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Assessing the agroecological performance and sustainability of Community Supported Agriculture farms in Flanders, Belgium

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Agroecology is receiving increasing attention and recognition as a concept for transitions to more sustainable agricultural and food systems. There is however a lack of characterization of agroecology in agricultural and food systems, while integrated and holistic measurements of their sustainability are scarce. Community Supported Agriculture (CSA) is considered to be a system explicitly based on agroecological principles and practices which shows potential in the face of the sustainability challenges in agriculture and food systems, but its link with agroecology and its holistic sustainability performance have remained understudied. Therefore, we applied the Tool for Agroecology Performance Evaluation (TAPE) to 24 Community Supported Agriculture farms in the Flanders region of Belgium in order to characterize agroecology and to assess their multidimensional sustainability performance. Our results show that Community Supported Agriculture farms can be characterized as advanced agroecological systems, highlighted by their high to very high performance on many of the elements of agroecology. Moreover, our results show positive outcomes on several sustainability criteria across environmental, social and economic dimensions such as soil health, presence of natural vegetation and pollinators and ecological management of pests and diseases, as well as dietary diversity and profitability criteria like gross value, added value and net revenue. The integration and role of animals in these agroecosystems and the importance of - and dependence on - labor are however identified as two critical aspects regarding the agroecological transitions and sustainability of Community Supported Agriculture. Our findings emphasize the exemplary role Community Supported Agriculture could play in broader agroecological transitions, which, coupled with their high performance on several sustainability criteria, highlight the potential contribution of Community Supported Agriculture, and by extension of agroecology itself, to more sustainable agricultural and food systems in Flanders and beyond.

KEYWORDS

agroecology, Community Supported Agriculture, agriculture and food systems, sustainability, assessment, TAPE, Flanders

1 Introduction

Agroecology is gaining increasing attention as a paradigm for transitions to sustainable agriculture and food systems, and it is vastly referred to as a science, a set of practices and a social movement (Wezel et al., 2009; Ewert et al., 2023). Over time, agroecology as a science has developed in both the scale of analysis and the disciplines used for its study, moving from an analysis at the field scale using agricultural and environmental disciplinary knowledge toward a scale that encompasses the whole food system requiring knowledge of social, economic, cultural and political disciplines (Wezel et al., 2009; HLPE, 2019). Agroecology therefore distinguishes itself as a more holistic and transformative approach to sustainable agriculture and food systems than other approaches such as sustainable intensification, climate-smart agriculture, conservation agriculture, regenerative agriculture and organic agriculture (IPES-Food, 2022). Evidence on agroecology points toward its potential positive impacts on, amongst others, soil health (Muchane et al., 2020; Domínguez et al., 2023; Lucantoni et al., 2023), (agro)biodiversity (Wanger et al., 2020; Tscharntke et al., 2021; Lucantoni et al., 2023), households income (Van der Ploeg et al., 2019; Stratton et al., 2021) and food security and nutrition (Bezner Kerr et al., 2021; Lucantoni et al., 2023).

A variety of actors and organizations have shown interest in and commitment to agroecology, each of them however developing different interpretations of agroecology and framing the concept based on their own views, priorities and interests. This has taken shape in the form of different definitions and frameworks, of which the Nyéléni Declaration (IPC, 2015), the 5 levels of agroecological transition proposed by Gliessman (2016), the 10 Elements of Agroecology proposed by the Food and Agriculture Organization (FAO) of the United Nations (Barrios et al., 2020) and the 13 Principles of Agroecology developed by the High Level Panel of Experts on Food Security and Nutrition (HLPE, 2019) are most commonly referred to. In this work, the 10 Elements of Agroecology will be used as the central framework. This framework was developed by the FAO as a guide for transitions to sustainable agriculture and food systems, based upon scientific literature and multi-stakeholder dialogues at the national, regional and global level. In their definition, agroecology is an integrated approach which simultaneously applies ecological and social concepts and principles to the design and management of agricultural and food systems, which seeks to optimize the interactions between plants, animals, humans and the environment while taking into consideration the social aspects that need to be addressed for a sustainable and fair food system (FAO, 2018a). The 10 Elements are key characteristics and features of agroecological systems that are deemed to be interlinked and interdependent. They consist of: (1) Diversity, (2) Synergies, (3) Efficiency, (4) Recycling, (5) Resilience, (6) Culture and food traditions, (7) Co-creation and sharing of knowledge, (8) Human and social values, (9) Circular and solidarity economy and (10) Responsible governance (Barrios et al., 2020).

Moving beyond these definitions and frameworks, a need has been identified for methods to assess agroecology in an interdisciplinary and holistic way (Darmaun et al., 2023). Assessments of agroecological transitions are however complicated by their diverse starting points and modalities, together with the broadening scope, scale and dimensions of agroecology (Wezel et al., 2020). Many of the above-mentioned definitions and frameworks have served as the basis for the development of assessment methods, of which Geck et al. (2023) provide an overview and critical discussion. One of the most prominent assessment methods for agroecology is the Tool for Agroecology Performance Evaluation (TAPE), developed by the FAO in order to evaluate agroecology, to measure progress in agroecological transitions and to build harmonized evidence of its contribution to sustainability (Mottet et al., 2020). The tool was created through a participatory and multistakeholder process and is based on the 10 Elements of Agroecology. It is a quantitative tool which simultaneously characterizes agroecology and assesses its performance, and it can be applied in any geographical location and ranging from the field to the farm, landscape and national scale although the focus lies on the field and farm scale (Darmaun et al., 2023; Geck et al., 2023). The TAPE received widespread interest and different actors, organizations and governments are adopting and adapting it, while it is currently in use in more than 30 countries in different geographic regions, territories and production systems, with most publications on its use coming from the Global South at the time of writing (Lucantoni et al., 2023).

Although agroecology can be used as a paradigm for sustainability transitions for different kinds of agriculture and food systems, the model of Community Supported Agriculture (CSA) seems to align particularly well with the concept of agroecology. A CSA farm is a community-based organization of producers and consumers in which the partaking households provide direct, upfront financial support for the local producers, while the producers in return aim to provide food in sufficient quantity and quality to meet the needs and expectations of the consumers (Groh and McFadden, 1998). The definition used by URGENCI, the international network for CSA, stresses the small and local scale as well as the agroecological way in which food is provided, while their guiding principles further emphasize, amongst others, the agroecological principles and practices with an explicit reference to the Nyéléni Declaration (IPC, 2015; URGENCI, 2016; Volz et al., 2016; Espelt, 2020). CSA is gaining increasing attention and the number of CSA farms is growing rapidly in many regions of the world as they are regarded as promising approaches to tackling the sustainability challenges in agriculture and food systems, as suggested by the systematic review of the sustainability performance of CSA farms by Egli et al. (2023). Although environmental, social and economic dimensions are considered to be intertwined, they are henceforth discussed separately for analytical reasons.

The environmental dimension of CSA is based on principles such as diversity, nutrient recycling and the reduction or elimination of synthetic inputs (URGENCI, 2016; Volz et al., 2016). A reliable evaluation of the environmental impacts has been hampered by a lack of harmonized data, although the few existing measurements and comparisons point to CSA as outperforming reference systems in measured effects such as fertilizer, pesticide and energy use and greenhouse gas emissions. Notably absent however is the measurement and comparison with a reference system regarding soil characteristics, crop and livestock diversity and productive outputs (Egli et al., 2023). The social dimension of CSA is based on principles such as solidarity, cooperation, support and community-building (URGENCI, 2016; Volz et al., 2016).

Research has predominantly focused on identifying motivational factors for supporting and participating in such a system, with environmental reasons, obtaining locally grown and organic produce and supporting local farmers and economies as the most commonly cited factors (Swisher et al., 2003; Brehm and Eisenhauer, 2008; Lang, 2010). Regarding social impacts, positive effects were found for satisfaction and income of farmers, and a positive effect was found among members regarding their behavior, well-being, health, knowledge transfer, learning and social and political engagement (Egli et al., 2023). Members were found to be predominantly white, highly educated and with a higher income, and women were found to be over-represented while socially disadvantaged populations were disproportionately absent (Lang, 2010; Volz et al., 2016; Egli et al., 2023). The economic dimension of CSA is based on principles of shared responsibilities, risks and rewards and of fair working conditions and a decent income for all involved (URGENCI, 2016; Volz et al., 2016). Notwithstanding this last principle, Galt (2013) highlights several controversies within the model, as farming operations are commonly economically viable but income for farmers is often low, with many farmers paying themselves low wages and thus engaging in self-exploitation (i.e. not earning revenues equal to the cost of their own labor). Regarding economic impacts, overall effects were found to be largely unclear, although Egli et al. (2023) found a higher profit per hectare than in reference systems, while operating costs were found to be higher due to the specificities of labor, delivery and marketing. Moreover, more labor is required than in traditional farms, but profit and sales per labor hour were found to be substantially higher (Egli et al., 2023).

Current assessments of the performance and sustainability of CSA systems are fragmented and heterogeneous in both scope and methods, making comparisons with other systems difficult and concealing the contribution of this system to more sustainable agriculture and food systems. The need thus arises for more holistic and integrated assessments of these systems, covering environmental, social and economic dimensions of sustainability (Fomina et al., 2022; Egli et al., 2023). As CSA systems are explicitly based on agroecological principles and practices, a characterization of their agroecological performance would moreover elucidate the linkages between the two concepts and potentially validate the hypothesis that these systems can be considered as highly agroecological.

In this study, we therefore apply the TAPE methodology to CSA farms in Flanders, Belgium, in order to characterize their agroecological performance, assess their multidimensional sustainability performance and moreover generate globally relevant evidence of the performance of agroecology. We contextualize the tool by translating it to the language and specific context of the farmers and by assessing the perceived importance of the indicators by the participating farmers.

2 Materials and methods

2.1 Case study site

Flanders, the northernmost region of Belgium, is one of the most densely populated and urbanized regions of the world, with a population of 6.4 million living on a surface area of 13 625 km^2, of which only 21.9% lives in rural areas. In 2021, it had an agricultural area of 624,634 hectares, comprising 46% of its total land area. Fodder crops (such as grassland and maize) and arable crops (such as potatoes and grains) took up the largest shares, accounting for respectively 59% and 30% of this agricultural area. Significantly less land was used for the production of vegetables (5%), fruits (3%) and ornamental plants (1%), while the remaining 2% is used for other and unspecified purposes. In 2021, Flanders had 23 218 agricultural holdings with an average farm size of 27 hectares. The number of holdings has been decreasing significantly over the past few decades, while average farm size has increased due to consolidation of the remaining farms. Flemish agriculture is characterized by its high degree of specialization, since 89% of its holdings are specialized in one of three subsectors: livestock farming (44%), arable farming (32%) and horticulture (13%). Although the agricultural area under certified organic practices is increasing at historically high rates, the share of organic agriculture is still very low in Flanders, as only 1.6% of the Flemish agricultural area was certified organic in 2021, which is significantly lower than the Belgian and European figures of 7,4% and 9,6% respectively (Departement Landbouw enVisserij, 2023a; IFOAM, 2023). Labor income for full-time farmers has on average been lower than that of full-time income of salaried labor in Flanders over the past few years, although there are high fluctuations between years and subsectors (Departement Landbouw enVisserij, 2023a).

Agricultural and food systems in Flanders are facing several challenges. On the environmental side, pollution is at the forefront with eutrophic nitrogen emissions to natural areas and water bodies, mainly caused by livestock emissions, exceeding critical thresholds (Vlaamse Milieumaatschappij, 2020a,b). Moreover, agriculture in Flanders is struggling with drought as the effects of climate change severely impact the availability of water. Water availability in the region is already a challenge given the very high percentage of impervious surfaces, frequent drainage of agricultural land and a high demand for water given its high population density (Vlaamse Milieumaatschappij, 2010). Other environmental challenges in Flemish agriculture include the reduction of the use of pesticides, the protection of soil health, and decreasing the dependence on non-renewable resources (De Keyzer, 2023). On the social and economic side, Flemish farmers are facing increasingly complex and tightening regulations, high administrative burdens and financial insecurities linked with big investments and low margins, leading to increased mental, physical, financial and social exhaustion. A quarter of all Flemish farmers are at risk of poverty and one in seven farmers is not even able to pay out an income to themselves (Messely et al., 2020; De Keyzer, 2023). Expanding the scope to the food system in Flanders, the consumption of healthy and nutritious food remains a challenge, as Smets et al. (2022) conclude that the food environment in Flanders is currently in a poor condition, with a widespread occurrence of food swamps, i.e. places with an abundance of unhealthy food options relative to healthy food options, potentially exacerbating the obesity epidemic in Flanders.

In this Flemish context, agroecology is emerging and developing as an alternative paradigm in a distinct way that does not closely fit the conventional trichotomy as a science, a movement

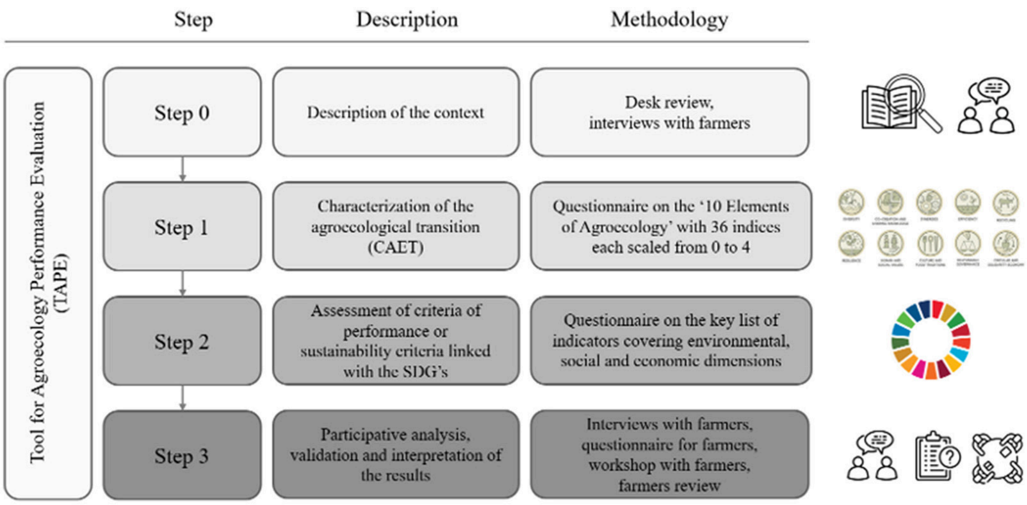

FIGURE 1
Schematic showing the different steps of the TAPE, their description and methodology 'Adapted or reproduced with permission from Flaticon.com; FAO (2018b), United Nations (2024).'

and a set of practices, while Stassart et al. (2018) found it to have significant transformative potential. Agroecological practices (crop rotation, intercropping with trees or other crops, the use of cover crops, the application of organic amendments to the soil, the minimization or elimination of the use of external (synthetic) inputs, biological pest and disease control, etc.) are used to lesser or greater extent, but are often not explicitly framed as agroecological (Tessier et al., 2021a,b). Agroecology is endorsed and campaigned for by a growing constellation of social movements, with Voedsel Anders acting as an umbrella organization for its 29 member organizations and Boerenforum as a strongly agroecology-inspired farmers organization acting as the Flemish member organization of La Via Campesina, the international farmer's organization focusing on peasant rights, farmers rights and food sovereignty (Boerenforum, 2023; Voedsel Anders, 2023). On a policy level, agroecology is not strongly or explicitly present yet, although the Flemish government launched a Food Strategy in which a Food Deal on agroecology is ongoing (Departement Landbouw enVisserij, 2023b). Mirroring the international trend, the number of CSA farms in Flanders is increasing rapidly. The first CSA farm in Flanders started in 2007, after which the number increased to around 70 farms at the time of writing, with several CSA farms in the process of starting up operations. Informal network exchanges quickly developed into the formation of a formalized network in 2011 called the 'CSA-Netwerk'. This network operates as an umbrella organization for CSA farms in Flanders, establishing a platform for knowledge exchange, building further on the concept and consolidating achievements, providing information and support to farmers and participants, promoting the concept within Flanders and acting as a forum on the topic of CSA (CSA-Netwerk, 2023).

2.2 Data collection and analysis

The methodology, guidelines and protocols of the Tool for Agroecology Performance Evaluation (TAPE) as described in Mottet et al. (2020) were used. The methodology consists of a stepwise approach which is visualized and elaborated in Figure 1.

CSA farmers were contacted through the contact information listed on the website of the "CSA-Netwerk". Out of a total of 69 farms listed, 57 were involved in food production, while the remaining farms focused on growing ornamental flowers. As involvement in food production was considered an important selection criterion for our study, only those farms were invited to participate. Of these 57 farms, 24 farms participated in our study. The sampled CSAs were spread across the region of Flanders (see Figure 2), with most farms situated in peri-urban areas close to larger urban centers such as the metropolitan areas of Antwerp, Ghent and Brussels.

Step 0 was performed by means of a desk review, which was carried out between February and May 2022, and by means of interviews with farmers during farm visits which took place between May and October 2022. **Step 1** was performed by using the CAET questionnaire proposed in the TAPE during on-farm interviews on all 24 participating farms. Based on these interviews, results were further disaggregated for age and size, as it was suggested that older and larger farms were often more agroecological and it was hence hypothesized that they would score higher on the CAET. Furthermore, a correlation analysis was carried out on the different variables in order to provide insights on the relationship between the different elements of agroecology and between the overall CAET and the underlying elements to highlight important driving factors in the CAET and to identify potential linkages between elements. **Step 2** was performed by using an adapted version of the criteria of performance questionnaire proposed in the TAPE, which was developed in the Qualtrics survey software to overcome some of the contextual challenges the original questionnaire faced, such as the language and the need for contextualized examples presented along the questions. The survey was sent out to be answered online between January and February of 2023. This survey received a total response rate of 19 out of 24 farms, where additionally several questions in the survey were not—or not completely—answered, leading to lower

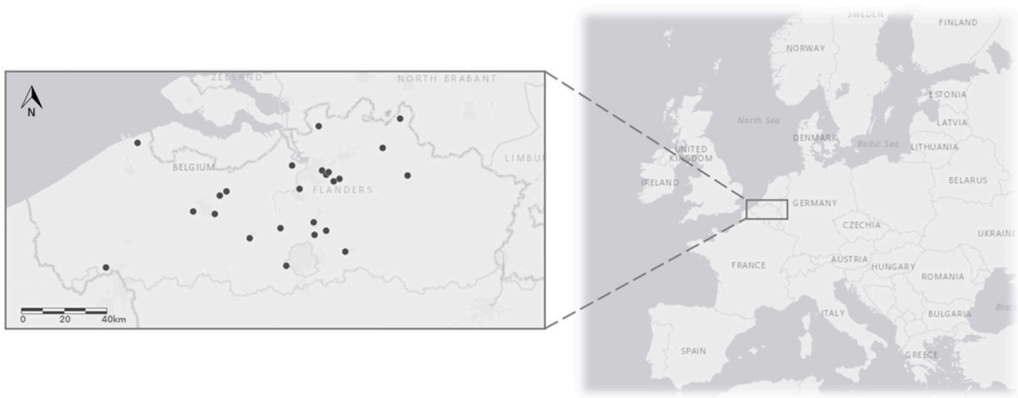

FIGURE 2
Map showing the surveyed CSA farms in Flanders, Belgium (ESRI, 2024).

response rates and thus sample sizes for some indicators. For the indicator of soil health, data was collected during the farm visits. Youth opportunities index and youth emigration index were not measured due the limited relevance of the questions in the specific case study context. Moreover, indicators which were not properly calculable or interpretable are not included in our results. **Step 3** was performed during a workshop during the yearly conference of the CSA network in March 2023, As a way to contextualize agroecology and the CAET questionnaire, farmers were asked to state the importance they attached to the different indices of each element used for the CAET in the online survey, depending on their specific context, with 0 = not important, 1 = somewhat important, 2 = quite important, 3 = important and 4 = very important. In addition, feedback received by participants through mail and personal contact during and after the farm visits also contributed to the validation and interpretation of the results. The reference year of the collected data is 2022.

3 Results

3.1 General results

The surveyed CSA farms had an average size of 4.2 hectares, notably smaller than the Flemish average of 27 hectares, while median farm size of the CSA farms was even lower at 2.35 hectares. The productive surface consisted on average of 2.3 hectares (53% of the total area), while the remaining surface was destined for permanent pastures (0.9 ha or 21%), natural vegetation (0.7 ha or 17%) and other uses such as buildings and pavement (0.4 hectares or 8%). Moreover, 29% of the surveyed farms were smaller than 2 hectares and could be regarded as smallholder farms, while this cut-off size is moreover regarded as an important turning point for the autonomy and circularity of the farm and for the integration of grazing animals, according to the surveyed CSA farmers. The majority of farms worked purely with subscriptions (i.e. members pay for a harvest share in advance of the growing season), in the form of either self-harvesting (45%) or packages (10%) or a combination of the two (10%). The remaining farms combined either subscription self-harvesting with loose sales (10%), subscription packages with loose sales (10%) or all three marketing channels (15%), with loose sales itself taking the form of self-harvesting, packages or other marketing channels such as direct sales in farmers markets and to restaurants and others. For those farms engaged with subscription self-harvest, harvest shares were bought by members which allowed them to come harvest on the field proportionately to the number of harvest shares they had, with each share representing an adult equivalent. On average, these farms each sold 203 harvest shares at an average price of €387 per year, with the number of shares ranging from 70 to 440 and the price ranging from €320 to €498.50. The farms engaged with subscription packages offered packages of fresh produce of which the size was dependent on the number of shares and the content was dependent on the available seasonal products, and this on a frequent, mostly weekly, basis. All surveyed farms were started on existing farmland and were (partly) converted to the CSA system by either professional farmers or by new entrants in agriculture, with the latter making up the majority of farms. In its form as a CSA system, the average farm was 4 years old, while 21% of farms were younger than 3 years, 46% of farms were between 3 and 6 years old and the remaining 33% of farms were more than 6 years old. All farms grew vegetables and herbs, although many also produced fruits (84%) and edible and/or ornamental flowers (74%). Farmers grew between 50 and 150 crop species with an average of 92, of which often still different varieties were cultivated. A large share of farms also raised chickens for eggs and/or meat (42%, 18 animals on average). Additionally, several farms were involved in beekeeping (47%), while only a few reared cows (11%, 3 animals on average), sheep (11%, 28 animals on average) and pigs (11%, 7 animals on average). Apart from the labor of the farm owner(s), 83% of the farms relied on external workers for additional labor, taking the shape of unpaid labor of volunteers, interns and people employed through care farming, as well as paid labor of seasonal workers and other employees.

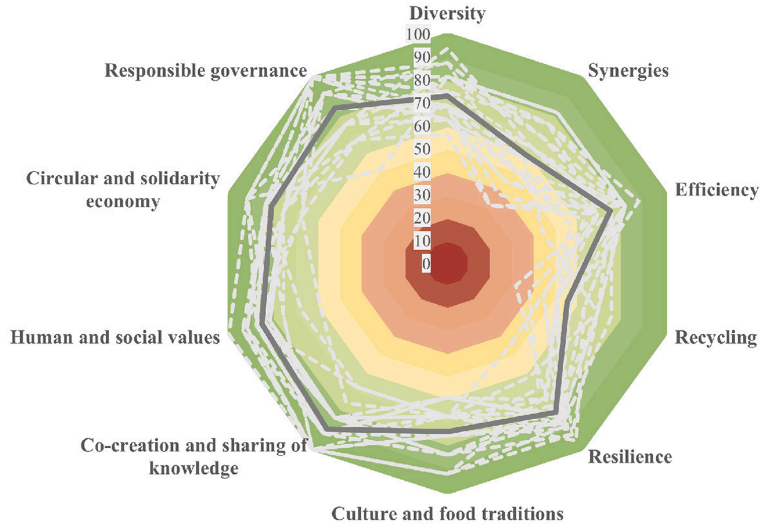

FIGURE 3
Radar graph visualization of the CAET for each individual farm (dotted lines) and the average (solid line) (adapted and modified from FAO, 2019).

3.2 Characterization of the agroecological transition (CAET)

3.2.1 The elements of agroecology

On average, the analyzed CSA farms had medium, high or very high scores on the elements of agroecology, as can be seen in Figure 3 and in the Supplementary Table 1.

A very high score was obtained on average on the elements Co-creation and sharing of knowledge (89), Human and social values (85), Responsible governance (84), Circular and solidarity economy (81) and Resilience (80). Regarding **Co-creation and sharing of knowledge**, this very high score was explained by the fact that all farms were strongly connected through platforms for horizontal creation and transfer of knowledge and good practices, while additionally they had very high interest in and very good access to agroecological knowledge. Moreover, farmers often strongly participated in local networks and organizations (neighborhood committees, local government, social organizations, etc.). Regarding **Human and social values**, farmers indicated that women were very empowered in their systems, although female farmers mentioned that there remain social and practical barriers to full equality (e.g. during pregnancy and childcare) while agriculture is sometimes still regarded as a male-dominated world. Labor conditions were believed to be good, although working conditions were deemed to be harsher than in other sectors and an important difference remained between the labor conditions of the owner, the employees and the interns on the farm. Youth empowerment and emigration showed mixed results, given that farmers identified a strong interest in agroecological farming and the CSA model by young people at a time where the general interest in agriculture in society and especially youth was perceived to be at an all-time low. This was however often not recognized in farmer's own children, who predominantly sought opportunities outside of the farms of their parents and outside of agriculture as a whole. Animal welfare was considered to be good to very good on farms that had animals, although questions were raised on how to approach and interpret what 'good' means in this sense. Regarding **Responsible governance**, farmers mentioned the existence of numerous producer organizations and associations, although it was highlighted that not all of them were functioning well and supporting their farming activities to the same extent. Producers were considered to be empowered on a micro scale although many stressed that on a macro scale, several laws, administrative burdens and government interventions were disempowering. Producers generally felt able to participate in the governance of land and natural resources, but stated that their power in influencing or making decisions was rather limited and that even the autonomy on their farms was still limited by laws and government interventions. Regarding **Circular and solidarity economy**, all products and services were marketed locally and a direct relationship with the consumer was present in almost all farms, while in some others the few intermediaries (other farmers, processors, restaurants, ...) that existed were seen as useful at adding value. When looking at the local food system, farmers highlighted that members of the farm were often quite independent from other sources regarding vegetables and, to a lesser extent, meat, eggs and fruit. However, when expanding the scope to beyond their members, food supply in local food systems was considered to be still largely dominated by supermarkets and big retailers. Regarding **Resilience**, the stability of production and income was deemed to be very high, while the subscription system and the support of the community in case of natural events and during specific harvesting activities were considered to be successful mechanisms to reduce vulnerability. These mechanisms were however seldomly regarded as a complete failsafe and farmers were still largely responsible for dealing with vulnerabilities. The environmental resilience and the capacity to adapt to climate change was perceived to be high although continuous interventions by the farmer were still required.

A high score was obtained on average on the elements Efficiency (75), Diversity (73), and Culture and food traditions (73). Regarding **Efficiency**, all farms scored very high concerning

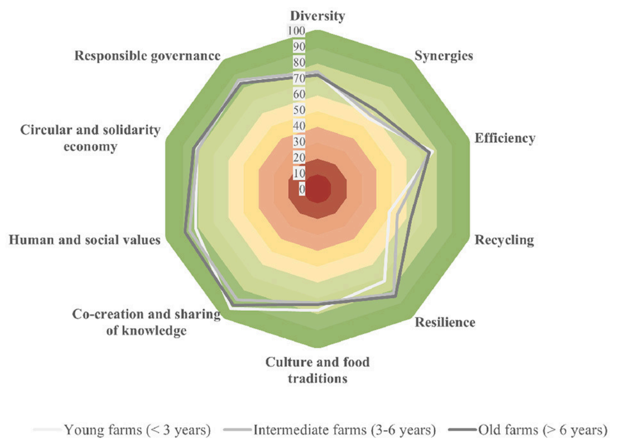

FIGURE 4
Radar graph visualization of the CAET disaggregated for young, intermediate and old farms (adapted and modified from FAO, 2019).

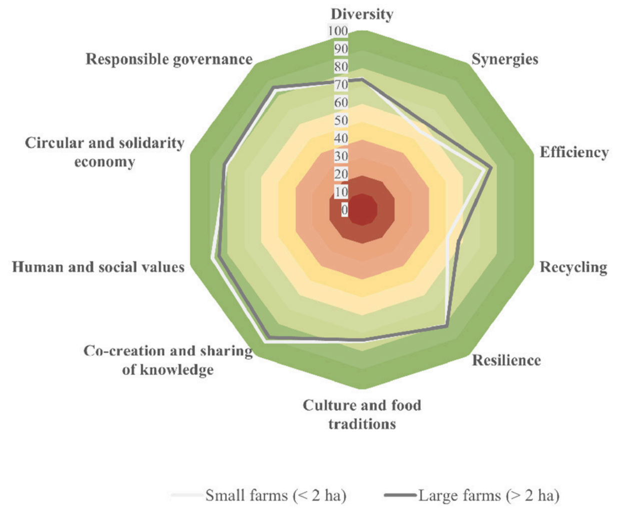

FIGURE 5
Radar graph visualization of the CAET disaggregated for small and large farms (adapted and modified from FAO, 2019).

the management of soil fertility, pests and diseases due to the fact that only organic practices were used. Productivity and households needs scored high, but farms depended significantly on external inputs such as manure, compost, seeds and breeds in their systems. Regarding **Diversity**, farms showcased a very high crop diversity given that close to 100 species were cultivated on average in diversified polyculture systems. Moreover, farms had a high diversity of activities, products and services and a high diversity of trees and other perennials. A low diversity of animals was however observed, given that 37.5% of farms did not have any animals and 42% had only one species of animal. Regarding **Culture and food traditions**, an appropriate diet and nutrient awareness was present among farmers, whereas a strong local or traditional identity and awareness was absent with most. The use of local varieties, breeds and traditional knowledge for food preparation was considered to be important, although this was deemed to be difficult to achieve in the specific regional context.

A medium score was obtained on average on the elements Synergies (58) and Recycling (55). Regarding **Synergies**, the management of soil and plants scored high due to the limited soil tillage and the use of solely organic amendments for improving soil health. Connectivity between elements of the agroecosystem and the landscape was considered to be high, although farmers stressed that they only could make improvements within the borders of their farm while their surroundings were regarded as being much less ecologically connected. The integration of trees in the agroecosystems was quite high, with many farmers implementing agroforestry and having different productive perennials in their system. The integration of crops and livestock was however very low, given the limited presence of animals on most farms. Those farms that had animals produced only negligible amounts of manure to be used as soil amendment, while external feed for the animals was often still required after having been fed with the available crop residues and feed crops. Regarding **Recycling**, biomass and nutrients were recycled on farm to a great extent and various practices and techniques were used to capture and save water. Renewable energy production and use was rather limited, with only a few farms producing and using solar energy. Nevertheless, many farmers indicated that solar panels would be installed in the near future, but that the use of fossil fuels for machinery and transport was going to remain significant even then. Seeds and breeds were seldomly recycled on the farms, with the very high diversity of crops and the more variable quality being regarded as a big obstacle to saving and using own seed. On average, no elements scored low or very low.

Results of the CAET were disaggregated for young (< 3 years, N = 5), intermediate (3-6 years, N = 11) and old (> 6 years, N = 8) farms and their scores are presented in Figure 4. Most scores on the elements differ relatively little between age groups, although an increasing trend with age can be distinguished for the elements Synergies (55, 57, and 62 respectively), Recycling (48, 53, and 62 respectively), Resilience (72, 82, and 84 respectively) and Human and social values (81, 85, and 88 respectively), while the total score for the CAET was increasing with age as well (74, 75, and 77 respectively).

Further, results of the CAET were disaggregated for small (< 2 ha, N = 7) and large (> 2 ha, N = 17) farms and their scores are presented in Figure 5. Here, larger farms had higher scores for the elements Synergies (54 and 60 respectively) and Recycling (50 and 57 respectively), while the total score for the CAET was slightly higher for larger farms as well (74 and 76 respectively).

3.2.2 Perceived importance of the indices of the CAET

The average results for the perceived importance of each CAET index are presented in Figure 6, and are aggregated for each element in Figure 7. On the level of the individual indices, significant variability of the perceived importance was found within most elements. Indices which were deemed to be of least importance (scores below 2.5) to the farmers were: Culture and food traditions: Local or traditional (peasant/indigenous) identity and awareness; Diversity: Animals; Culture and food traditions: Use of local varieties/breeds and traditional (peasant/indigenous) knowledge for food preparation; Recycling: Management of seeds and breeds and Synergies: Crop-livestock-aquaculture integration. Indices which were deemed to be most important (scores above 3.5) to the farmers were: Efficiency: Management of soil fertility, Efficiency: Management of pests and diseases, Synergies: Soil-plants system management, Recycling: Water saving and Circular and solidarity economy: Products and services marketed locally. The other indices received an importance between 2.5 and 3.5 and can be considered as relatively important. The stated importance of the indices was highly and significantly correlated (0.63***) with the actual scores on the indices, indicating that farmers scored higher on the aspects they found important and lower on those they found less important.

When aggregated on the level of the elements, some variability exists between the perceived importance of each element, although most elements had scores around 3, indicating that farmers found them overall important. The element 'Culture and food traditions had the lowest perceived importance, while the element 'Circular and solidarity economy' had the highest perceived importance. The perceived importance of the elements was not significantly correlated with the actual scores on the elements.

3.2.3 Correlations between the elements of agroecology and the overall agroecological transition

The correlations between the elements and the overall score for the CAET and the correlations between the elements themselves is presented in Table 1. Given that the CAET is made up of the scores on the individual elements, positive correlations are expected, but nonetheless there are important differences showing the relative importance of different elements in the overall agroecological transition on the surveyed farms. The element of Resilience was highly and significantly correlated with the overall CAET, as well as the elements Human and social values and Synergies, indicating that these elements were important in determining the overall score on the CAET. Further, Co-creation and sharing of knowledge was highly and significantly correlated with the overall CAET, while Efficiency, Culture and food traditions, Responsible governance, Circular and solidarity economy and Diversity were significantly correlated with it. Only the element Recycling was not significantly correlated to the overall CAET. Individual elements which were found to be pairwise highly and significantly correlated are Human and social values & Resilience, Resilience & Synergies, Synergies & Diversity, Responsible governance & Culture and food traditions and Human and social values & Co-creation and sharing of knowledge. Moreover, Human and social values & Synergies and Responsible governance & Co-creation and sharing of knowledge were significantly correlated.

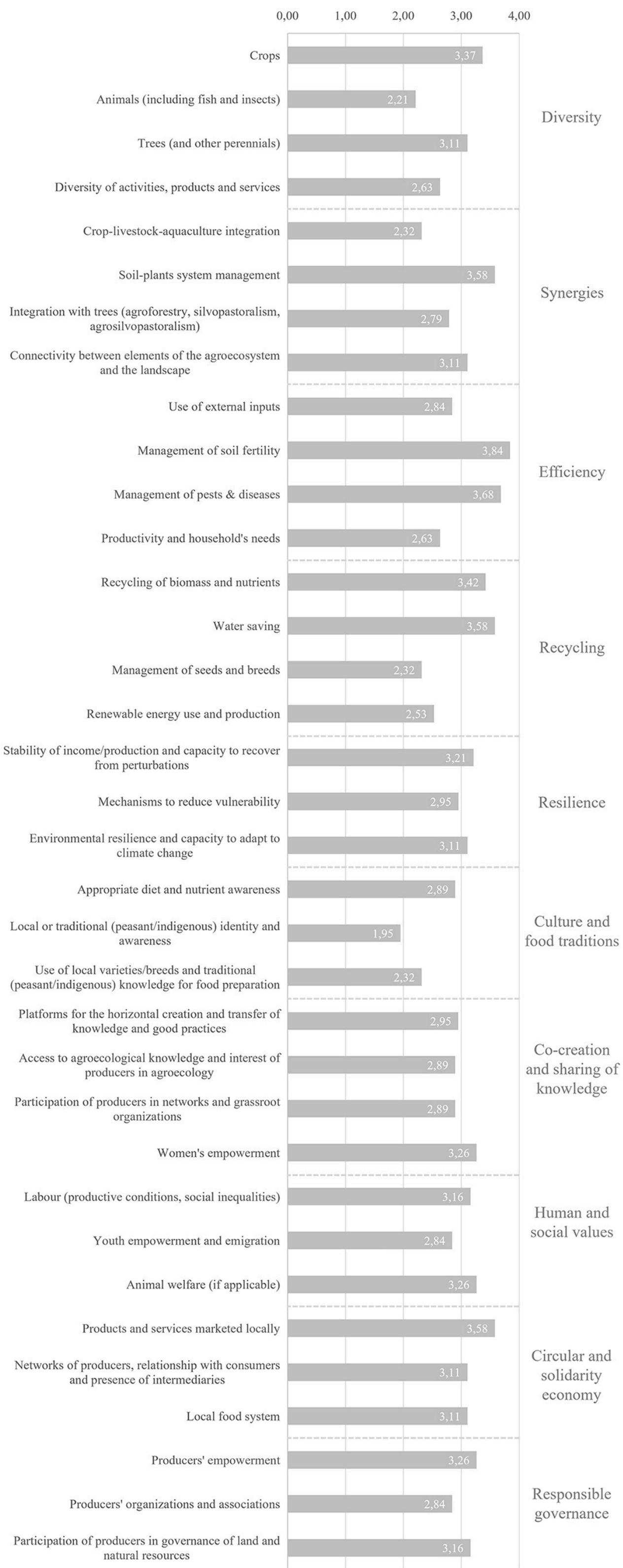

FIGURE 6
The perceived importance of the indices of the CAET ($N = 19$).

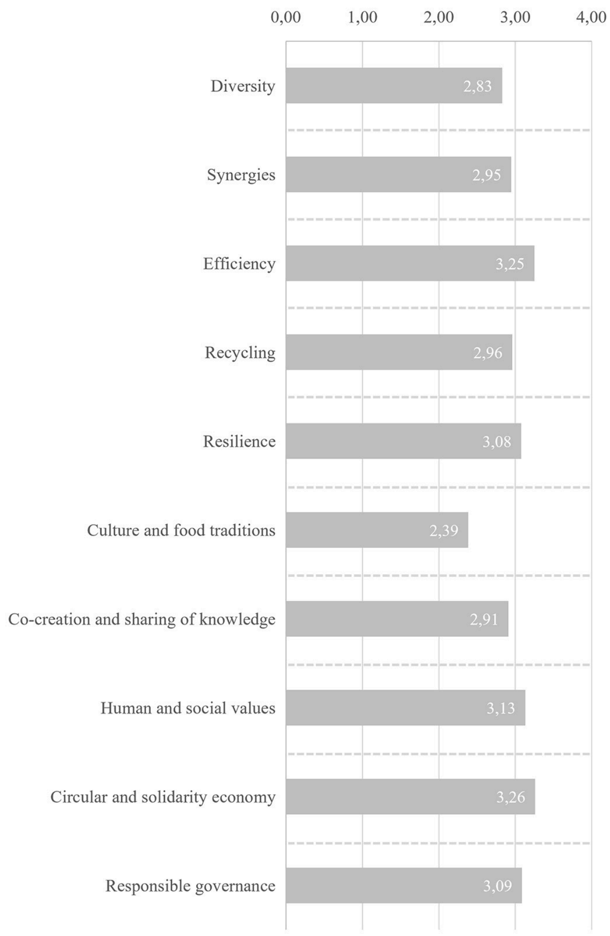

FIGURE 7
The perceived importance of each element of the CAET (*N* = 19).

3.3 Core criteria of performance: the multidimensional performance of agroecology

3.3.1 Overall results

The average values of the calculated criteria of performance are presented in Table 2. Results are further elaborated in the following subsections, disaggregated by the environmental, social and economic dimensions. Where no calculation was possible, feasible or relevant, these criteria were omitted, and alternative criteria are proposed in the Discussion.

3.3.2 Environmental sustainability

Regarding the management of pests and diseases, the large majority (93%) of farms stated that ecological management was most important, of which preventative measures (93%), biodiversity and spatial diversity (86%), encouraging the reproduction of beneficial organisms (64%), the use of cover crops to stimulate biological interactions (43%) and the use of natural repelling plants (36%) were mostly used. For the remaining farms (7%), organic pesticides, all of which had the lowest possible toxicity level, were most important. Given that all farms were certified organic, there was no use of synthetic pesticides and fertilizers. On farms on which animals were reared, either no antibiotics were used or the use of antibiotics was only used curatively. The soil health index was on average 4.275 out of 5, with scores ranging from 3.3 to 5, indicating that farms had very good soil health. Crop diversity index and animal diversity index was not calculated, but crop and animal diversity are elaborated in the general results. Presence of natural vegetation and pollinators on farm scored 67% on average, based on the fact that the majority of farms reported either abundant (32%) or significant (58%) presence of pollinators and other beneficial animals, while only a small minority (10%) reported a low presence. Moreover, all farms reported having either abundant (32%), significant (21%) or small (47%) areas of natural and varied vegetation such as natural meadows, wildflower strips, trees, hedgerows and natural ponds. Beekeeping with honeybees or other domesticated bees was done on 47% of farms, while in another 37% they were not reared but were still reported to be widespread in the agroecosystem.

3.3.3 Social sustainability

The dietary diversity index for farmers was high as they had a diet in which on average at least 7 out of 10 food groups were consumed on a daily basis. From the interviews, it became clear that farmers diets were strongly based on the vegetables, fruits and other products they produced themselves, while they consumed only small amounts of bought food (mostly grains and derived products, but also meat, beverages and food consumed while dining out). These expenditures for food for self-consumption were reported to be on average €1.136 on a yearly basis, but this should be interpreted carefully as the number of samples for this criterion was very low with only 5 observations. Regarding employment on the farm, it should be repeated that most CSA farms are no typical family farms and that the workforce is rather heterogeneous, often consisting of volunteers, interns and people employed through care farming, as well as paid labor of seasonal workers and other employees. Of all farm owners, 19% classified as youth (15-34 years), while 34% classified as women. Youth and women empowerment was perceived by farmers to be higher in CSA systems than in other farming systems in the region. Regarding access to land, all farmers had legal recognition of their ownership or use of the land. However, some farmers perceived that their access to land was still insecure, and that acquiring land is very difficult due to high land prices and the existing land tenure laws.

3.3.4 Economic sustainability

When expressed per hectare, gross value of the agropastoral production was on average €34.084 and the value added of the agropastoral production per hectare was on average €24.945, while expenditures for farming inputs per hectare were on average €3.385. When expressed per employed family member, gross value of the agropastoral production was on average €65.446, while the added value of the agropastoral production was on average

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TABLE 1 Matrix of correlation between the 10 elements of agroecology and the overall CAET.

	CAET	Diversity	Synergies	Efficiency	Recycling	Resilience	Culture and food traditions	Co-creation and sharing of knowledge	Human and social values	Circular and solidarity economy	Responsible governance
Diversity	0.42*	1.00									
Synergies	0.67***	0.62**	1.00								
Efficiency	0.51*	0.32	0.31	1.00							
Recycling	0.20	-0.17	0.05	0.13	1.00						
Resilience	0.81***	0.21	0.66***	0.23	0.29	1.00					
Culture and food traditions	0.48*	-0.12	-0.12	0.08	0.07	0.23	1.00				
Co-creation and sharing of knowledge	0.59**	0.15	0.14	0.21	-0.05	0.30	0.43	1.00			
Human and social values	0.79***	0.33	0.48*	0.27	-0.04	0.71**	0.35	0.52**	1.00		
Circular and solidarity economy	0.43*	0.07	0.36	0.31	0.03	0.38	0.09	0.06	0.31	1.00	
Responsible governance	0.46*	-0.11	0.01	0.02	-0.22	0.29	0.56***	0.41*	0.34	-0.05	1.00

Variables are highly correlated when their correlation lies between 0.7 and 0.9, moderately correlated when their correlation lies between 0.5 and 0.7 and lowly correlated when their correlation lies between 0.3 and 0.5. These correlations were tested on statistical significance using a t-test, after which three stars (***) were given when the correlation is highly significant ($p \leq 0.001$), two stars (**) when it was highly significant ($p \leq 0.01$), one star (*) when it was significant ($p \leq 0.05$) and no stars when the correlation was not significant ($p > 0.05$).

TABLE 2 Results of the criteria of performance.

Criteria of performance		Value	Sample size (*N*)
Environmental criteria			
1	Expenditure for chemical pesticides per hectare (€)	0	14
2	Soil health index	4,275	24
3	Expenditure for chemical fertilizers per hectare (€)	0	14
4	Presence of natural vegetation and pollinators on farm (%)	67	19
Social criteria			
5	Dietary diversity index (%)	77	14
6	Expenditures for food for self-consumption (€)	1,136	5
7	Percentage of farm owners classifying as youth (15-34 years) (%)	19	20
8	Percentage of farm owners classifying as women (%)	34	20
Economic criteria			
9	Gross value of agropastoral production per hectare (€)	34,084	19
10	Gross value of agropastoral production per person (€)	65,446	19
11	Value added of agropastoral production per hectare (€)	24,945	14
12	Value added of agropastoral production per person (€)	55,434	14
13	Expenditures for farming inputs per hectare (€)	3,385	14
14	Net revenue from agropastoral activities per person (€)	49,785	15
15	Value added on gross value of agropastoral production (VA/GVP)	0.77	14
16	Perception of the evolution of income (%)	66	14

€55.434. Net revenue from agropastoral activities per person was on average €49.785. The ratio between value added and gross value of the agropastoral production (VA/GVP) was on average 0,77. The large majority of farmers perceived their income to be stable and on an increasing trend.

4 Discussion

CSA farms are shown to provide a radically different approach to agriculture and food in the context of Flanders. They are smaller than the average Flemish farm but cultivate a remarkable diversity of vegetables, fruits, herbs and flowers with some additionally engaging in the rearing of animals such as chickens, honeybees, cows, sheep and pigs, while maintaining a significant area of their land for natural vegetation in the form of natural meadows, wildflower strips, trees, hedgerows and natural ponds (see Figure 8). Farmers rely on ecological and organic farming practices for improving and maintaining soil health and managing pests and diseases. The main consumers—often called members or participants of the CSA—subscribe to a harvest share with which they either come harvest on the fields or pick up a freshly picked package of produce at the farm, while being able to participate in the decision-making processes on the farm together with the farmers. As a further diversification, CSA farmers often engage with other marketing channels in short food supply chains such as local farmers markets and restaurants. These findings resonate with earlier descriptions of CSA in Flanders in the mapping report of Community Supported Agriculture in Europe by Volz et al. (2016). The CSA system differs markedly from the usually highly specialized and intensive Flemish agriculture which is facing increasing environmental, social and economic challenges. By developing alternative, ecological and local food systems, CSA farms have a high potential to tackle the interlinked environmental, social and economic dimensions of the sustainability challenges in agriculture and food systems in Flanders and beyond (Egli et al., 2023).

Our characterization of the agroecological transition confirms our hypothesis that CSA farms in Flanders are highly agroecological, showcased by high or very high scores most of the elements of agroecology. Following the categorization of farms according to their CAET score, as proposed by Lucantoni et al. (2021), a large majority (83%) of CSA farms can be considered to be *agroecological* (CAET > 70), while 13% can be considered to be *in transition to agroecology* (60 < CAET < 70) and the remaining 4% *in an incipient agroecological transition* (50 < CAET < 60). No CSA farms can be considered as *non-agroecological* (CAET < 50). These findings are in line with the agroecological characterization of CSA farms in Germany performed by Vicente-Vicente et al. (2023), who found them too to be strongly aligned with agroecology. These findings further elucidate the strong linkages between agroecology and CSA and confirm that CSA farms can be considered as highly agroecological systems which can serve as exemplary systems that integrate the environmental, social and economic principles and practices of agroecology. They could therefore serve as lighthouse farms in the agroecological transition of other farms, lighting the way for agroecological transitions on the landscape, territorial and regional level and beyond (Rosset et al., 2011; Wezel et al., 2014, 2020; Nicholls and Altieri, 2018).

Our finding that older and larger farms were more advanced in their agroecological transition than younger and smaller farms,

FIGURE 8
Photos taken at four participating CSA farms showcasing the diversity of vegetables, fruits, herbs, flowers and trees.

was largely explained by their respective higher scores on Synergies and Recycling - elements on which scores were lowest overall. The indices underlying these elements notably include the integration of animals on the farm, which was overall found to be low and of which the age and size of the farm are determining factors as farmers often postponed integrating animals until their crop production was considered to be optimized, demonstrating the importance of the temporal dynamics of agroecological transitions in which the various components of the agroecosystem and their interactions are reconfigured through a process of design (Tittonell, 2020). Agroecology is moreover predominantly prescribed for and embraced by smallholder agriculture (Tittonell et al., 2020), although the integration of animals necessitates sufficient land, especially in the context of agroecology in which the dependence on external feed is minimized and land-based rearing of animals is prioritized. Integrating animals into the farm could therefore be regarded as an important catalyst of their agroecological transition, although it is highlighted as a challenge by the farmers participating in this study as the necessary additional land, external inputs and labor are already considered to be critically scarce and/or expensive in Flanders. Notably, farmers attached relatively low importance to those indices related to the integration of animals, while farmers argued that the absence or scarce presence of animals on the farm should not necessarily be penalized as the integration of animals often occurs at scales higher than that of the farm itself, with neighboring farmers or other community-members often exchanging manure and animal feed by which integration is also achieved locally in a context with very high livestock densities and excesses of manure on the regional scale (Müller, 2015).

Our assessment of the perceived importance of the indices by the participating farmers was conceived as a novel means to contextualize the TAPE, as generally recommended in its guidelines (Mottet et al., 2020) and as argued by Namirembe et al. (2022). In our study, this contextualization is especially interesting as it was performed by farmers who explicitly self-identify with agroecology and whose farms are strongly aligned with agroecology. Our finding that farmers scored highest on those indicators they found most important indicates a high degree of fulfillment in what can be considered as their own interpretation of agroecology. Our method of contextualization could serve as an example in other uses of the TAPE, while the outcome of our contextualization could serve as the basis for the prioritization of further research, initiatives and policies to support agroecological transitions in the context of CSA and Flanders more broadly.

From the analysis of the correlations between the elements of agroecology and the overall agroecological transition, the element Resilience stands out as it was found to be most significantly correlated with the CAET, highlighting that more agroecologically advanced systems were more resilient while conversely resilience was a key property of agroecologically more advanced systems. Resilience was moreover found to be increasing with the age of the farm, accentuating the temporal dynamic of building resilience and advancing in the agroecological transition. Resilience can thus be considered as an emergent property of advanced agroecological systems while it is generally considered as a goal of sustainable food system transitions as a whole (Tittonell, 2020), signifying the contribution of agroecology to sustainable agriculture and food systems. Furthermore, the relative importance of Synergies in the overall CAET—together with its relatively lower score on average—indicates that this element could be an important entry point for the further advancement of CSA farms in the agroecological transition.

Our assessment of the performance of CSA farms on several criteria in the environmental, social and economic dimensions of sustainability shows predominantly positive results. In the **environmental dimension**, soil health was found to be good to very good, resonating with the often explicit focus on soil health as a starting point for environmental and broader sustainability in the principles and practices of both CSA and agroecology (Siegner et al., 2020; Domínguez et al., 2023). CSA farms purposefully do not use synthetic fertilizers and pesticides and instead relied heavily and - by their own accounts - successfully on ecological management of pests and diseases, further guaranteed by their organic certification. Organic certification can thus be considered as an important although not strictly necessary step in the agroecological transition of farms given that the principles and practices of agroecology and organic agriculture also converge to a large extent (Migliorini and Wezel, 2017). Moreover, natural vegetation such as natural meadows, flower strips, hedgerows and trees was significantly to abundantly present as they were deliberately maintained as a source of ecosystem services that underpin for example the ecological management of pests and diseases and pollination of insect-pollinated crops (Holland et al., 2017), while simultaneously a significant to abundant presence of pollinators and other beneficial insects was reported on the farms. In the **social dimension**, CSA farms were often distinct from so-called family farms in which a central family provides capital and labor, as is the case in a large majority of farming operations in Europe, Belgium and Flanders (Departement Landbouw en Visserij, 2020; EUROSTAT, 2023). Farms were often lead by sole farmers or a group of farmers without family-ties, and the workforce on the farm was often significantly expanded by additional workers in the form of volunteers, interns and people employed through care farming, as well as paid labor of seasonal workers and other employees. On many farms, the coming and going of volunteers and interns made up a steady flow of labor in a typically very labor-intensive system, for which the alternative of paid labor is deemed to be expensive, heterogeneous and increasingly hard to find (Popescu et al., 2021). Farmers moreover were largely self-sufficient in the products they produced on their farms, with the large diversity in vegetables, fruits and other products leading them to have equally diverse diets, while the need for external food purchases was relatively low and mostly limited to those products they did not produce themselves such as grains and legumes, animal products and beverages. In the **economic dimension**, positive criteria on gross value, added value and net revenue - both per hectare and per farmer - indicate that farming operations are profitable, while farmers' income was generally - and especially for the agroecologically more advanced farms - perceived to be on the increasing trend, in line with the findings of Van der Ploeg et al. (2019) and Stratton et al. (2021). The ratio between the value added and the gross value of production (VA/GVP) was found to be high and positively correlated with the element Resilience, confirming the findings of Van der Ploeg et al. (2019) who found that this ratio is strategic in distinguishing agroecological systems from conventional systems as agroecological systems try to increase this ratio by enhancing the quality and use-efficiency of internally available resources, by reducing the dependence on external inputs and by putting labor central again in farming, thereby making them more resilient in the face of external shocks. This high economic viability of CSA farms is in line with the findings of Egli et al. (2023), although they also stressed that more labor is needed in order to capture these higher returns per labor unit. Farmers' income, although it is stated to be positive and on an increasing trend, was however raised as a point of concern by the farmers and the 'CSA-Netwerk'. Farmers tend to pay themselves relatively low wages when compared to their labor, confirming the finding of Galt (2013) that CSA farmers often engage in self-exploitation due to their stated sense of providing food at affordable prices for their communities. The centrality of labor, of which a significant share is unpaid in CSA farms, implies the need for a shift from more capital-intensive to more labor- and knowledge-intensive farming in a context in which labor is however increasingly expensive and difficult to attract (Popescu et al., 2021). Unpaid labor might fill a large part of the labor needs of many CSA farms at the moment, but it can be questioned whether this dependency on unpaid labor is equitable and part of a sustainable farming model (Galt, 2013; Van der Ploeg et al., 2019).

We identify several limitations to our work. The CSA farms included in our sample are statistically not representative for the whole population of CSA farms and its results and conclusions should therefore be extrapolated with care. However, farmers participating during the participatory interpretation of the results regarded our sample as relevant enough for a valid interpretation on the population level. Looking beyond the region of Flanders, CSA farms throughout Europe—and beyond—are to a large extent based on the same principles and practices as elaborated in Volz et al. (2016) and hence we expect our findings to hold for CSA more generally to some degree, although we acknowledge that their operations and characteristics are very context-dependent. We further identify several biases which might have influenced our results and their interpretation. Participation bias potentially lead to the self-selection of those farmers more actively engaged with research, which could be linked with—and potentially confound—important variables under study in our work, such as the score on the element Co-creation and sharing of knowledge. Moreover, in questions in which the perceptions of farmers were underlying the outcome, an "upward" or "downward" social desirability bias could have influenced the results based on the conversation with the farmers during the interviews: an 'upward' bias stemming from the self-identification with agroecology, which could lead to farmers wanting to have high scores on their characterization; and a 'downward' bias stemming from an idealistic sense in agroecologically-inspired farmers in which they felt further progress in the agroecological transition still had to be possible and necessary. Furthermore, an assessment of the sustainability performance centered on agroecology and its specific interpretation of sustainability might lead to a self-fulfilling and so-called agroecology bias, highlighting the additional need for other, more neutral tools in order to comprehensively compare agroecology with alternatives (Geck et al., 2023). Moreover, several indices and criteria proposed in the TAPE methodology were of little relevance to the specific regional context or the context of CSA farms, and where possible these indices were contextualized to make relevant interpretations possible. On the other hand, several sustainability criteria were calculated but their interpretation was not sufficiently relevant leading to these criteria being left out, but for some of which we propose alternatives below.

We recommend the following adaptations to the TAPE based on its use in the context of CSA farms and that of Flanders, although we deem our recommendations to potentially hold more broadly beyond these contexts and have relevance in other farming systems and regions. (1) Access to land is often not just a legal or institutional issue, as the challenge may lie in the availability, affordability and long-term certainty of land ownership or tenure. This is especially the case in Flanders, where high pressures on agricultural land from both agricultural and non-agricultural activities and a lack of long-term visions on land use in the political sphere make access to land for new farmers increasingly difficult (Kerselaers et al., 2013; Vandermaelen et al., 2023); (2) Youth empowerment and migration is often not the only problem regarding youth in agriculture, as is the case in Flanders where a lack of interest of youth in agriculture and a lack of generational renewal due to high investment costs or debts and an uncertain political atmosphere are the most pressing issues; regarding youth in agriculture (Coopmans et al., 2020, 2021); (3) Economic criteria for farm profitability should be harmonized to be in line with international, national and regional reporting (such as the Farm Accountancy Data Network in the European Union) allowing for meaningful comparisons with already collected and often publicly available data (EUROSTAT, 2023); (4) Demographic indicators relating to the composition of ownership of and the workforce on the farm insufficiently capture the heterogeneity of an increasing number of farming systems where there is no central family providing labor and capital, as is the case in Flanders and especially in CSA. Moreover, the demographic indicators do not acknowledge or enable to take into account family compositions and gender identities that do not fit the gender binary; (5) While diversity is one of the elements of agroecology and can be regarded as a cornerstone of CSA systems, it is still insufficiently captured with the methodology, as for example farms cultivating at least four different crops can already receive the highest possible score for the crop diversity index of the CAET. Moreover, the diversity of crops in CSA systems makes it difficult - if not impossible, given that farmers often don't harvest themselves - to measure the yield of all crops, leading to a structural underreporting in diversified systems of this criterium which Egli et al. (2023) found to be already an underreported outcome in their systematic review of sustainability outcomes of CSA, highlighting the need for the development of appropriate and relevant methods to overcome this bias; (6) Dietary diversity of farmers, although a relevant indicator in a context of subsistence agriculture, only covers a very small proportion of consumers of the produced food - if any at all - in a context where the food produced is increasingly sold to others instead of consumed by farmers themselves. A more relevant indicator might be the dietary diversity and nutritional value of the food produced on the farm itself, in line with other relevant studies on dietary and health outcomes in CSA systems as identified by Egli et al. (2023); (7) The questionnaire on the criteria of performance was considered by many participating farmers as very long and detailed, leading to some dropping out throughout this step and thus leading to lower sample sizes for some criteria in our study. Therefore, attention should be given to further reducing the length and the time requirement of completing the questionnaire by, for instance, developing regionally contextualized versions where more relevant criteria would replace those who ultimately might not be calculable or interpretable.

These proposals raise the issue of balancing the need for assessing agroecology in a manner that is both globally comparable on the one hand side while being locally relevant on the other, as highlighted by Geck et al. (2023). To balance the existing trade-offs between the evaluation purpose, the time requirement and the level of participation in the existing methods, Darmaun et al. (2023) propose to use a combination of approaches to improve the assessment of agroecology. Looking at sustainability assessments in agriculture and food systems in Flanders, Coteur et al. (2019) stress that apart from the assessment itself, attention should be given to the dynamics of cooperation and communication between chain actors surrounding the assessment, while the tools used should additionally aim at supporting farmer's strategic decision-making from developing and implementing improvement strategies to monitoring their results (Coteur et al., 2020). The assessment performed in this study should therefore be regarded as the starting point for a broader participative process in which researchers, farmers and other stakeholders engage with each other in agroecological transitions from the farm to the food system level.

Voicing the need of participating CSA farmers, the use of the TAPE should be expanded to other farming systems in Flanders and beyond, as this would allow for the comparison of their agroecological characterization and sustainability performance with other, more conventional systems. Moreover, assessing additional relevant criteria proposed in the list of advanced criteria in the TAPE (such as nutritional value of agricultural production, water use efficiency and water pollution, greenhouse gas emissions and carbon sequestration) could further expand the evidence on the multidimensional sustainability of the systems under study and in line with the challenges and needs of agriculture and food systems in their specific context. Furthermore, as sustainability challenges in agriculture and food systems are inherently complex; holistic and integrated approaches should be prioritized in not only assessments but also transition strategies and government interventions to support these transitions.

5 Conclusions

While in literature it is acknowledged that CSA farms are based on agroecological principles and practices and can thus be regarded as agroecological farming systems, a characterization of their agroecological performance remained largely absent. Moreover, current sustainability assessments of CSA - and other farming systems by extension - are fragmented and heterogeneous, concealing the contribution of these systems to more sustainable agriculture and food systems. In order to fill this knowledge gap, we applied the TAPE - a holistic and integrated methodology for the characterization of agroecology and assessment of the sustainability performance of farming systems - to CSA farms in the region of Flanders in Belgium, where agriculture and food systems are facing increasing environmental, social and economic pressures and challenges.

Our characterization shows that CSA farms in Flanders are strongly aligned with agroecology, exemplified by their very high scores on the elements Co-creation and sharing of knowledge, Human and social values, Responsible governance, Circular and solidarity economy and Resilience, while high scores were obtained on the elements Efficiency, Diversity and Culture and food traditions. The lowest scores were obtained for the elements Synergies and Recycling, although the farms can still be regarded as moderately advanced on these. Older and larger CSA farms were more advanced in the agroecological transition, especially on the elements Synergies and Recycling on which farms generally scored lowest. In order to contextualize the TAPE, the perceived importance of the indices by the participating farmers was assessed, showing that farmers scored highest on those indicators they found most important, while our method of contextualization could serve as an example for the contextualization in other uses of the tool and providing an entry point for further research, initiatives and policies to support agroecological transitions in the context of CSA and Flanders.

Moreover, CSA farms performed well on several criteria in the environmental, social and economic dimensions of sustainability. In the environmental dimension, they showcased good to very good soil health, successful reliance on ecological management of pests and diseases and, associated with and underpinning it, a significant to abundant presence of natural vegetation and pollinators and other beneficial insects. In the social dimension, the labor of the farm owner(s) was often supplemented with additional unpaid workers in the form of volunteers, interns and people employed through care farming, as well as paid labor of seasonal workers and other employees, while farmers themselves were largely self-sufficient in their diets given that they produced a wide diversity of vegetables, fruits and other products. In the economic dimension, positive gross value, added value and net revenue indicate profitable farming operations, while income was stated to be positive and on the increasing trend over time.

Based on our characterization of agroecology and our assessment of the multidimensional sustainability of CSA farms in Flanders, we argue that CSA, being based on agroecological principles and practices, effectively showcases a high agroecological performance. In addition, its sustainability performance in the environmental, social and economic dimensions showcase multiple positive and promising outcomes in the face of both global and regional challenges in agriculture and food systems. We identify the integration of animals into the farming system and the strong dependency on -often unpaid - labor as two critical challenges for the agroecological transition and sustainability of CSA in Flanders, and further determine several important limitations to our work that should be taken into account when interpreting our results and delineating similar future research efforts. Finally, we confirm the TAPE as a relevant and holistic framework for the characterization of agroecology and the assessment of the sustainability of farms, although we propose several adaptations to the TAPE in order to move toward more contextualized applications in Flanders on the one hand and on CSA farms on the other.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

RS: Conceptualization, Methodology, Investigation, Software, Data curation, Formal analysis, Visualization, Writing – original draft. JD: Conceptualization, Supervision, Writing – review & editing. DL: Methodology, Validation, Writing – review & editing. SS: Conceptualization, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2024.1359083/full#supplementary-material

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