. The *economic* dimension had the lowest number of papers, with $n = 471$ at the beginning, $n = 45$ at the end.

3.2. Distribution by dimension

A closer look at the four dimensions reveals that the *health* dimension, with approximately 110 papers, accounts for approximately half of the final number of papers (see Fig. 2).

This result means that most authors address and measure the health impacts of CRFSIs. This finding is also reflected in previous studies (Brennan et al., 2021). Therefore, researchers have linked health impacts primarily with the topic of CRFSs. With 47 papers (20 %), the *education* dimension had the second-highest number of papers. This result shows that the effects of CRFSIs can also be measured in education, as highlighted by Adams et al. (2014) and Dannefer et al. (2016). The *economic* dimension followed closely behind, with 41 papers. Finally, the *community development* dimension, with 36 papers (approximately 15 % of the total number of papers), featured a narrower range of indicators and metrics.

3.3. Distribution by year

The year of publication was an important indicator for the review from which initial findings could be derived. The period from 2010–2020 was considered (see Fig. 3).

Over the past ten years, there has been a significant increase in the number of papers in all dimensions addressing the social impact of CRFSIs. Since the beginning of the observation period, the *health* dimension accounted for the largest share of papers. In 2010, the *education* dimension was not even included in the research. Only at the beginning of 2012 were these social impacts identified and analyzed in the papers, albeit to a lesser extent. Since 2015, there has been an increase in the overall number of papers published. Examining the overall trend over the decade, we can observe consistent growth in publications related to the social impacts of CRFSIs in all four dimensions: health, community development, economics, and education. This general upward trend suggests that the importance of the social impacts of CRFSIs has grown significantly in the scientific community and that the measurability of social impacts is also coming to the forefront. When comparing the periods 2010–2015 and 2016–2020, we observe a notable acceleration in the number of publications across all dimensions in the latter period, further emphasizing the increasing focus on this area of research.

3.4. Spatial distribution by dimension

The review included only English-language papers, but the results clearly show that the social impact of CRFSIs has been addressed not only in English-speaking countries but also in a range of research on the subject worldwide (see Fig. 4).

In total, the topic was analyzed in 44 countries representing 6 different continents. North America has the largest number of papers ($n = 109$), which may be because only English-language papers were analyzed. Europe follows with $n = 68$. This number includes both

Table 1
Summary of the article selection process.

	PAPERS IDENTIFIED	TITLE AND KEYWORD SCREENING	ABSTRACT SCREENING	DUPLICATES ELIMINATION	FULL TEXT SCREENING	ZOTERO STORAGE
	Records identified through database searching	*Records after title and keyword screening (n=) to exclude obvious errors*	*Records after abstract screening (n=) Empirical research that includes promising indicators*	*Number of papers with full text available after duplicate are removed*	*Records after full text check for indicators and metrics informing the results table*	*Number of papers with full text available and stored in Zotero*
Education	8486	2873	504	235	48	48
Health	7503	1072	487	227	133	117
Community development	1299	370	189	147	53	40
Economic	471	246	121	76	45	45
Total	17,759	4561	1301	685	279	250
Total after data cleaning (merging of duplicates across groups; removal of non-peer-reviewed papers; removal of nonempirical papers)						234

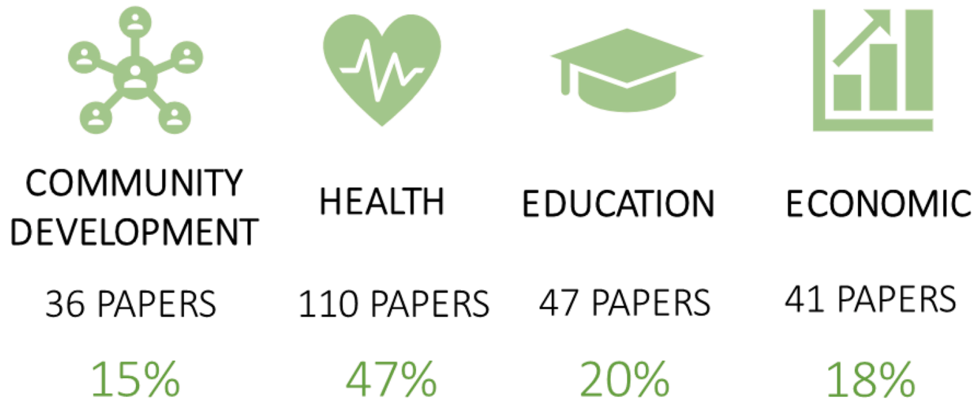

Fig. 2. Classification of reviewed papers into the four social dimensions.

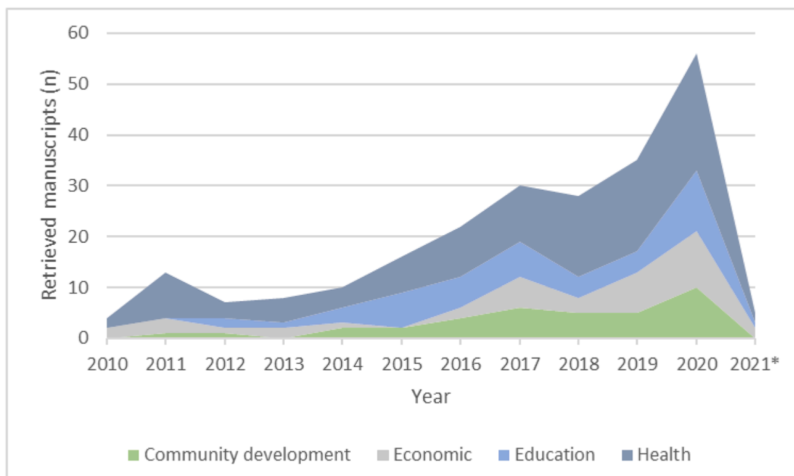

Fig. 3. Number of papers by year. * Some manuscripts ($n = 5$) that were released in 2020 and later assigned to a journal in 2021 are included in the graph.

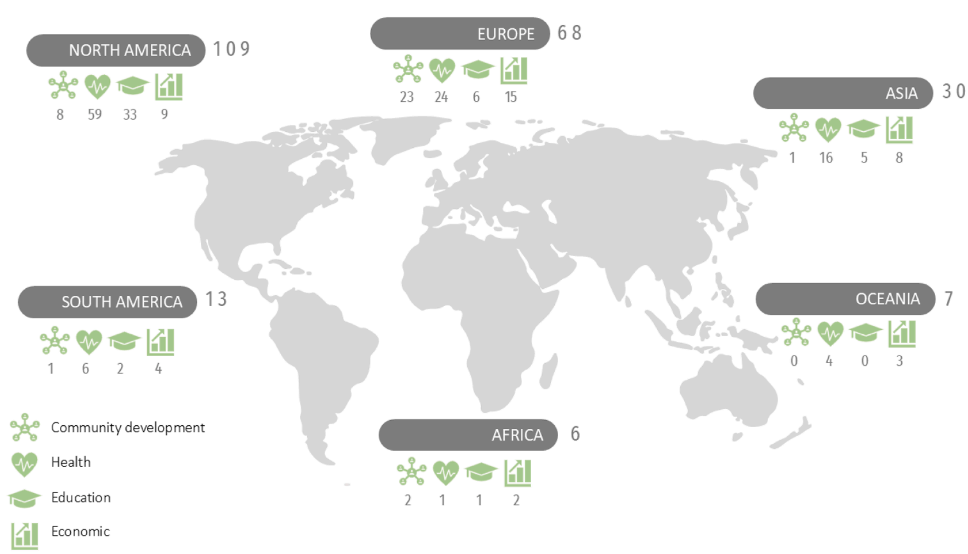

Fig. 4. Paper distribution by geographical area and social impact dimension.

individual countries in Europe, such as urban areas in Spain or Sweden, and international collaborations between multiple European countries (Monaco et al., 2017; Mulazzani et al., 2017; Škamlová et al., 2020). Papers from Asia ($n = 30$), South America ($n = 13$), Oceania ($n = 7$) and Africa ($n = 6$) are also included in the total of 234 papers.

All continents, except for Africa, have in common that the *health* dimension always has the largest number of papers. In Asia, Oceania, South America and North America, this dimension accounts for more than half of the papers. This finding shows that researchers have prioritized this type of social impact in their research. At first glance, these impacts may be easier to measure than, for example, social impacts in the field of education. In terms of the *community development* dimension, Europe has the largest number of papers ($n = 23$), meaning that one-third of the researchers in Europe have focused on community impacts. In Africa, one-third of the filtered papers are community oriented ($n = 2$). Within North America, this dimension has received the least attention ($n = 8$). This trend was also observed in Asia, Oceania, and South America.

With respect to the papers that measure and present the economic impact, the analysis shows that on all continents except North America, this dimension includes a higher number of papers than does the *education* dimension. In Europe, this dimension has the third highest number of papers, with $n = 15$, but in Africa, it accounts for the highest number of papers, equal to the *community development* dimension. In Asia, South America and Oceania, papers with indicators and metrics for the economic dimension account for the second largest number of papers. North America is the only continent where the *education* dimension has more papers than does the *economic* dimension. With $n = 33$ and a share of approximately 30 % of the total, North American researchers are the most active in this area worldwide. In contrast, Oceania does not have a single paper in this review addressing this dimension. The other regions have also not focused much on *education*.

3.5. Methodological approach of the analyzed papers

An analysis of the methods used in the papers shows that the majority use *quantitative* methods to measure social impacts (59 %; see Fig. 5). This large number of quantitative approaches indicates that most studies aimed to make these impacts reproducible and to find patterns in the numerical data. This finding supports the underlying assumption of the paper that social impacts can indeed be quantified.

Only 12 % of the papers used *qualitative* methods. This category is closely followed by *mixed* methods studies (11 %). The other methodological classifications, with the exception of *interventions* (10 %), tend to make up a smaller proportion of the overall sample. Only 2 % of the studies used *spatial analysis*, which include Caputo et al. (2020), Gustafson et al. (2013), Jilcott et al. (2011), Mcguirt et al. (2018) and Wang et al. (2014). The share of the *LCA* method is also relatively low at 1 % (Bergstrom et al., 2020; Caputo et al., 2020; Zhen et al., 2020). The *medical study* method accounts for a slightly higher but still small share (5 %). Exemplary papers on this topic include Zick et al. (2013), Walsh et al. (2020) and Porter et al. (2019).

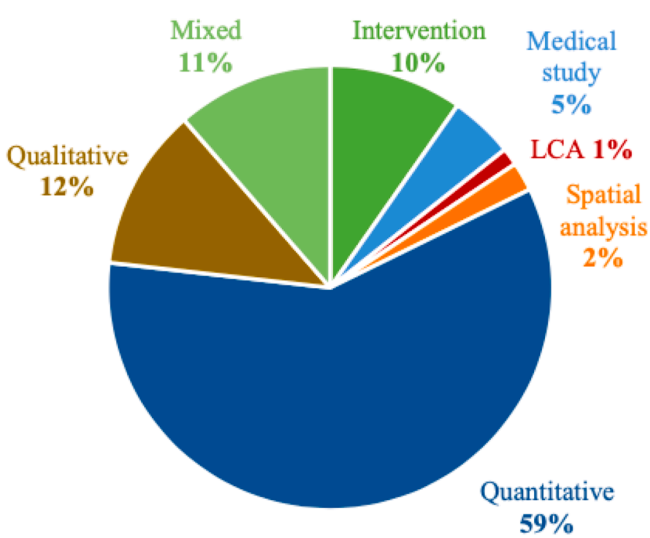

Fig. 5. Overall distribution of methodological approaches ($n = 234$).

3.6. Measuring the social impacts of CRFSIs

3.6.1. Educational impacts

A detailed analysis of the four dimensions reveals a dominance of *quantitative* research methods. The *education* dimension accounts for 53 % of all the studies analyzed ($n = 47$; see Fig. 6**a**).

A striking feature of this dimension related to *interventions*, which accounts for the second largest proportion of studies under *education* (28 %) and the largest proportion overall compared with the other three dimensions. Interventions are used specifically in *education* in the context of CRFSIs to measure students' changes and developments after a certain activity or program. Interventions can therefore be used as an effective basis for measuring social impact in the field of education. The *mixed* methods approach was used in 11 % of the studies in this field to demonstrate the impact of specific educational programs implemented in the context of CRFSIs. Purely *qualitative* methods were used in only 6 % of the studies reviewed. Medical studies accounted for 2 % of studies (see Fig. 6**a**). *LCA* and *spatial analysis* were not used in any of the reviewed papers.

The indicator categories in the literature review also show a dominance of the *education* dimension in terms of frequency ($n = 47$). A total of 11 of the 23 indicator categories were covered in the papers with an *education* focus (see Fig. 6**b**). There papers have either several indicators in the same dimension but with different metrics or have completely different sets of indicators that are intended to be linked (Adams et al., 2014; April-Lalonde et al., 2020). In particular, the indicator categories "knowledge/awareness" ($n = 32$), "diet/consumption" ($n = 32$) and "educational impact/skill development" ($n = 26$) were the most represented. In particular, the first and third indicators are clearly associated with this dimension because of their reference to *education*. The indicator of nutrition also appears frequently because papers often explore the link to nutritional changes or habits in schools (Dannefer et al., 2016), in addition to benefits or changes in knowledge or skills, e.g., of students (Kim & Park, 2020).

These three dominant indicator categories are followed at a considerable distance by the category "stakeholder attitude" ($n = 19$), which addresses attitudes and expectations. The papers in this category analyze attitudes toward local food systems and new farming methods such as aquaponics (Love et al., 2015; Brown-Fraser et al., 2015; Sonti et al., 2016). The next category is "health/well-being" ($n = 15$). Papers in this area, such as those by González-Fernández et al. (2020) or Laquatra et al. (2018), address perceived and reduced stress or benefits for children's health resulting from CRFSIs.

Table 2 provides an overview of the results of the literature review, including the indicators, the metrics, and their sources.

The indicators described above for the *education* dimension are also associated with different metrics. For indicator categories that appear more frequently in papers, such as the categories "diet/consumption" or "knowledge/awareness", there is no single metric that is universally used by researchers to measure the social impact of CRFSIs. Instead, many potential metrics are used.

Another striking common feature of many indicators across the

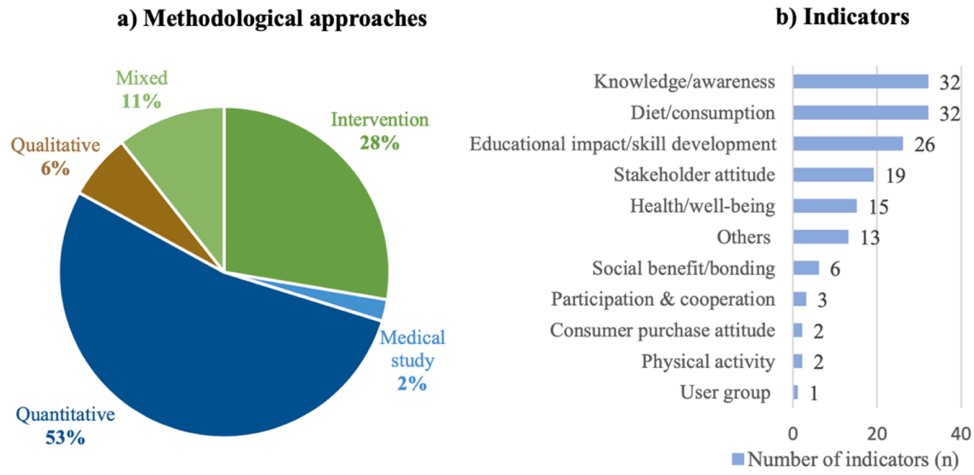

Fig. 6. Distribution of methodological approaches (a; $n = 47$) and distribution of the indicators (b; $n = 151$) for the education dimension.

dimensions is that, in addition to clearly defined units such as kg or cm, by which "health/well-being" are measured, the indicators are often measured via Likert scales. These scales are "a psychometric response scale primarily used [...] to obtain participant's preferences or degree of agreement with a statement or set of statements" (Bertram, 2007). Likert scales can therefore be used to capture participants' ratings. Typically, the ratings of individuals are combined to produce a total score, which then provides information about the extent to which all respondents agree or their average view. It is therefore a way of measuring indicators that cannot be directly quantified, especially those with a social focus and that relate to the respondents' point of view, such as "social benefit/bonding", "emotions", "educational impact/skill development" or "knowledge/awareness". The high proportion of Likert scales is therefore also reflected in Fig. 6, which shows that the papers adopted primarily quantitative methods. Researchers worldwide employ these scales to make subjective indicators objective.

In addition to rating scales, papers often refer to numerical data, such as "no. of school-gardening initiatives" (Gómez-Villarino & Ruiz-Garcia, 2021) or "no. of participants/meeting" (Adams et al., 2014). Through these data, researchers aim to reflect a development or a current situation. This insight is particularly important for the "knowledge/-awareness" indicator.

Another striking feature across the analyzed dimensions is that the indicator categories "diet/consumption" and "health/well-being" present many metrics in quantitative terms, which are derived from educational initiatives; a variety of these indicators can be identified. Specific quantities such as kg or g are used (Veldheer et al., 2020). In the category "health/well-being", metrics such as beats/minute (BPM) or blood pressure values measured in mm Hg are used (ibid.). BMI, which is measured in kg/m^2 (ibid.), is also used in this category. One of the reasons for the use of these metrics is that these indicators are related to the health conditions and physical characteristics of a person, which, unlike education-related indicators, can be measured in concrete units. Nevertheless, Table 2 shows that the latter are also measured in "Others".

3.6.2. *Health impacts*

For the *health* dimension ($n = 110$), *quantitative* methods constitute the majority of the research methods (64 %). *Mixed* methods are the second most commonly used method (11 %), followed by *interventions* (9 %; see Fig. 7**a**).

Compared with the other three dimensions, *health* has the highest proportion of medical studies. The reason is that, as the term suggests, medical studies analyze the health of individuals (National Cancer Institute, 2024). While educational interventions still account for approximately 28 % of all interventions, they are only the third most common method used in evaluating the health dimension. *Medical studies* were used to a similar extent (8 %).

As the *health* dimension has the largest number of papers, there is also a larger number of indicator categories ($n = 17$). The impacts related to the *health* dimension are related to the involvement of an individual in the activities of a CRFSI rather than to the presence of a CRFSI in a geographical area. This dual nature of the impact helps explain the higher number of indicators in this dimension and the difficulty in defining an indicator or set of indicators capable of measuring its impact.

Fig. 7**b** clearly shows that the "health/well-being" indicator category is the most represented ($n = 98$). The reason is that most of the papers in the *health* dimension address the impacts on health, both physical and mental. For example, the extent to which CRFSI or activities affect the mental health of participants (Ambrose et al., 2020) or certain physical areas, such as blood pressure (Porter et al., 2019), is important. Researchers should also be able to determine the effects of CRFSIs on body weight, for example. For example, George et al. (2015) and Litt et al. (2017) use such biometric data to determine how dietary changes related to a CRFSI can affect obesity.

However, diet also plays a central role in health-related papers, as diet can have a significant impact on the health of everyone. This fact is also reflected in the large number of mentions of the "diet/consumption" indicator category ($n = 54$). Many papers examine, among other points, the relationship between diet and physical well-being or changes in participants' diet (Carney et al., 2012; Hartwig & Mason, 2016).

Indicator categories such as "knowledge/awareness" or "income"

Table 2
Social indicators and the associated metrics and sources from studies focusing on the education dimension.

Social indicators	Metrics	Selected references
Social dimension 1: Education		
Knowledge/awareness	• Likert scale evaluation of knowledge gain • No. of correct answers • No. of respondents reporting knowledge/skill improvement • No. of participants • Likert scale evaluation of environmental attitudes • No. of mothers reporting increased maternal knowledge • Likert scale evaluation of the importance of knowledge exchange • No. of pro-environmental behaviors • No. of educational methods	Hardin-Fanning et al., 2018; Hoefkens et al., 2012; Kim & Park, 2020; Morano & Tzouanas, 2017; Nordhagen et al., 2019; Rogers et al., 2020; Rogge et al., 2020; Schneller et al., 2015; Stallings et al., 2016; Teo et al., 2019; Wooten, 2018; Zendehdel et al., 2018
Diet/consumption	• Cups/day; servings/day (fruit & vegetables); vegetables/day • No. of households consuming garden vegetables • No. of teachers noting dietary changes • Times/month, week, day (frequency of fruit, vegetable, or beverage intake before and after intervention); days/week (of main meals & snacks) • No. of different fruit types consumed • Likert scale evaluation of dietary preferences • Likert scale evaluation of the willingness to try new fruit & vegetables • Consumed food in g (fruit & vegetables); g/day (total fiber, added sugar, saturated fats); gram/1000 kcal • Community garden ranking as produce source (1st, 2nd or 3nd) • Likert scale evaluation of dietary self-efficacy of students • % (salt intake) • kcal/day (energy consumption) • teaspoon/day (added sugar consumption)	April-Lalonde et al., 2020; Castro et al., 2013; Dannefer et al., 2016; Di Noia et al., 2015; Di Noia et al., 2017; Gatto et al., 2012; Greer et al., 2018; Gregory et al., 2016; Kim & Park, 2020; Plaka & Skanavis, 2016; Raj et al., 2016; Saxe-Custack et al., 2021; Stallings et al., 2016; Teo et al., 2019; Veldheer et al., 2020
Educational impact/ skill development	• Student grades • No. of universities/teachers recognizing benefits from campus garden • Likert scale evaluation of school engagement • No. of school-gardening initiatives • No. of families observing positive effects on their children • No. of correct answers • No. of opportunities/high impact activities for students • Likert scale evaluation of changes in child behavior • No. of respondents reporting learning outcome	Burt et al., 2020; Craver & William, 2014; Dannefer et al., 2016; Duram & Klein, 2015; Gatto et al., 2012; Gómez-Villarino & Ruiz-Garcia, 2021; Grier et al., 2015; Hoefkens et al., 2012; Laquatra et al., 2018; Morano et al., 2020; Sonti et al., 2016
Stakeholder attitude	• Likert-scale evaluation of attitudes toward local food • No. of respondents willing to pay for aquaponic products • No. of respondents experiencing improvements through community gardens • No. of universities recognizing benefits of campus garden • No. of respondents reporting a learning outcome • Likert scale evaluation of motivation for aquaponics • Likert scale evaluation of emotional intelligence of students • Likert scale evaluation of user satisfaction	Brown-Fraser et al., 2015; Di Noia et al., 2015; Duram & Klein, 2015; Grebitus et al., 2017; Greer et al., 2018; Love et al., 2015; Miličić et al., 2017; Moore et al., 2014; Park et al., 2016; Sonti et al., 2016
Health/well-being	• No. of families noticing positive effects on their children • Likert scale evaluation of children's quality of life • mm Hg (blood pressure) • beats/minute (heart rate) • Likert scale evaluation of psychological distress • No. of applicable responses regarding perceived stress • kg/m^2 (BMI) • Cm (waist circumstances)	González-Fernández et al., 2020; Laquatra et al., 2018; Saxe-Custack et al., 2021; Teo et al., 2019; Veldheer et al., 2020
Others	• Likert scale evaluation of self-perception of hydroponic and cooking skills • Participants' attitudes toward science • Urban farming internship impact • Influencing factors for aquaponics • Likert scale evaluation of food neophobia	Craver & William, 2014; Gregory et al., 2016; Kim & Park, 2020; Love et al., 2015; Park et al., 2016; Patchen et al., 2017; Saxe-Custack et al., 2021; Sonti et al., 2016; Teo et al., 2019
Social benefit/bonding	• Likert scale evaluation of gardeners' social capital • Likert scale evaluation of social cohesion and gardening/local products • No. of teachers reporting impacts of school gardens on family relationships	Diekmann et al., 2020; Ding et al., 2020; Park et al., 2016; Plaka & Skanavis, 2016
Participation & cooperation	• No. of participants/meeting • No. of participants attending and departing • No. of teachers reporting communication improvements between schools due to school gardens	Adams et al., 2014; Moore et al., 2014; Plaka & Skanavis, 2016
Consumer purchase attitude	• No. of respondents reporting changes in purchase behavior • No. of respondents willing to pay for aquaponic products	Laquatra et al., 2018; Miličić et al., 2017
Physical activity	• Activities/week; times/week	Teo et al., 2019; Verldheer et al., 2020
User group	• Employment status	Rogge et al., 2020

tend to be less relevant in this dimension. The focus is increasingly on promoting the well-being and health of individuals or specific groups, with a greater emphasis on promoting nutritious and sustainable dietary practices.

Table 3 supports the hypothesis that there are indeed quantitative metrics for the social impact of CRFSIs. As described in Table 3, for the *health* dimension, it is also apparent that different types of metrics appear in the reviewed papers. Among others, Likert scales are also used here for different indicator categories (Othman et al., 2018; Ornelas et al., 2018; Hanson et al., 2019; Hawkings et al., 2011). The number of different elements, such as shops or visits also emerges as an important metric (Lindsay et al., 2013; Lee et al., 2010).

In addition to the specific units described above, which are often used for *health* indicators, Table 3 shows that indicator categories addressing the general market situation ("neighborhood food environment", "distance connection") also have specific measurable metrics. These include distance units such as miles or meters (Gustafson et al., 2013; Mcguirt et al., 2018). However, the temporal component as a metric of social impact is also highlighted in the results. The reason is that the sectors "participation & cooperation", "frequency at outlets visits", "distance connection" or "consumer purchase attitude" are also measured using time units such as hours or minutes individually or in relation to other temporal components such as week or month (Hawkings et al., 2015; Minaker et al., 2016; Ma et al., 2020; Mcguirt et al., 2018; Jilcott Pitts et al., 2013).

Time units also play an important role in the indicator category "physical activity", as this category is also measured in minutes or hours (Hoefkens et al., 2011; Van Lier et al., 2017). As shown in Table 3, time units are also used in different metrics in combination with other units, such as kg or O^2. These units are used, for example, to determine energy expenditure or oxygen uptake to draw conclusions about the benefits of a CRFSI (Park et al., 2015; Tharrey et al., 2020). It is also clear from this table that specific metrics were not always available in the papers or were not listed as such (Parsons et al., 2019). However, these papers are isolated cases.

3.6.3. Community development impacts

For the *community development* dimension (n = 36), although *quantitative* methods account for approximately half of all methods identified in this area (47 %), *qualitative* methods account for the second largest share (39 %; see Fig. 8**a**).

The reason is that interviews are often used to assess the *community development* dimension of CRFSIs, as previously highlighted by Jean (2015). *Mixed* methods account for 11 % of all studies. The smallest share in this dimension (3 %) is represented by *medical studies. LCA* and *spatial analysis* are not used to study the *community development* dimension.

Fig. 8**b** shows that $n = 12$ indicator categories were identified for this dimension. The most common method is "social benefit/bonding" (n = 21), which aims to assess the social benefits of a particular measure, policy or intervention. This literature review highlights the social benefit of CRFSIs. In this context, the indicator allows researchers to analyze how a CRFSI affects the community and what benefits it brings to people. This indicator, which has the greatest social relevance, can be found, for example, in the papers by Celata and Sanna (2019), Gasperi et al. (2016) or Hunter et al. (2019). In the latter, the researchers use this indicator to examine, among other things, the impact on criminal activity. Compared with the other dimensions, it appears more frequently in *community development* papers.

This is followed by the categories "participation & cooperation" and "others", each with n = 14. The papers belonging to the first category (Som Castellano, 2017; Torres et al., 2018; Krikser et al., 2019) address, for example, the participation and frequency of gardening activities or general participation in local food systems or neighborhood councils. In this context, the papers also examine cooperation between different organizations or associations. The latter covers a wide range of aspects,

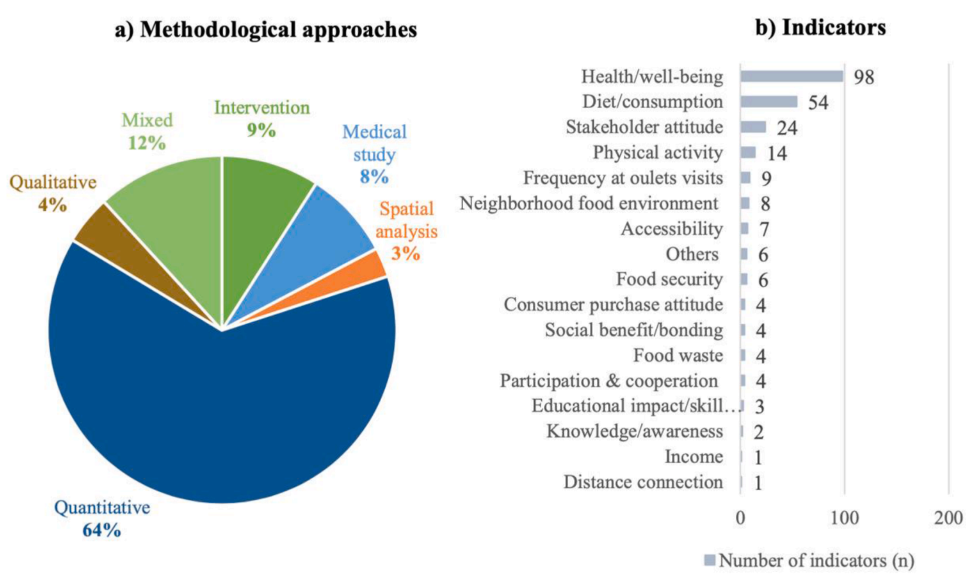

Fig. 7. Distribution of methodological approaches (a; n = 110) and distribution of the indicators (b; n = 249) for the health dimension.

Table 3
Social indicators and the associated metrics and sources from the review for the health dimension.

Social indicators	Metrics	Selected references
Social dimension 2: Health		
Health/well-being	• Likert scale evaluation of well-being/general health • sAA levels before and after activity (salivary a-amylase, μg/mL) • Warwick–Edinburgh mental wellbeing scale (WEMWBS) • kg polycyclic aromatic hydrocarbons (PAHs)/day; kg rice/day • Intake/day/age; intake/day/gender • Mg arsenic/kg • Days of exposure/year; distress episodes/month • Gram of heavy metals intake/week (through food) • Likert scale evaluation of quality of life • mmol/l (hemoglobin A1c, vitamin D. serum beta carotene) • Beats/minute (resting heart rate) • Breaths/minute (resting breathing rate) • No. of reported health problems • Likert scale evaluation of perceived stress • Likert scale evaluation of stress recovery • μg/l (salivary cortisol level) • mm Hg (blood pressure) • kg/m^2 (BMI of participants) • kg/m^2/year (BMI of gardeners vs. nongardeners) • cm (waist circumference) • mg/dL (fasting blood glucose) • kg (hand strength; weight gain of participants)	Aktary et al., 2020; Ambrose et al., 2020; Barnidge et al., 2015; Booth et al., 2018; Davis et al., 2011; Depa et al., 2018; Dewi et al., 2017; Farahbakhsh et al., 2017; Gerber et al., 2017; Harada et al., 2021; Hawkins et al., 2011; Hoefkens et al., 2011; Jilcott et al., 2011; Koay & Dillon, 2020; Korn et al., 2018; Leung et al., 2011; Litt et al., 2017; Litt et al., 2018; McFarland et al., 2017; Minaker et al., 2016; Mohamed et al., 2018; Nagata & Liehr, 2020; Ngweme et al., 2021; Nunes et al., 2017; Porter et al., 2019; Roncarolo et al., 2016; Singleton et al., 2016; Soga et al., 2017; Traina, 2019; Triguero-Mas et al., 2020; Van den Berg & Custers, 2011; Van den Berg et al., 2010; Van Lier et al., 2017; Wang et al., 2020
Diet/consumption	• No. of servings/portions consumed • Healthy Eating Index scores • Portions/day; servings/day; cups/day; intake/day (of fruit & vegetables) • Times/week, day, month (frequency of specific eating behaviors: lunch in canteens, family meals, fruit & vegetables, or fast-food consumption) • g of salt, sugar, fruit & vegetables, fiber, and food intake; g/minute (eating rate); g/day/person (fruit & vegetable consumption); mg (calcium) • No. of spoons of added sugar • No. of food additions • No. of schools with vending machines for soft drinks & sweets • Likert scale evaluation of willingness to eat fruit & vegetables • No. of healthy & unhealthy dishes • No. of people meeting national recommendations • % nutrients/2000kcal • Impact of food traffic light system on energy intake	Barnidge et al., 2015; Bimbo et al., 2015; Carney et al., 2012; Davis et al., 2011; Delaney et al., 2017; Fagerberg et al., 2019; Farahbakhsh et al., 2017; Gans et al., 2018; Hanson et al., 2019; Hardy, 2018; Hoefkens et al., 2011; Katz-Shufan et al., 2020; Kegler et al., 2020; Litt et al., 2011; Litt et al., 2018; Lo et al., 2019; Luszczki et al., 2019; Mcguirt et al., 2018; Minaker et al., 2016; Mohamed et al., 2018; Ornelas et al., 2018; Pellegrino et al., 2018; Pitts et al., 2014; Savoie-Roskos et al., 2016; Singleton et al., 2016; Staub et al., 2019; Tharrey et al., 2020; Van den Berg et al., 2019; Van Lier et al., 2017; Wilkins et al., 2015; Zoellner et al., 2012
Stakeholder attitude	• Likert scale evaluation of the importance of different benefits • No. of correct responses • Frequency of positive and negative comments (No., %) • No. of themes identified in relation to urban agriculture • Likert scale evaluation of attitudes • Likert scale evaluation of motivational factors • Likert scale evaluation of body appreciation • Likert scale evaluation of self-esteem • Likert scale evaluation of happiness • Likert scale evaluation life satisfaction	Carney et al., 2012; Dobson et al., 2020; Hanson et al., 2019; Helen & Gasparatos, 2020; Koay & Dillon, 2020; Mourão et al., 2019; Othman et al., 2018; Othman et al., 2019; Ruggeri et al., 2016; Staub et al., 2019; Swami, 2020; Wang et al., 2020; Wood et al., 2016; Younis et al., 2020
Physical activity	• O_2/minute (VO_2) • MET (Metabolic equivalent of task: ml x kg x minute) • Minutes; days/week; hours/day (duration of physical activity) • beats/minute (change in activity frequency) • kJ/kg/day (energy expenditure)	Dewi et al., 2017; Hawkins et al., 2015; Hoefkens et al., 2011; Park et al., 2015; Tharrey et al., 2020; Van den Berg et al., 2010; Van Lier et al., 2017; Wallace et al., 2019
Frequency at outlets visits	• No. of visits to farmers' markets • Times/month at farmers' markets • Hours/week of gardening activity • No. of women using farm-to-consumer retail	Hawkins et al., 2015; Lindsay et al., 2013; Minaker et al., 2016; Ruelas et al., 2012; Singleton et al., 2016
Neighbor-hood food environment	• Stores/mile • No. of shops offering a variety of fruit & vegetables • No. of healthy & unhealthy food outlets • No. of food outlets within 0.5 km of home • No. of farmers' markets/100,000	Gustafson et al., 2013; Jilcott et al., 2011; Lee et al., 2010; Leung et al., 2011; Mcguirt et al., 2018; Park et al., 2011
Accessibility	• No. of salad bars in schools • No. of shops offering a variety of fruit & vegetables • No. of farmers' markets/100,000 • Likert scale evaluation of fruit & vegetables accessibility • km (distance to markets)	Bimbo et al., 2015; Blumenschine et al., 2018; Hanson et al., 2019; Lee et al., 2010; Wang et al., 2014
Others	• Staff availability • Target Hazard Quotient (THQ) • Parental support for healthy eating projects • No. of consultations with general practitioners	Koay & Dillon, 2020; Parsons et al., 2019; Traina, 2019; Van den Berg et al., 2010

(*continued on next page*)

Table 3 (*continued*)

Social indicators	Metrics	Selected references
Food security	• No. of applicable answers • kg (weight) • kg/m² (BMI) • Fat	Cheyne et al., 2020; Godoy et al., 2017
Consumer purchase attitude	• No. of market visits • Times/week, month, year (purchasing fruit & vegetables at local markets)	Lo et al., 2019; Jilcott Pitts et al., 2013
Social benefit/bonding	• Likert scale evaluation of social support • Likert scale evaluation of sense of community	Aktary et al., 2020; Gerber et al., 2017
Food waste	• g/month (plate waste) • Likert scale evaluation of food waste concerns • Degree of food waste/plate (none, one quarter, half, three quarters, all)	Gase et al., 2014; Prescott et al., 2019; Sheen et al., 2020
Participation & cooperation	• Participation hours of urban agriculture	Ma et al., 2020
Educational impact/ skill development	• Likert scale evaluation of behavioral capability	Ornelas et al., 2018
Knowledge/awareness	• Likert scale evaluation of general nutrition knowledge • No. of correct answers	Hanson et al., 2019
Income	• Available budget for implementing a healthy diet	Parsons et al., 2019
Distance connection	• Miles, minutes to food outlets	Mcguirt et al., 2018

such as gentrification or ecosystem service scores (Camps-Calvet et al., 2016; Carolan et al., 2020).

As with the other dimensions described above, the indicator category "stakeholder attitude" is the fourth most common indicator ($n = 11$) in the papers analyzed in this dimension. The attitudes or motivations toward urban agriculture or local food systems are analyzed, for example, in the papers by Specht et al. (2016), da Silva et al. (2016) and Menconi et al. (2020).

This category is followed by "knowledge/awareness" ($n = 8$) and "distance connection" ($n = 7$). The former analyzes distance in relation to, for example, markets or CRFSIs. In the paper by Krikser et al. (2019), for example, the social impact of CRFSIs was analyzed by measuring the distance from gardens and the place of residence. Other papers such as Caneva et al. (2020) and Opata et al. (2020), focus on the distance to markets. Regarding the "knowledge/awareness" indicator category, the focus is often on the generation of knowledge through CRFSs. In contrast to the *education* dimension, the focus here is not on students but on the influence of age, gender or other sociodemographic characteristics on nutritional knowledge (Sichert-Heller et al., 2011).

With respect to the metrics for the *community development* dimension (see Table 4), similar results can be seen in the tables described above. Likert scales are also used, especially for indicators that focus on personal attitudes ("stakeholder attitude") or individual perceptions ("social benefit/bonding"). Examples of this tool can be found in the papers of Suyin Chalmin-Pui et al. (2021); Specht et al. (2016) and Gasperi et al. (2016).

Notably, there are fewer specific units for this dimension than for the other two dimensions. There are some exceptions, such as "physical activity", which is measured in beats/minute (Tharrey et al., 2019); "costs", which is measured in fee/year (Krikser et al., 2019); "health/well-being", which is measured in terms of cortisol levels (nmol l-1) and the BMI (kg/m^2) (Suyin Chalmin-Pui et al., 2021); and "distance connection", which uses the distance units of kilometers and meters (Dubová et al., 2020; Krikser et al., 2019). However, in comparison with

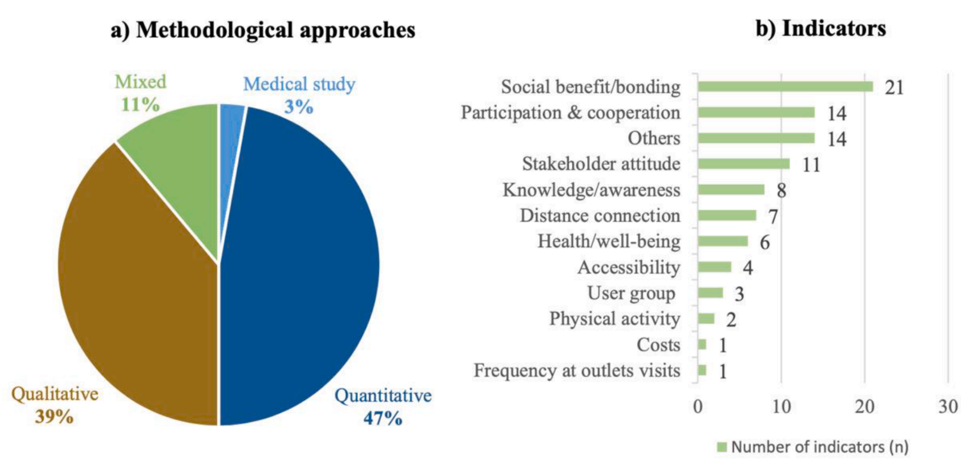

Fig. 8. Distribution of methodological approaches (a; $n = 36$) and distribution of indicators (b; $n = 92$) for the community development dimension.

Table 4
Social indicators and the associated metrics and sources from the review for the community development dimension.

Social indicators	Metrics	Selected references
Social dimension 3: Community development		
Social benefit/ bonding	• Reduction in crime • Likert scale evaluation of agreement with survey questions • Times/month (participation in social activities) • No. & types of activities • Self-assessment of degree of achievement • No. of disadvantaged participants reached • Increased perception of safety • Likert scale evaluation of importance of social exchange • Likert scale evaluation of agreement on agricultural understanding	Celata & Sanna, 2019; Gasperi et al., 2016; Hunter et al., 2019; Kaiser et al., 2020; Obach et al., 2014; Rogge et al., 2018; Sanyé-Mengual et al. 2020; Škamlová et al., 2020; Specht et al., 2016
Participation & cooperation	• Characteristics of participants (age, education, race, income, etc.) • Days/week engaged in formal neighborhood councils • Rate of participation • Types of initiators and coauthors (individual activists/local community; business companies/local businesses; NGO sector, association; city/district authorities; schools, universities)	Krikser et al., 2019; Obach et al., 2014; Som Castellano, 2017; Torres et al., 2018
Others	• Ecosystem service scores • Community development • Gentrification • Impact of mobile phones on gender equality • No. of intangible heritage elements • Land use patterns • Means of transport (%) • Minutes (travel time) • Likert scale of negative effects (dirt, noise, odors)	Camps-Calvet et al., 2016; Caneva et al., 2020; Carolan et al., 2020; Dubová et al., 2020; Gasperi et al., 2016; Krikser et al., 2019; Langemeyer et al., 2017; Mulazzani et al., 2017; Obach et al., 2014; Paltrinieri et al., 2018; Rogge et al., 2018; Sekabira et al., 2017; Specht et al., 2016; Teh et al., 2015; Ulug & Horlings, 2019; Vukušić, 2018
Stakeholder attitude	• Likert scale evaluation of different production systems • Likert scale evaluation of UA products • No. of reasons of applicants • Likert scale evaluation of preference for green and open spaces • Ecosystem services perceived by gardeners • No. of reasons matched with responses • Frequency of positive and negative comments	da Silva et al., 2016; Dobson et al., 2020; Menconi et al., 2020; Scott et al., 2017; Specht et al., 2016
Knowledge/ awareness	• Nutrition knowledge test scores by demographic factors (age, gender, BMI, educational level) • Likert scale evaluation of awareness of garden activities	Krikser et al., 2019; Sichert-Heller et al., 2011; Torres et al. 2018
Distance connection	• km (home-garden, market-market, infrastructure) • m (schools and investigated place) • Distance categories (short, medium, large)	Caneva et al., 2020; Dubová et al., 2020; Krikser et al., 2019; Opata et al. 2020; Scott et al., 2017
Health/well-being	• nmol l-1 (Diurnal cortisol level) • Likert scale evaluation of mental well-being • Self-reported well-being score after intervention • Likert scale evaluation of perceived stress • Age and gender of the participants • kg/m^2 (link between BMI and nutritional knowledge)	Sichert-Hellert et al., 2022; Suyin Chalmin-Pui et al., 2021; Tharrey et al. 2019
Accessibility	• No. of months of adequate household food provisioning • Accessibility score	Caneva et al., 2020; Leah et al. 2021; Rogge et al., 2018
User group	• Age of applicants • Demographic composition & financial situation (income, financial situation, age, sex, education) • Employment status	da Silva et al., 2016; Tharrey et al., 2019
Physical activity	• Beats/minute (heart rate) • Likert scale evaluation of activity level	Suyin Chalmin-Pui et al., 2021; Tharrey et al., 2019
Costs	• Fee/year	Krikser et al., 2019
Frequency at outlets visits	• Days/week of garden visits	Dubová et al., 2020

Tables 2 and 3, the *community development* dimension works less with concrete metrics and instead uses primarily the number of different components or ratings of subjects as a measure. Therefore, although measurability in this dimension is not given to the same extent as in the other dimensions, the measurability is still recognizable, albeit in a different form, owing to different measurement methods and the quantitative approach.

3.6.4. *Economic impacts*

In the *economic* dimension ($n = 41$), as in the other three dimensions, *quantitative* methods predominate (63 %; see Fig. 9**a**).

Qualitative and *mixed* methods followed, with 14 % each. Compared with the dimensions described above, the largest share of *LCA* methods (7 %) are in this dimension. *Spatial analysis* is less frequently used (2 %) to analyze the social impacts of CRFSIs in relation to the *economic* dimension.

In contrast to the other dimensions, there are considerable differences in the indicator categories. A total of 11 indicator categories can be found here (see Fig. 9**b**). With $n = 25$, the "economic efficiency" category is the most represented and is present in numerous articles (Hashimoto et al., 2019; Zhen et al., 2020; Castilho-Barros et al., 2018). It is frequently used as an indicator category in economic publications because it is an important concept for assessing the allocation of resources and the performance of an economy. “Economic efficiency” refers to how well economic resources are used to satisfy people’s needs. Furthermore, using “economic efficiency” makes it possible to compare different economies or policies. By comparing efficiency, it is possible to identify which approaches or policies are delivering the best results and

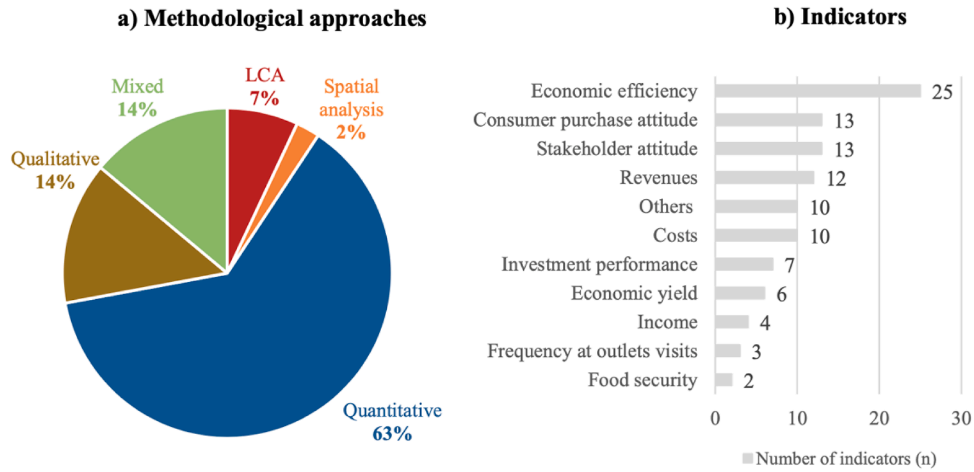

Fig. 9. Distribution of methodological approaches (a; $n = 41$) and distribution of the indicators for the economic dimension ($n = 105$).

which may need to be improved.

This indicator category is followed by "consumer purchase attitude" and “stakeholder attitude”, both with $n = 13$. These categories are relevant, as the purchase behavior of different user groups is often analyzed and compared in these papers, such as Bavorova et al. (2016) or Berg & Preston (2017). These categories also provide direct insights into the preferences and decision-making processes of consumers. Compared with the other dimensions, the "consumer purchase attitude" indicator category has the most mentions ($n = 13$), which means that purchasing behavior is a central aspect in economic articles. “Stakeholder attitude” refers to the attitudes of consumers or stakeholders toward new integrated technologies in the field of agriculture or even the local implementation of this system. The category "revenues" ($n = 12$) refers to CRFSIs business models. It examines how much income operators generate through the products they produce (McDougall et al., 2018) or how this income develops through direct sales (Plakias et al., 2019). The other indicator categories presented in Fig. 9**b**, moreover reveals that the *economic* dimension shows the greatest difference in terms of the type of indicators.

The indicators for the *economic* dimension have mainly a direct economic reference and fewer indicators with a direct social or health reference, which is also reflected in the metrics. Table 5 shows that these indicators are often measured in specific units of quantity or money. The currency units play an important role in the metrics for "income", "costs", "revenues", "economic efficiency", "purchase attitude" and "economic yield", among others. These indicators use monetary units either alone or in combination with units of quantity (kg) or time (year, month). This type of metric is used, for example, in the papers by Kantavichai et al. (2019), Caputo et al. (2020) and Bergstrom et al. (2020). In addition to monetary units, percentages are often used ("revenues" and "economic efficiency") to compare different CRFSIs (Cechin et al., 2021; Castilho-Barros et al., 2018). These metrics are used to show profitability and general efficiency, among other factors.

In contrast, the indicator categories "stakeholder attitude” and, in some cases, "consumer purchase attitude" stand out in this table, as they are measured via Likert scales, which are based more on individual assessments than on specific units (Bavorova et al., 2016; Demartini et al., 2017; Grebitus et al., 2017).

4. Discussion

4.1. Discussion of the four dimensions

4.1.1. Educational impacts

The paper’s first dimension, *education*, is also the one for which the most records were found, based on the screening of titles, keywords, and abstracts. Despite the sharp decrease in the number of papers considered for the analysis of indicators and metrics (mainly because many records were reviews rather than scientific articles), the results indicate that CRFSIs have a strong social impact, especially in the field of education.

For this dimension, quantitative metrics represent >50 % of the total. Several of the indicators are strongly related to the *health* dimension, diet and fruit and vegetable consumption (Dannefer et al., 2016; April-Lalonde et al. 2020; Raj et al., 2016), which makes extensive use of quantitative indicators. This relationship between the two dimensions underlines the purpose of several studies in assessing the eating habits of children in relation to the school environment (Laquatra et al., 2018). Interestingly, interventions represent the second largest share of methodological approaches. Indeed, an increase in educational activities involving new teaching methods and hands-on approaches has been reported in recent years. A CRFSI can be a means of advancing these activities, as also shown by the number of indicators (21 %) that measure the knowledge of stakeholders related to certain aspects of urban agriculture before and after specific interventions (Grier et al., 2015; Morano et al., 2020; Pourjavid et al., 2020). A link with the *health* dimension was also found in the case of interventions. Several indicators found are indeed used to evaluate the effectiveness of CRFS educational initiatives (e.g., the management of an urban vegetable garden or small hydroponic systems in schools) to improve stakeholders’ eating habits. Accordingly, the category “diet/consumption” accounts for 21 % of the indicators in the *education* dimension.

4.1.2. Health impacts

The review highlights that the *health* dimension of CRFSIs plays a critical role in assessing their social impacts, as evidenced by the numerous studies found. Despite the identification of numerous indicators, most studies focus on how CRFSIs enhance mental health and diet, with less emphasis on accessibility and food security. These three elements—mental health, diet, and food security—are interrelated, although they address different aspects of individual well-being. Several literature reviews have explored the relationships between diet and well-being (Appleton et al., 2024), access to food and healthy diets (Baker et al., 2024), and well-being with food security (Lacsa et al., 2024).

The diversity of indicators and metrics reflects the multidimensional nature of health, which is shaped by social, cultural, and political contexts. This review draws on extensive research conducted mostly in North America and Europe, where the focus has been on promoting mental health and sustainable, healthy diets. The analysis shows that the impacts of an CRFSI are considered both through individual participation and the initiative’s presence in a region. Therefore, CRFSIs can influence mental health or diet directly through active involvement, or

Table 5
Social indicators and the associated metrics and sources from the review for the economic dimension.

Social indicators	Metrics	Selected references
Social dimension 4: Economic		
Economic efficiency	• JPY/years (annual income, land rent, operational cost, construction cost) • Benefit to cost ratio (BCR<1, BCR>1) of different types of farms • US-$ (gross income & operating costs) • US-$/ha/year (gross annual margins) • % (profitability index) • Retail value – in terms of costs (including costs of mains water/hour) • Rate of return • $ (savings from urban gardening through self-production)	Algert et al., 2014; Castilho-Barros et al., 2018; Cechin et al., 2021; Csortan et al., 2020; Hashimoto et al., 2019; McDougall et al., 2018; Safi et al., 2011; Souza et al., 2019; Ünal & Franquesa, 2010; Zhen et al., 2020
Consumer purchase attitude	• Likert scale evaluation of the estimation of willingness to support local food production • Money/kg (estimation of purchase intention for local products) • Likert scale evaluation of the estimation of purchase intention • Frequency of local produce purchase • Measurement of expenditure on local produce	Bavorova et al., 2016; Berg & Preston, 2017; Cechin at al., 2021; Eichhorn & Meixner, 2020; Grebitus et al., 2017; Jürkenbeck et al., 2019; Rebouillat et al., 2020; Rehman & Selvaraj, 2013; Solanki & Inumula, 2021
Stakeholder attitude	• Likert scale evaluation of farmers' reasons for participating in SFSCs • Frequency of consumer motivations for shopping at farmers markets (%) • Likert scale evaluation of urban agriculture-related consumer attitudes • Likert scale evaluation of consumers' reasons against urban agriculture • Perceived economic benefits of urban gardens by users	Demartini et al., 2017; Fernandez et al., 2020; Grebitus et al., 2017; Leiper & Clarke-Sather, 2017
Revenues (value)	• US-$ (direct sale earnings) • € (total generated value) • SEK/month (production process costs) • % (gross revenue, operating profit, gross margin) • US-$/ha/year (total annual revenues) • US-$/kg (produce harvested) • yen/sales • €/year • direct sales earnings	Bergstrom et al., 2020; Castilho-Barros et al., 2018; Elepu & Mazzucco, 2010; McDougall et al., 2018; Mihailovic et al., 2020; Monaco et al., 2017; Plakias et al., 2019; Safi et al., 2011; Ünal & Franquesa, 2010; Yoshida et al., 2019
Others	• Relevance of consumer–producer interactions in sales (%) • Subsidies for small-scale-fisheries (%) • No. of people employed • hours/day; income/day (labor productivity) • No. of farm successions	Guyader et al., 2013; Liontakis et al., 2020; Monaco et al., 2017; Mondaca-Schachermayer et al., 2011; Opitz et al., 2019; Pölling et al., 2017; Sangun et al., 2018; Thiao et al., 201; Yoshida et al., 2019; Zhen et al., 2020
Costs	• SEK/month (production process costs) • €/kg (costs of production) • $/kg/year (costs of production) • $/m^2 (setup costs, current costs) • $/ha/year (costs of production) • Years (duration of cost coverage)	Bergstrom et al., 2020; Caputo et al., 2020; Castilho-Barros et al., 2018; Csortan et al., 2020; Safi et al., 2011
Investment performance	• Net present value • Net value/kg • Net cash flow (% of total earnings) • Payback period (years)	Bergstrom et al., 2020; Castilho-Barros et al., 2018; Cechin et al., 2021; Souza et al., 2019; Ünal & Franquesa, 2010
Economic yield (volume)	• kg (average catch); kg/m^2 (mean yield of vegetable farms); kg/trip; kg/hour of labor • €/ha (generated value/unit of agricultural area) • Total catch x price • kg/day (fishing productivity on vessels)	McDougall et al., 2018; Monaco et al., 2017; Mondaca-Schachermayer et al., 2011; Thiao et al., 2012; Ünal & Franquesa, 2010
Income	• $ (farmers' market consumers' income) • Baht/year (average annual income for fishermen) • Multidimensional Poverty Indicator (MPI) of fishermen	Elepu & Mazzucco, 2010; Kantavichai et al., 2019; Marín-Monroy & Ojeda-Ruiz de la Peña, 2016
Frequency at outlets visits	• Visit times/season • Hours at farmers' markets	Elepu & Mazzucco, 2020; Solanki & Inumula, 2021
Food security	• Household dietary diversity score • Household food insecurity access score	Khumalo & Sibanda, 2019

indirectly by improving access to fresh produce and green spaces within a geographical area. The time dimension is also important, as many studies consider how health or diet changes over time. The heterogeneity of health definitions and the variability of metrics complicate the development of comprehensive indicators, making cross-study comparisons challenging. However, this review paves the way for developing guidelines that include mandatory and optional indicators tailored to different contexts, along with potential metrics. These developments could help standardize analyses within specific geographical or political contexts and should be based on local priorities and available resources to maximize data collection and enhance comparability between studies.

4.1.3. Community development impacts

The topic of *community development* impacts has been found to yield more qualitative than quantitative metrics than the other three dimensions do. This finding is due to the inherent difficulty in parameterizing this topic. Notably, however, 47 % of the metrics are quantitative, indicating numerous avenues for quantitative analysis. The relevance of community development impacts in relation to CRFSIs is paramount, given that these systems are designed to transform communities. Consequently, the assessment of their impacts is focused primarily on their social benefits and stakeholder engagement (Hunter et al., 2019; Gasperi et al., 2016). In this context, Europe has the greatest focus on this category, which facilitates the homogenization of indicators and the expansion of knowledge. Conversely, compared with the health topic, this topic is marginal in Asia, South America and Oceania. Even in North America, the use of metrics from community development is very limited.

The Likert scale is a prominent feature of this topic, as it effectively transforms qualitative data into semiquantitative data. The measurability of this topic has been demonstrated in various studies (Suyin Chalmin-Pui et al., 2021; Kaiser et al., 2020). However, the great variability of indicators makes comparisons challenging. One potential solution is the proposal of guidelines that include compulsory indicators and optional indicators for different contexts.

4.1.4. Economic impacts

The review shows that the *economic* impact of CRFSIs has been widely studied in the literature, and several indicators have been adopted to assess whether such impacts have been positive or negative. Of course, such a question cannot be answered in a univocal manner but rather on a case study basis. However, the present study shows that CRFSIs, which are usually deemed relevant mainly for their social impacts, also have a key impact on the local economy. Notably, the indicators adopted in the analyzed literature consider the economic impact on all the stakeholders involved in local supply chains. Producers and consumers are the main focuses, as both the profitability for the former and the spending habits of the latter have been widely analyzed.

However, the actual measurability of the economic impact is crucial, as its quantifiability is debated. The present research shows that several indicators can be assessed. The indicators are mainly quantitative; therefore, specific aspects of budgets and economic performance are assessed. A lack of more nuanced indicators that measure economic performance in a more varied way could better support further research. In conclusion, CRFS initiatives can create an economically efficient system that can be measured for all the stakeholders involved with the aim of creating sustainable local food systems that promote economic resilience and sustainability.

4.2. Limitations and outlook for further research

The literature review shows that a CRFSI can have measurable social impacts. Owing to the large number ($n = 19$) of researchers involved in the study, there may be inconsistencies or deviations in the implementation of the PRISMA method, especially with respect to the consideration of topics and decisions about what should be included or excluded. Hence, a paper that was on at the borderline between inclusion and exclusion could be classified differently by other researchers if the methodology was applied again. However, this possibility applies to individual cases only. Another important aspect is that some papers could, in principle, have been included in more than one social impact category during the screening process because of overlapping content. However, for the review process, the researchers made a final assignment to one of the four dimensions. Notably, in some of the papers included in the results, only the indicators were presented, but the associated metrics were missing. In other cases, planned studies used an analytical approach, including indicators and metrics, but no results were yet available. Importantly, these potential limitations of the approach may also affect the interpretation of the results. Nevertheless, this literature review provides valuable insight into the social impacts of CRFSIs and suggests ways in which these impacts can be measured and evaluated.

To address the identified gaps, future studies should develop standardized evaluation frameworks that explicitly link indicators and metrics. Moreover, the long-term effects of CRFSI interventions need to be investigated, particularly whether behavioral changes such as improved eating habits in vulnerable groups are sustainable. The transferability of CRFSI models to resource-poor regions and the role of digital tools (e.g., AI-supported real-time analyses of community feedback or blockchain-based supply chains) could be key areas of innovation. There has also been little research into cultural aspects such as intersectional inequalities (e.g., gender-specific differences in participation in urban farming projects). In the future, more clinical studies or more educational interventions could be conducted by researchers in relation to CRFSIs and their social impacts to provide further evidence of, for example, long-term health effects and dose−response relationships. The scope of spatial studies should also be expanded through the use of the identified indicators and metrics.

This analysis emphasizes the potential of CRFSIs as catalysts for sustainable food systems and highlights the urgent need for transdisciplinary research. Only through cooperation between science, civil society and politics can CRFSIs be further developed from local model projects into globally scalable solutions, and their social impacts can be evaluated, for example, through the development of open data platforms or the inclusion of marginalized groups in impact measurement.

5. Conclusion

The greatest challenges in measuring social impact lie in the complexity of data collection and methodological limitations. Invasive measurement methods to obtain physical health data such as blood analyses, not only require the active participation of participants and consistent adherence to protocols by researchers, but also raise ethical questions - especially for vulnerable groups such as children, whose involvement is limited by data protection concerns and their ability to provide consent. In addition, resource-intensive processes, specialized data analysis and interdisciplinary expertise are needed, which can exceed time and financial capacities. Another problem is the narrow focus of previous and ongoing research on certain social dimensions or population groups, whereas more holistic studies in other areas such as community development or education remain underrepresented.

This review provides a systematic overview of concrete metrics and indicator-based methods for empirically measuring the four social dimensions. It demonstrates the measurability of social impacts in the CRFSI context by presenting indicators and metrics to assess progress and outcomes for all four social dimensions (health, education, community development and economic). The results indicate both concretely measurable metrics, such as kg, € or m, and other metrics, such as the Likert scale or the number of different components, for example, the number of initiatives. These other metrics, which are not defined as concrete units, can also be used to make the indicators related to individual assessments or personal attitudes measurable. Such metrics and their evaluation, which often lead to scoring systems and averaging, can also be used to ascertain the social impact of CRFSIs.

The focus of social impact measurements can vary spatially, as different locations can have different focuses. Overall, the measurability and research of the health impacts of CRFSIs widespread worldwide, especially in North America and Europe, but there has also been an increase in other social impacts, such as the education, economic or community development dimensions, in terms of the annual publication trend. All four social dimensions are strongly correlated and can contribute to the growth of the others.

In addition, this review provides a comprehensive framework for researchers planning projects or designing studies focused on CRFSIs and their social impacts. This framework serves as a collated representation of the relevant measurement methods and indicators, enabling researchers to design studies effectively and assess the social impact of CRFSIs. In conclusion, this review demonstrates that social impacts are quantifiable and measurable and highlights the potential for the comprehensive compilation presented in this paper to be used as a foundational resource to assist others in effectively assessing and quantifying the social impacts of CRFSIs.

CRediT authorship contribution statement

K. Specht: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **C. Iodice:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **F. Monticone:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **P. Tonini:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **M. Petruzzelli:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **L. Carotti:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **R. Fox-Kämper:** Validation, Supervision, Project administration, Methodology, Funding acquisition, Data curation, Conceptualization. **S. Toboso-Chavero:** Writing – review & editing, Data curation. **F. Orsini:** Supervision, Project administration, Funding acquisition, Data curation. **A. Samoggia:** Supervision, Project administration, Funding acquisition, Data curation. **M. Vittuari:** Supervision, Project administration, Funding acquisition, Data curation.

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.

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Supplementary materials

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Data availability

Data will be made available on request.

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