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Understanding business model sustainability in food production systems through Life Cycle Thinking

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Abstract

The sustainability of global food systems represents a critical challenge across developed and developing countries, considering its long-term impacts not only in environmental terms but also societal and economic. Social and economic sustainability of the food system is getting the spotlight due to the emerging societal need of improving stakeholders' livelihood and well-being. In this context, business models (BM) play a vital role in shaping the food system and provide promising opportunities for boosting sustainability in agri-food production. Due to the qualitative nature of social issues, socio-economic (positive or negative) impacts are more complex to be assessed through quantitative measures. Therefore, methods and metrics for social sustainability assessment need to be further explored for a reliable quantification of socio-economic impacts, for not only scientific but also societal and policy purposes. To this scope, Life Cycle Thinking (LCT) is regarded as a promising approach to investigate the sustainability of BM in food systems in different global regions, and can be combined with additional methodologies to encompass the complexity of socio-economic drivers and impacts in food system sustainability. This work seeks to address the following research questions: (1) How can LCT be applied to assess the sustainability performance of BM in food production? (2) How can BM be designed to foster sustainable practices in agricultural production? (3) What are the main socio-economic factors that are connected to the sustainability of food BM in different regional contexts?

Three scientific works (the thesis' chapters) collaborate to address these questions transversally. First, an assessment framework is developed to assess social handprints generated by City Region Food System initiatives on stakeholders' well-being. Second, a case study of a horticultural farmers' cooperative in Costa Rica drove the analysis of life cycle environmental and economic costs connected to agroecological practices to improve the cooperative's BM sustainability. Third, Costa Rican coffee farmers were reached to understand the psychosocial and behavioural factors driving the adoption of sustainable agricultural practices in coffee production, and to unveil a social impact pathway towards farmers' well-being based on statistical modelling. Together, these studies allow to examine the subject of sustainable BM from diverse perspectives, offering valuable implications for enhancing the socio-economic sustainability of agricultural practices.

This thesis advances the understanding of BM sustainability in food production and shows the potential of the LCT approach in addressing environmental, economic, and social dimensions to ultimately improve BM sustainability in food systems. The outcomes provide an in-depth view into socio-economic impacts of food system BM, investigating possible metrics, frameworks, and BM applications for sustainable development. Lastly, the research highlights the importance of tailored, context-specific approaches in addressing sustainability challenges in food systems and underscores the need for continued innovation and collaboration to support global transitions towards more sustainable food systems.

Keywords: Life Cycle Thinking; Business Model; Social Life Cycle Assessment; Environmental Life Cycle Costing; City Region Food System; Coffee

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Introduction

I. The sustainability of food systems across developed and developing countries

The concept of "sustainable development", officially born with the "Our Common Future" report by the United Nations Environment Programme (UNEP) Commission Brundtland (World Commission on Environment, 1987), is one of the most challenging concepts driving both international research and policy agendas. In the last decades, the concept has evolved and changed its shape through several different stages. Great emphasis has been placed on environmental sustainability to shift towards more efficient productive systems that allow optimised use of natural resources and minimised externalities such as greenhouse gas emissions and waste (Hegab et al., 2023). But the concept also embraces a socio-economic perspective, reckoned as indispensable: the societal development should aim at environmental, economic and social sustainability simultaneously (Mensah, 2019). The concept of sustainable development is linked to the principles of socio-economic metabolism and colonisation of nature, as presented by Fischer-Kowalski and Haberl (1998). Through the colonisation of natural systems, human societies tend to derive maximum benefit for their own social purposes and well-being (Fischer-Kowalski and Haberl, 1998), benefits which are referred to as ecosystem services (MEA, 2003).

The first human activity where the intersection between social and natural spheres is manifested is feeding: human beings exploit natural resources for the nutritional intake they need to produce energy, through an action of colonisation. Scholars emphasise the intrinsic nature of food system relying on the interconnection of human and natural spheres (McGreevy et al., 2022), stressing the relevance of community well-being, which is at the heart of agri-food systems sustainability (Blackstone et al., 2024). Current agri-food systems and their production and consumption patterns proved to be unsustainable, leading to various negative externalities, including environmental degradation (Accorsi and & Manzini, 2019; IPBES, 2019), food insecurity (FAO, 2023), and exploitative labour conditions (Mani et al., 2016). To this scope, the need for a "safe and just operating space" for human food systems requires the adoption of systemic thinking and integrated approaches able to unveil the interconnections between the environmental, economic, and social spheres towards sustainable development (Lüth et al., 2023; TEEB, 2018).

On a global scale, the shift towards sustainable food systems requires tackling diverse challenges in different context across the world. A great effort is needed to adapt possible solutions to local territories in both developed and developing countries. In the European Union (EU), the improvement of the food system resilience is not only at the heart of the Farm to Fork Strategy, the Food2030, and the Green Deal, but also essential to face the need for reacting to external shocks (EU 2020), which can exacerbate systemic weaknesses and widening inequities in the access to basic needs (HLPE 2020). Conversely, in developing regions like Latin American and Caribbean (LAC), the challenges are often more acute, with limited access to resources (including food), technology, and markets exacerbating the vulnerabilities of smallholder farmers and rural communities (OECD-FAO, 2019). This region produces the 13% of the net value of global agriculture and fish production and exports the 70% of the total production value (OECD-FAO, 2024). Still, sustainable food production in LAC is not only an environmental or economic issue but also a matter of social justice, significantly impacting the livelihoods and well-being of marginalised communities (Intini et al., 2019).

II. The role of business models in the transition of food systems towards sustainability

Food system sustainability requires not only regulation and policy interventions to minimise negative externalities, but also proactive stances towards new opportunities and multiple stakeholder engagement (Finkbeiner et al., 2010). To this scope, businesses play a key role in delivering sustainability outcomes, given that they administer most of the planetary resources and the means to extract, transform, and deliver them (Chofreh et al., 2018; Geissdoerfer et al., 2018). Sustainable businesses have gained attention, reflecting the shift from linear, profit-seeking approaches to more sustainable ones, including bioeconomy, circular economy, nature-based solutions, and social inclusion, inter alia. Sustainable businesses focus on shared value creation for the society, targeting a wide variety of stakeholders, including the environment (Evans et al., 2017). These trends led to the generation of an extensive sustainable mass market capable of attracting both sustainable niche entrepreneurs eager to expand their business, and traditional mass corporations inclined to pursue innovation (Schaltegger et al., 2016). As a result, a correlation arises between sustainability, competitiveness, and growth, facilitating the dissemination of sustainability management tools such as Life Cycle Thinking (LCT) (Laasch, 2018).

However, systematising business sustainability requires both understanding the business operational framework and designing a robust innovation strategy (Boons and Lüdeke-Freund, 2013). The business model (BM) serves as architecture to explicit how "an organisation creates, delivers and captures value" (Osterwalder and Pigneur, 2010), and allows to discover sustainable innovation opportunities (Geissdoerfer et al., 2018). As sustainability emerged as a business imperative, many scholars strove to incorporate sustainable value paradigms in BM (Laasch, 2018). To this end, Sustainable Business Models (SBM) allow to "capture economic value while maintaining or regenerating natural, social and economic capital beyond organisational boundaries" (Schaltegger et al., 2016). On top of driving sustainable innovation, SBM propose win-win solutions to address the trade-offs in sustainable value creation, including the needs of various actors (Antikainen and Valkokari, 2016; Boons and Lüdeke-Freund, 2013). Accordingly, participatory approaches and stakeholder engagement are recommended for the design of these models (Bellucci et al., 2020). SBM are expected to make non-sustainable BM obsolete (Geissdoerfer et al., 2018) and should be considered as the next paradigm in BM research (Shakeel et al., 2020). Yet, the existing tools for sustainability assessment are non-specific and fail to consider the peculiarities of the diverse sectors and their impacts on environmental and human contexts.

The debate around agri-food sector's sustainability is shaped by the emphasis on the concerning impacts of the entire supply chain on ecosystems and local communities, especially related to food security, food waste and losses, and the "triple burdens of malnutrition" (undernutrition, overnutrition, and nutritional deficiencies) (El Bilali, 2019). However, the agri-food system's features comprise a fertile ground for sustainable innovation, being "rooted in their communities" and responsive to diverse stakeholders' interests (Barth et al., 2017). The cyclical nature of seasonal food production, alongside its increasing vulnerability to climate change and extreme events, call for long-term planning, while its reliance on finite natural resources requires efforts on resource optimisation. To this scope, SBM can facilitate the adoption of sustainable agricultural practices (SAP), promote fair trade and ethical sourcing, and support local economies through short supply chains and direct marketing strategies. Since agri-food innovation has been traditionally focused on increasing productivity (Ulvenblad et al., 2019), research on sustainability in agri-food BM is still emerging and further exploration is recommended to create a solid theoretical basis through systematic approaches for the implementation of agri-food SBM (Miranda et al., 2023).

One of the most prevalent tools for studying agri-food SBM is the Business Model Canvas (BMC), developed by Osterwalder and Pigneur (2010), thanks to its simplicity in dissecting the four fundamental functions of a BM, i.e. value proposition, value creation, value delivery, and value capture, which are then depicted in the nine components of the BMC. Nevertheless, many scholars stress the need of incorporating additional perspectives in the BMC to make it applicable to SBM (Daou et al., 2020; Evans et al., 2017; Laasch, 2018). The integration of LCT into BMC has been acknowledged as promising to address BMC shortcomings in investigating sustainable value (Bradley et al., 2020; Joyce and Paquin, 2016).

III. How to analyse socio-economic issues for sustainable business models around the world: the Life Cycle Thinking approach

Assessing the BM sustainability in food systems requires a comprehensive approach that encounters the entire value chain alongside the complex landscape of stakeholders. On one hand, a mixed methods research approach, integrating in a singular study both qualitative and quantitative techniques, aids a thorough comprehension of sustainability (Scerri and James, 2010; Tashakkori and Creswell, 2007; Timans et al., 2019). On the other, the LCT approach stands out for its holistic vision that integrates not only the different phases of the life cycle of a product or service, but also the various dimensions of sustainability, i.e. the environmental, economic, and social.

According to the perspective adopted, LCT can provide an evaluation of the sustainability impacts of a particular product, process or service (via an attributional approach) or forecast possible future consequences resulting from interventions (through a consequential approach). The LCT framework consists of Life Cycle Assessment (LCA) addressing environmental impacts (ISO 14040, 2006; ISO 14044, 2006), Life Cycle Costing (LCC) quantifying full costs, with the aim of optimising cost-effectiveness (Hunkeler et al., 2008), and Social Life Cycle Assessment (S-LCA) assessing both positive and negative social impacts (UNEP, 2020). However, to overcome the limitations of S-LCA in allocating impacts to product level and better conciliate with the BM perspective, the Social Organisational Life Cycle Assessment (SO-LCA) (D'Eusanio et al., 2022; Martínez-Blanco et al., 2015) is adopted as reference method.

The life cycle analysis process is divided into four iterative phases, which can also be followed for all life cycle sustainability assessment tools (LCA, LCC, and S-LCA) (ISO 14040, 2006; ISO 14044, 2006): a) Goal and Scope definition, setting the functional unit and system boundaries for the study, along with underlying assumptions; b) Life Cycle Inventory, including data gathering and validation; c) Life Cycle Impact Assessment, in which impact categories and indicators are selected, the inventory data is classified and allocated according to impact categories, and the characterisation model is defined; d) Interpretation of results, identifying hotspots, and potentially providing recommendations for decision-makers to improve the analysed sustainability performances.

LCT allows for the identification of key impact hotspots (Böckin et al., 2022), and the integration of the three sustainability pillars supports the interpretation of trade-offs in the analysis of BM sustainability (Goffetti et al., 2022), to ultimately maximise positive impacts and minimise negative ones. Also, LCT can support cross-regional evaluations, with the aim to uncover good practices and takeaways from different contexts. In this sense, the enhancement of knowledge, the bridging of research gaps, and the application of LCT to BM in both developing and developed contexts may yield scenario analyses and policy frameworks to effectively tackle food system sustainability challenges.

IV. State of the Art in Social Life Cycle Assessment (S-LCA) and Social Organizational Life Cycle Assessment (SO-LCA)

Scientists alert to an increasing urgency to incorporate in sustainability assessments quantifiable metrics of socio-economic issues within food systems. Social impacts are extremely complex to be assessed due to their multifaceted nature, which requires interdisciplinary approaches for the identification of their multilayered characteristics (Iofrida et al., 2018). The interpretation of social impacts is subjected to diverse value systems shaped by cultural perspective and contextual challenges, increasing the level of complexity (Grubert, 2018). As a result, the social dimension is frequently neglected in favour of environmental and economic sustainability analyses, receiving increased attention only in the last few years s (Arcese et al., 2018), therefore advocating for deeper investigation on methodological developments and applications (Blackstone et al., 2024; Kühnen and Hahn, 2019). However, S-LCA is historically the most controvert among life cycle methodologies and still struggles in its development and scientific grounding (Iofrida, Strano, et al., 2018; Sakellariou, 2018).

S-LCA focuses on products or services across their entire life cycle, from raw material extraction to end-of-life management, and aims to identify and quantify social effects through measurable indicators (UNEP, 2020). The International Standard Organisation has recently published a specific standard for the application of the S-LCA methodology, providing a standardised framework also for integrating social considerations into sustainability assessment (ISO 14075, 2024). The SO-LCA can be considered as a twin of the S-LCA method, yet the focus relies on the social consequences at the organisational level rather than specific products or services (D'Eusanio et al., 2022). As a result, the goal and scope definition phase differs significantly between S-LCA and SO-LCA, along with the inventory phase (Martínez-Blanco et al., 2015). SO-LCA includes considerations on the social repercussions of management decisions and operational practices, such as labour practices, ethical sourcing, and relations with the local community, among the others. However, the impact assessment and interpretation can be performed similarly.

For the impact assessment, two main approaches are adopted: Type I (reference scale) and Type II (impact pathway). The Type I approach relies on predefined performance benchmarks to evaluate social impacts by comparing social performance to a set of predetermined criteria or best practices, often using an ordinal or qualitative rating systems. The assessment is typically qualitative, relying on expert judgment, stakeholder surveys, and secondary data to classify the studied system into predefined impact levels. The UNEP (2020) guidelines highlight that this approach facilitates comparability across assessments and allows for the integration of normative frameworks, such as international labor standards or human rights guidelines. However, its limitations include a lack of direct causal linkages between activities and social outcomes, potentially reducing its explanatory power.

In contrast, the Type II approach, or impact pathway method, establishes a cause-effect relationship between specific activities, their social mechanisms, and ultimate impacts on stakeholders. This method aligns with the ISO 14075 (2024), which emphasises the need for analysing systematic linkages between inventory data, intermediate indicators, and final impact categories in more robust and evidence-based assessments. As a critical point, Type II assessments require a more extensive data availability, often integrating quantitative modelling and statistical analysis to establish correlations between business activities and social outcomes, demanding interdisciplinary integration with e.g. social science methodologies (e.g., behavioural economics modelling).

V. Objective of the research

This thesis aims to explore the potential of LCT in addressing sustainability of BM in food production cooperatives across diverse socio-economic contexts, focusing on EU and LAC. By seeking social, economic and environmental evidence, the current work proposes different methodological frameworks to evaluate the contribution of BM to sustainable food systems. The research raises three main questions to be addressed:

1) How can LCT be applied to assess the sustainability performance of BM in food production?
2) How can BM be designed to foster sustainable practices in agricultural production?
3) What are the main socio-economic factors that are connected to the sustainability of food BM in different regional contexts?

Through this comprehensive exploration, the thesis contributes to the academic and practical understanding of how LCT can be exploited to not only assess but also enhance the sustainability of BM in food production. The findings are expected to provide valuable insights for policymakers, business owners, and other stakeholders pursuing the establishment of inclusive, resilient, and equitable food systems across diverse regional contexts.

VI. Thesis structure

This thesis is organised into three chapters, each focusing on different aspects of sustainability assessment for BM in food systems. Together, these chapters explore diverse contexts and sectors, including City-Region Food Systems (CRFS) in EU and agricultural production practices in LAC, to test the potential of LCT in providing insights on BM sustainability across the world.

Chapter 1 introduces a novel framework for assessing the social handprint of BM within CRFS. It emphasises the importance of urban-rural linkages in promoting sustainable food flows and highlights the concept of social handprints, or positive social impacts, on stakeholders' well-being. By integrating S-LCA with other analytical approaches such as the BMC and the Theory of Change, this chapter provides a methodological foundation for evaluating and improving the social contributions of CRFS initiatives to well-being.

Chapter 2 focuses on the horticultural farming in Costa Rica, to explore the environmental and economic dimensions for sustainable business modelling. The chapter examines agroecological practices in terms of both environmental footprints and economic viability, using Environmental LCC (E-LCC). It also identifies market barriers and opportunities for SBMs in the Costa Rican horticultural sector and proposes a SBM for a local cooperative of small farmers in Costa Rica, to provide relevant takeaways for business-owners and policy makers in developing contexts.

Chapter 3 investigates the social sustainability of coffee production in Costa Rica by analysing the factors influencing farmers' adoption of SAP. It employs a mixed-method approach combining the Theory of Planned Behaviour and S-LCA to model the impact pathway from behavioural factors to perceived well-being through Structural Equation Model. Findings provide insights into the psycho-social and behavioural drivers that shape sustainability outcomes and improve farmers' well-being, which can be exploited by business-owners and decision-makers in the design and implementation of sustainable BM and policy interventions for sustainable food systems in developing contexts.

Conclusions present the main outcomes for current research, the major challenges for the applicability of the followed approaches, and recommendations for future research and policy implementation at the EU and LAC level.

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Chapter 1 : Exploring social handprints on well-being: a methodological framework to assess the contribution of business models in City-Region food systems

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Abstract

Acknowledging urban-rural linkages as crucial forces driving resource and food flows, the City Region Food System (CRFS) approach gained momentum as a premise to stimulate the transition towards more sustainable food systems. CRFS initiatives (CRFSi) represent potential game-changers implementing innovative business models (BM) addressing human well-being as a core goal of sustainability. Building on learnings from the EU-H2020 project FoodE, an assessment framework is proposed to unveil social handprints on stakeholders' well-being in CRFSi BM.

The assessment framework is grounded on the Social Life Cycle Assessment (S-LCA) methodology combined with a mixed-method approach. The BM Canvas is used to support the analysis of the product system and its main activities, along with the interpretation of impact assessment, while the Millennium Ecosystem Assessment is adopted for defining both the Area of Protection and the impact categories, and the Theory of change is followed to draw the qualitative impact pathway. The assessment framework is implemented in a case study to verify its applicability.

Results provide a life-cycle-based assessment framework to unveil social handprints in CRFSi, monitor BM performance, and support decision-making to improve CRFSi's social sustainability. The assessment framework operationalises a social handprint approach to assess positive social impacts on well-being through a qualitative impact pathway presenting social handprints in terms of person-equivalent. Critical aspects in social handprints are qualitatively interpreted considering the BM Canvas to identify the strengths and weaknesses as well as potential improvements of the BM. This ready-to-use framework provides an easily understandable measure of people directly benefiting from the CRFSi activities, along with an ad hoc interpretation of the BM characteristics and the related potentiality for social handprints.

This paper provides a pragmatic conceptualisation and methodological framework for the assessment of positive impacts to be applied to social business in CRFSi. The framework can be directly exploited by business owners and decision-makers to assess and improve BM for social handprint maximisation. Further development is recommended to advance the S-LCA methodology towards social handprint assessment with specific reference to BM, along with validation through both scientific community consultation and real case studies applications, to ultimately support European and local policy-makers in the definition and assessment of economic activities having positive social impacts.

Keywords: city-region food system, social life cycle assessment, business model, social handprint, well-being

1.1. Introduction

The global food system is struggling to reduce its environmental footprint (IPBES, 2019) while ensuring the right to food (FAO, 2023) and fostering social equity and community well-being (McGreevy et al., 2022). Cities are crucial to the transition towards sustainable food systems (Ellen MacArthur Foundation, 2019; Morgan and Sonnino, 2010). Cities, i.e. urban areas (UN-Habitat, 2020), are typically intended as consumption sites, attracting 80% of food produced in the world (EAT, 2022) and burdening rural areas (Säumel et al., 2022), deemed mainly as production sites (Arthur et al., 2022; Weerabahu et al., 2022). The City Region Food Systems (CRFS) approach has been developed (RUAF et al., 2015) to analyse the relations between food production and consumption in geographical and socio-economic terms (Blay-Palmer et al., 2018) pointing out the multidimensional nature of the food system (Blay-Palmer et al., 2021; Morgan, 2015). Several scholars attempted to disclose CRFS overall sustainability impacts (Doernberg et al., 2022; Dubbeling et al., 2017; Fei et al., 2023; Vicente-Vicente et al., 2021), while Cirone et al. (2023) investigates and defines CRFS initiatives (CRFSi) as key entities and units of analysis, by questioning their sustainability impacts and related business models (BM).

In sustainability science, life cycle perspectives are believed essential for sustainability assessments (Sala et al., 2013a). Acknowledging sustainability as an intrinsically anthropocentric concept, human well-being is named as the main area of protection for a Life Cycle Sustainability Assessment (Schaubroeck and Rugani, 2017; Soltanpour et al., 2019; UNEP, 2020). Researchers recognise sustainability performance as the capacity of an organisation to generate societal benefits and help stakeholders meet their needs (Kroeger and Weber, 2014; Kühnen et al., 2022). However, the social dimension, including stakeholders' perspectives, receives relatively less scrutiny in food system sustainability research and in the analysis of trade-offs in the agricultural sector (Breure et al., 2024; Toussaint et al., 2022). Further research is needed to understand the social benefits of CRFSi that can enhance overall sustainability performance, on top of reducing environmental footprint (Hawes et al., 2024). Beyond mitigating negative impacts, life cycle-based sustainability assessments should strive to foster positive contributions to sustainable development (Sala et al., 2013a). Especially in Social Life Cycle Assessment (S-LCA), experts hint at limited attention to positive social impacts and advocate for their assessment (Brenes-Peralta et al., 2021; Di Cesare et al., 2018; Kühnen and Hahn, 2019), thus opening new possibilities for methodological advancements in the field of S-LCA (Sala et al., 2013b).

Noteworthy impacts on well-being can be generated by businesses (Durand and Boarini, 2016; UNEP, 2021). Social businesses are organisations that employ market-driven approaches to reach a social or environmental target (Defourny and Nyssens, 2017), whose maximisation is their own ultimate goal beyond profit-seeking (El Ebrashi, 2013; McClean et al., 2021). In social entrepreneurship research, social impacts are considered as "beneficial outcomes" generated by business activities for target stakeholders (Rawhouser et al., 2019). In social BM, social impacts are part of a "blended value" creation (Defourny and Nyssens, 2017). Therefore, there is an emerging need to assess the impacts on people's well-being generated by businesses (Shinwell, 2018). To this scope, a framework was presented by the Organisation for Economic Cooperation and Development (OECD) to unveil the non-financial performance of businesses and their effects on stakeholders' well-being (Siegerink and Shinwell, 2022). In this sense, the evaluation of BM through a social lens can support stakeholders in science-based assessment to foster decision-making for the increase of social opportunities (Gilsing et al., 2022). Furthermore, the emphasis in the field of business sustainability should be redirected from merely mitigating negative burdens to actively improving beneficial outcomes (Sala et al., 2013a). For a business to be net positive, handprints should outweigh footprints, from here the need to measure social handprints (Benoit Norris et al., 2020; Croes and Vermeulen, 2021).

Grounding on previous research on CRFSi sustainability assessment (Cirone et al., 2023; Petruzzelli et al., 2022b), the current paper focuses on how to assess and quantify the positive contributions generated by BM in CRFSi on stakeholders' well-being. To do so, it aims to develop and apply a methodological framework rooted in the S-LCA approach, and more specifically the Social Organisational Life Cycle Assessment (SO-LCA), where the CRFSi BM is intended as unit of analysis and positive impacts are meant as social handprints. A pragmatic conceptualisation for the assessment of social handprint is provided along with a methodological framework to be applied to social businesses in CRFSi. Evaluation of social handprint stems from a qualitative impact pathway unfolding from CRFSi activities towards impacts on stakeholders' well-being. The impact pathway follows the ISO standard 14075 (2024) relying on the Theory of Change, while a new characterisation model is proposed to express social handprint in person-equivalent (person-eq) as novel unit of measurement of human well-being. The proposed assessment framework represents a first step towards the evaluation of social handprints generated by BM in CRFSi and can support business-owners along with policy-makers at European Union and local level in the improvement of BM positive impacts towards sustainable food systems.

1.2. Methods

Conceptual background

In line with Sala et al. (2015), the following paragraphs describe the guiding principles and the definitions adopted for the development of the assessment framework. To this end, a transdisciplinary approach is followed (Sala et al., 2013a) in combining SO-LCA with BM for the methodological framework development. The set of literature-based definitions adopted for the assessment framework development can be consulted in Table a in Annex Chapter 1 (A-C1). Additional methodological inputs derived from a scoping review (see Table b in A-C1) inspired the methodological framework development. To this scope, three guiding principles are presented as conceptual background for the development of the CRFSi social handprint assessment framework.

<u>Guiding principle I: Social handprint approach</u>

Among the existing frameworks on positive social impacts presented by Di Cesare et al. (2018), the concept of handprints was coined by Gregory Norris (2013) and responds to the need to overcome the limitations of footprint quantification. As opposed to footprint conceived as human negative pressure on planetary boundaries (Galli et al., 2012), handprints are intended as positive contributions resulting from changes in human activities compared to business-as-usual (Norris, 2013; UNEP, 2020). Footprints measure the current status, whereas handprints refer to positive changes that go beyond the mere mitigation of footprint (Croes and Vermeulen, 2021). Considering its potential to support decision-making, SO-LCA is acknowledged as a crucial approach sustaining social handprint assessment (Husgafvel, 2021; Kühnen and Hahn, 2019). By addressing social handprints, the current work aims to complement the evaluation of negative impacts (or footprints as opposed to handprints) within holistic sustainability assessments, such as life cycle thinking methods, to provide a comprehensive view of the studied phenomenon. Indeed, the quantification of positive contributions in SO-LCA alongside combining handprint and footprint assessments can contribute to understanding net positive contributions of businesses (Benoit Norris et al., 2020; Croes and Vermeulen, 2021).

<u>Guiding principle II: Conceptualisation of human well-being and its constituents for direct impact assessment</u>

CRFS are recognised as a fundamental field where human-nature interactions unfold, in the shape of linkages between ecosystems and human well-being. The Millennium Ecosystem Assessment Framework (MEA, 2003) focuses on these linkages and provides a conceptual basis for the definition of human well-being and its features, which is adopted in the current study. The main constituents of well-being are defined as basic material for a good life, health, good social relations, security, and freedom of choice and action (MEA, 2005). In the current study, constituents of well-being represent the main impact categories for the assessment, on which social handprints are quantified.

<u>Guiding principle III: Business model thinking</u>

To understand the positive contributions of business on human well-being, the Business Model Thinking is employed to investigate how value is created, delivered, and captured within a business, and therefore address BM as unit of analysis for the proposed assessment framework. To understand the BM structure, the Business Model Canvas (BMC) (see Figure a. in A-C1) was employed as an interpretative lens to investigate the case study, outline the BM features, and interpret the impacts according to the related BM components. The main topics of the BMC are the offer, customers, infrastructure, and financial viability split into nine basic building blocks for comprehensively understanding the BM. The offer is centrally positioned in the value proposition building block; customer segments, channels and customer relationships focus on the customer side; key resources, key activities, and key partnerships on the infrastructure side; while the revenue streams and cost structure allow to balance financial viability. Following the indications of Rauter et al. (2019), the analysis of the BMC building blocks is exploited for the identification of the core activities and stakeholders needed to define the goal and scope of a (S-)LCA (see section 2.2).

Development of the CRFSi social handprint assessment framework

The S-LCA methodology (UNEP, 2020) serves as main guide to develop the present framework. The methodological steps adhere to the standardised S-LCA phases, i.e. goal and scope definition, life cycle inventory, impact assessment and interpretation, as well as the adoption of stakeholder categories as targets of the social handprints (see Guiding principle I in Conceptual background) (Figure 1.1). For the goal and scope phase, the BMC tool (see Guiding principle III in Conceptual background) is applied for the analysis of the product system, including the materiality assessment of the core activities and stakeholders. To identify and prioritise relevant stakeholders for the analysis, a stakeholder mapping process can be supported by the Netmap approach (Schiffer and Hauck, 2010). Visual representation of system boundaries, BMC and stakeholder mapping was developed through a Miro board (Miro©, 2023). To select social indicators for the impact assessment, findings from the FoodE project pilots' sustainability assessment were combined with a literature review on social assessment and indicators for CRFS sustainability (see Annex A-C1, Table c). The selection of SMART (specific, measurable, achievable, relevant, time-bound) indicators should rely on a participatory process involving stakeholders to verify their applicability in the specific context.

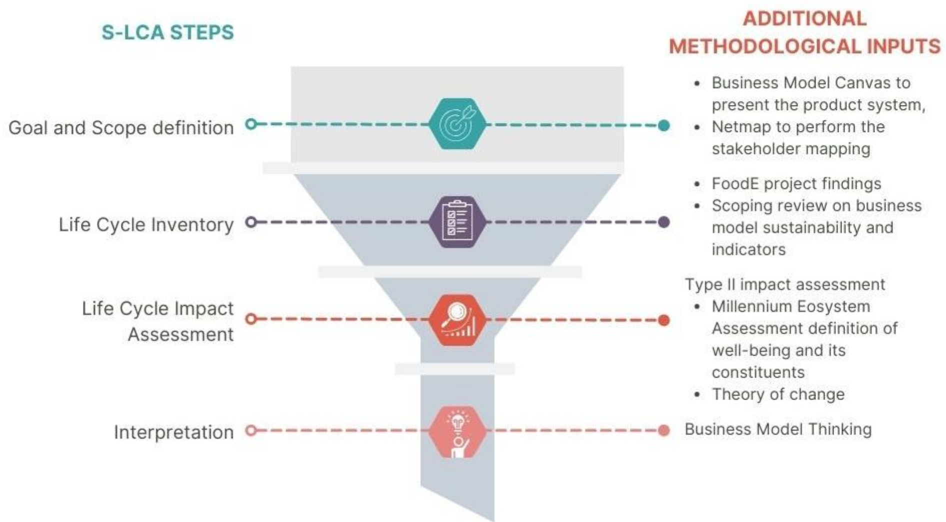

Figure 1.1: S-LCA steps and additional methodological inputs for the assessment framework development.

For the impact assessment, the study adopts the Type II impact pathway approach to "describe the underlying social mechanisms" (UNEP, 2020) leading to impacts on stakeholders' well-being (see Guiding principle II in Section 2.1). In this study, a qualitative impact pathway is outlined based on a Theory of Change approach, inspired by Michelini et al. (2020) and following the ISO standard 14075 (2024). As highlighted by Orou Sannou et al. (2023), the Theory of Change disclose the route in which activities can generate expected outcomes. To this aim, the impact pathway follows the structure displayed in Figure 1.2. For the application to the case study, the assessment framework can be tailored according to stakeholder feedback collected through interviews.

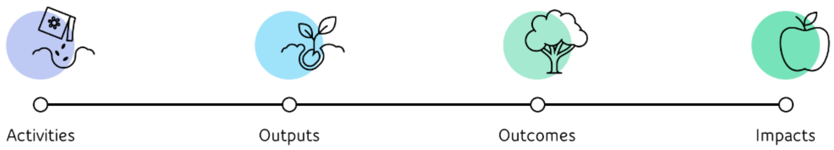

Figure 1.2: Graphical representation of the Theory of Change steps.

Application of the assessment framework to a case study

The framework was used to assess the social handprint of an existing BM in a CRFSi, with the aim of testing its applicability and identify potential criticalities when applying it to a CRFSi. The Eta

Beta social cooperative located in the peri-urban area of Bologna city since 1992, which was included in the H2020 FoodE database on European CRFSi (Petruzzelli et al., 2022a), was selected as a case study for complying with the following requirements: (1) including urban or peri-urban food production activities, (2) having available data of at least 3 years of activities and (3) being economically self-sufficient. A depiction of the case study area, including Eta Beta horticultural gardens and restaurant, can be found in Figure b, c, d in A-C1. Eta Beta focuses on the social inclusion and job placement of people with vulnerabilities, hereon considered as the users of the CRFSi. Users include people with social vulnerabilities (migrants, including unaccompanied minors, NEETs, former detainees, and unemployed), and people with physical and mental health disorders (disabled people, psychiatric patients). The CRFSi's activities are meant for both educational and rehabilitative purposes and include the production, processing, and distribution of organic agricultural products, catering services, woodworking, and artistic pottery and glass processing, as well as the organisation of training courses and cultural events. The CRFSi is economically self-sustainable thanks to the sale of organic food products and art objects of glass and ceramics, which business is expected to keep on growing. The Eta Beta cooperative produces, processes, distributes, and serves organic food which enters the CRFS through farmers' markets, the Eta Beta restaurant and catering service, commercial relations with other restaurants, and specific events organised or supported by the Eta Beta cooperative, inter alia. In 2022, the cooperative accounted for 50 employees (11 coming from vulnerable groups), and 54 vulnerable users in traineeship, while no volunteers were involved in the activities. Information on the case study was retrieved during a series of semi-structured interviews (see A-C1 Table d) with the staff cooperative to a) outline the case study, b) perform the stakeholder mapping, c) fill the BMC building blocks with information on the CRFSi activities, and d) co-develop the whole assessment framework. The reference year for the data collection is 2022.

1.3. Results and discussion

CRFSi social handprint assessment framework

The aim of the assessment framework is defined as the quantification of social handprints directly generated from a CRFSi on the well-being of the involved stakeholders. As suggested by Norris (2013), social handprints are addressed as changes compared to the business-as-usual. To this end, a simplified model is outlined for the business-as-usual scenario, associated with the food systems problems jeopardising sustainability (van der Gaast, 2023), to visualise the main changes entailed by CRFSi and generating social handprints. The business-as-usual scenario is described as a food business adopting profit-seeking as the main aim, based on conventional agricultural production or products, complying with minimum standards mandated by law (e.g. minimum wage, working hours, etc.) but not providing any additional contribution to social aims such as e.g. social inclusion, food security and healthy diets, fair livelihoods, skill development.

Considering the nature of CRFSi, a great variety of functions can be involved (Petruzzelli et al., 2022b), on which the definition of the functional unit (FU) depends. To embed CRFSi multifunctionality, the functional unit has to be defined considering three degrees of flexibility: a) the typology of the initiatives (e.g. urban agriculture, circular economy restaurant, small-scale fishery, etc.); b) the food supply chain stage involved (production, processing, distribution, etc.); c) the type of food handled (e.g. fruit and vegetable, fish, processed food, etc.). Therefore, authors suggest adopting an organisation-based FU (D'Eusanio et al., 2022, 2020; Martínez-Blanco et al., 2015) to allow the application of the framework to different CRFSi and the comparability of the assessments. The FU for the proposed assessment framework is accordingly defined as "the activities of a CRFSi yearly", and the reference flow is set to one year of activity. A materiality assessment of the product system identifies the main activities having social handprints. A stakeholder mapping supports the selection of stakeholder categories as targets of the social handprints. Stakeholder categories are selected based on UNEP (2020) guidelines and adapted according to the stakeholder mapping and materiality assessment, and prioritised according to the degree of influence that the CRFSi has on the stakeholders' well-being. Moreover, the core activities and stakeholders are allocated to the BMC building blocks. System boundaries are set on a cradle-to-gate basis and include only food-related activities and connected flows of resources (cut-off criteria).

Since human well-being is defined as the main area of protection, the constituents of well-being (MEA, 2005) are selected as impact categories. It must be stressed that indicators related to security tend to address the minimisation of negative impacts rather than the generation of positive impacts, for which reason no indicator was identified to assess CRFSi's social handprint on security. Based on these assumptions, the impact categories are defined as follows: basic material for a good life, freedom of choice and action, health, and good social relations. Table 1.1 displays the structure of the assessment framework on thematic areas, output and outcome indicators, and impact categories (definitions for each item are described in Table a in A-C1, while referenced output indicators are displayed in Table e in A-C1). Authors assumed that although activity outcomes can, directly and indirectly, influence more constituents of well-being (i.e. the impact categories), only primary direct impacts are observed in the assessment in favour of reduced complexity of the assessment framework.

Table 1.1: Components of the assessment framework.

Thematic area	Stakeholder category	Output indicator	Description	Unit	Outcome indicator	Impact category
Job quality	Workers	Wage and benefits	Employee wages including benefits	€	Living wage	Basic material for life
		Employment for vulnerable people	Number of disadvantaged workers employed	N	Job opportunities for vulnerable people	
		Gender equal pay	Number of equally paid female/non-binary employees	N	Gender equality	
Education and skill development	Workers	Skills development for workers	Number of employees trained	N	Professional skills development	Freedom of choice and action
	Users	Skills development for vulnerable people	Number of vulnerable people in traineeship	N	Professional and relational skills creation	
	Consumers	Knowledge sharing in the local community	Number of participants per number of events (e.g. workshops)	N	Raised awareness	
Work-life balance	Workers	Working hours	Number of weekly hours worked per employee per week	h/week	Fair working hours	
		Annual leave	Number of paid annual leave days	N/year	Fair annual leave	
		Parental leave	Number of paid parental days	N/year	Fair parental leave	
Food security and quality	Consumers	Organic km0 fresh food sold	Kg of organic and locally produced fruits and vegetables sold	kg	Recommended daily nutritional intake for fruits and vegetables	Health
		Food served	Kg of organic, plant-based and	kg	Recommended nutritional intake	

			locally produced food served			
	Workers and users	Food provided	Kg of organic, plant-based food served at the canteen	kg	Recommended nutritional intake	
Physical health	Users	Physical activity	Hours spent per person in gardening activity	h/week	Recommended weekly physical activity	
Social support	Workers and users	Social relationships	Hours spent with other people during activities	h/week	Increased social relations	Good social relations

The OECD Well-being framework is considered to verify the comprehensiveness of the output indicators in evaluating BM impacts on the key dimensions of current well-being (Siegerink and Shinwell, 2022). Among these dimensions, six were selected for the current framework as the main thematic areas to be addressed by the selected indicators, including job quality, education and skill development, work-life balance, food security and quality, physical health, and social support. The considered activities generate outputs that are assessed through output indicators. Output indicators are used to calculate outcomes generated by the case study. Outcomes are interpreted as determinants of well-being that the initiative can provide. Determinants of well-being (i.e. outcomes) are allocated (classification) onto specific constituents of well-being (i.e. impact categories), according to their potential to generate positive impacts. Impacts are deemed as the ability of the case study to fulfil a specific need providing improved well-being. In specific cases, outcomes are compared to national or international recommended values to set the constraint for the fulfilment (characterisation) (Table 1.2): a determinant of well-being is assumed concerning the identified recommended value, whose achievement can thus generate an outcome. The achievement is expressed in binary terms and the impact is estimated in person-eq as the unit of measurement representing the people affected by the outcome on a one-year (365 days) basis. To this end, impacts are normalised according to their time extent, so that they represent the actual contribution of the specific impact on a person's one-year (365 days) life (e.g. daily events, monthly wage, yearly employment, etc.) (normalisation).

Table 1.2: Characterisation model of outcome indicators.

Outcome indicator	Characterisation model description	Calculation
Living wage (i_1)	Employee yearly wage (W_{emp}) are compared to yearly Living wages for a typical family (W_{liv}) for a	$\begin{cases} W_{emp} \geq W_{liv} \rightarrow i_1 = 1 \cdot N_{emp} \\ W_{emp} < W_{liv} \rightarrow i_1 = 0 \cdot N_{emp} \end{cases}$

	specific country as calculated by Vionnet and Sacayon (2023) (at World Bank average exchange rates), and multiplied by the number of employees (N_{emp}) to convert i_1 into person-eq.	
Job opportunities for vulnerable people (i_2)	The proposition "p = a job opportunity is provided to a vulnerable person" is used to convert i_2 into person-eq.	$\begin{cases} p = true \rightarrow i_2 = 1 \cdot N_p \\ p = false \rightarrow i_2 = 0 \cdot N_p \end{cases}$
Gender equality (i_3)	The wage for a female/non-binary person (W_f) is compared to the wage for a male person (W_m) and multiplied by the number of female/non-binary people (N_f) to convert i_3 into person-eq.	$\begin{cases} W_f \geq W_m \rightarrow i_3 = 1 \cdot N_f \\ x_f < x_m \rightarrow i_3 = 0 \cdot N_f \end{cases}$
Professional skill development (i_4)	The proposition "q = the worker is trained or the user is in traineeship" is used as a proxy for professional and relational skills creation to convert i_4 into person-eq.	$\begin{cases} q = true \rightarrow i_4 = 1 \cdot N_q \\ q = false \rightarrow i_4 = 0 \cdot N_q \end{cases}$
Raised awareness (i_5)	The aggregated number of people participating in the events yearly (P) is divided by the weeks of the year, considering each person should participate to one event per week.	$i_5 = \frac{P}{52}$
Fair working hours (i_6)	Working hours (h) for each employee are compared to fair working hours for European countries as indicated by the International Labour Organisation (2018) and (Eurofound, 2017) (i.e. 35 weekly hours maximum for a full-time job, 20 weekly hours minimum for part-time job) and multiplied by the number of employees (N_{emp}) to convert i_6 into person-eq.	$\begin{cases} 20 \leq h \leq 35 \rightarrow i_6 = 1 \cdot N_{emp} \\ h < 20 \cap h > 35 \rightarrow i_6 = 0 \cdot N_{emp} \end{cases}$
Fair annual leave(i_7)	The paid annual leave in the CRFSi (AL_{emp}) is compared to the minimum paid annual leave (AL_{min}) as determined by national laws and specific collective labour agreements, and multiplied by the number of employees (N_{emp}) to convert i_7 into person-eq.	$\begin{cases} AL_{emp} > AL_{min} \rightarrow i_7 = 1 \cdot N_{emp} \\ AL_{emp} \leq AL_{min} \rightarrow i_7 = 0 \cdot N_{emp} \end{cases}$
Recommended nutritional intake of fruits and vegetables (i_8)	Recommended nutritional intake for fruits and vegetables is defined according to the Food and Agriculture Organisation (FAO)'s Food-based dietary guidelines for the specific country in which the CRFSi is operating. The amount of food sold or served by the CRFSi in a year (f_y) is divided by the daily recommended nutritional intake multiplied by 365 (days per year) (RNI_y), providing a measure of person-eq.	$i_8 = \frac{f_y}{RNI_y}$
Recommended hours of physical activity per week (i_9)	Hours spent by users in gardening activities are compared to recommended hours of physical activity per week defined by the World Health Organisation (WHO) guidelines (h_{WHO}) and multiplied by the number of users (N_{us}) to convert i_9 into person-eq.	$\begin{cases} h_{us} \geq h_{WHO} \rightarrow i_9 = 1 \cdot N_{us} \\ h_{us} < h_{WHO} \rightarrow i_9 = 0 \cdot N_{us} \end{cases}$
Relational skills creation (i_{10})	The time spent by users with other people (both other users and workers) (t_{op}) during their traineeship activities (t_{train}) is adopted as a proxy of the increase in social relationships, and and multiplied by the	$\begin{cases} t_{op} > \frac{1}{2} t_{train} \rightarrow i_{10} = 1 \cdot N_{pers} \\ t_{op} \leq \frac{1}{2} t_{train} \rightarrow i_{10} = 0 \cdot N_{pers} \end{cases}$

	number of people (N_{pers}) to convert i_{10} into person-eq.	
Total	The total social handprint in terms of person-eq is calculated for each impact category by adding up all the indicators described above.	$total_{person\ eq} = \sum_{n=1}^{x} i_n$

Each impact category (i.e. constituent of well-being) accounts for a final measure of person-eq. Each category weights equally on the total impact quantification (weighting). To measure the share of each thematic area, outcome indicator, and impact category, activities variables are assigned as presented in Table 1.3. Numbers for each category will be weighted and finally aggregated into a final number of person-eq for which the overall well-being is improved by the CRFSi's activities.

Table 1.3: Activity variables (AV) for each thematic area, outcome indicator, impact category and area of protection.

Thematic area	AV	Outcome indicator	AV	Impact category	AV	Area of protection	AV
Job quality	25%	Living wage	8,33%	Basic material for life	25%	Well-being	100%
		Job opportunities for vulnerable people	8,33%				
		Gender equality	8,33%				
Education and skill development	15%	Professional skills development	5%	Freedom of choice and action	25%		
		Professional and relational skills creation	5%				
		Raised awareness	5%				
Work-life balance	10%	Fair working hours	5%				
		Fair annual leave	5%				
Food security and quality	12,5%	Recommended daily nutritional intake for fruits and vegetables	12,5%	Health	25%		
Physical Health	12,5%	Recommended weekly physical activity	12,5%				
Social support	25%	Increased social relations	25%	Good social relations	25%		

Finally, impacts are interpreted considering the BMC building blocks. Relying on a backward process, the strengths and weaknesses are identified and qualitatively associated with the BMC building block representing the activity that has generated them. This step allows to identify the BM components generating the most relevant impacts and the ones which need further improvement to increase the CRFSi social handprint.

Application of the assessment framework to a case study

Goal and scope definition

The application of the assessment framework proposes a quantification of the social handprint generated by the Eta Beta cooperative on stakeholders' well-being. Figure 1.3 displays the boundaries of the system related to the functional unit of one year of activities of the cooperative. The boundaries (cradle-to-gate) include two main subsystems, both involving educational activities: the Eta Beta Garden producing and distributing organic horticultural products, and the Eta Beta Kitchen processing and serving organic food. The Eta Beta Garden subsystem considers the production of horticultural products, which are both processed in loco and sold fresh to customers via farmer's markets and restaurants. Both food produced in the garden, and food products purchased from other farmers are processed within Eta Beta Kitchen into jams, pickles, vacuum-packed vegetables, and preserves, and sold to restaurants and direct customers. The catering service relies on the garden horticultural products (both fresh and processed) for 80%, allowing to avoid food waste of the surpluses. Considering the cut-off criteria described in section 3.1, activities on woodworking, artistic creation, pottery, plant production and vivarium are not considered in the assessment as falling out of the scope of the analysis. The main determinants of well-being (MEA, 2005) in the case study directly impacting stakeholders are identified as organic food provision, employment and job, knowledge and skills creation, and social support. Additional determinants of well-being provided by the initiative fall out of the scope of the current study having an indirect impact on stakeholders' well-being.

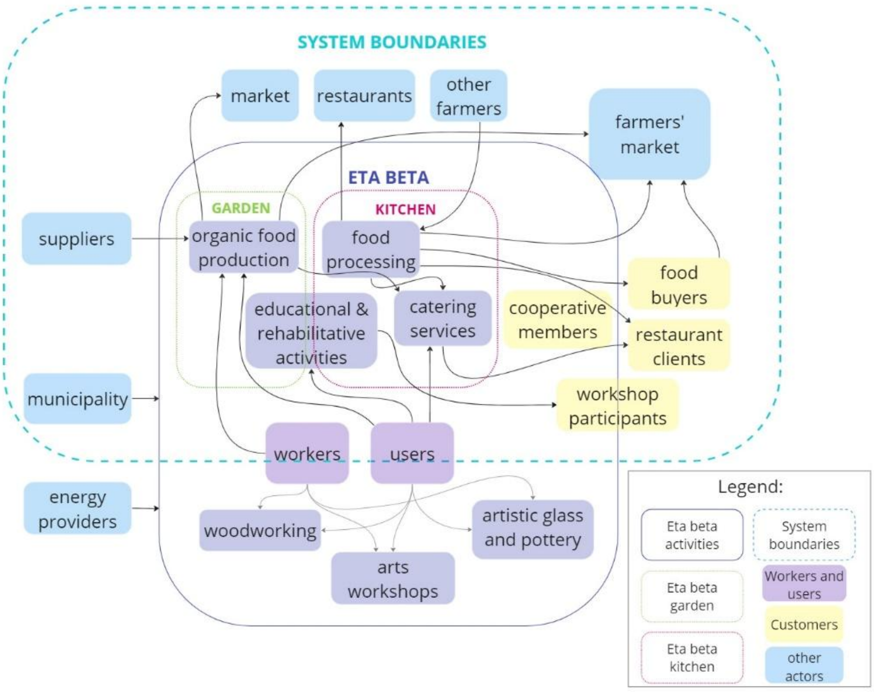

Figure 1.3: System boundaries of the Eta Beta cooperative.

To analyse the product system, a materiality assessment is conducted based on the BMC structure which allows the identification of the most relevant activities and flows of resources for the evaluation of potential impacts (Figure 1.4). The value creation of the cooperative consists of agroecological production and processing of organic food products for the social inclusion and training of vulnerable people. The cooperative's value proposition stands for both (food-related) goods and services which are provided involving physical, human, and intellectual resources and delivered to customers (and users) through direct relations and a range of channels. Relationships with both customers and key partners are further explored through stakeholder mapping (see Figure 1.5). An extensive description of the case study BMC is provided in Table f in A-C1.

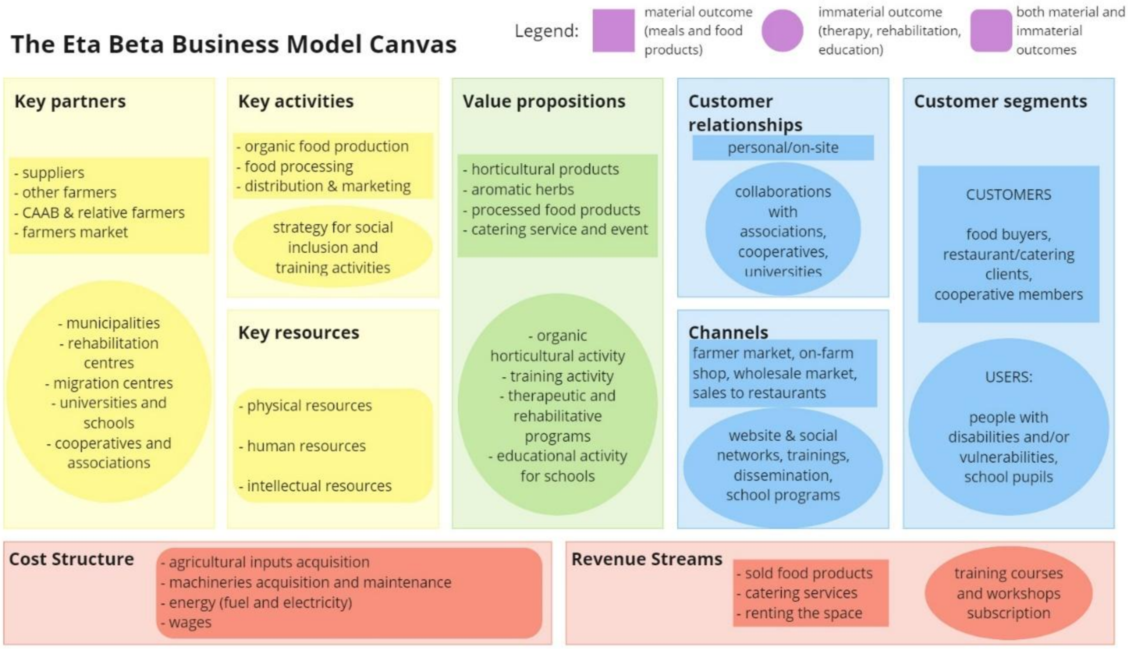

Figure 1.4: The Eta Beta Business Model Canvas.

The stakeholder mapping allowed to identify the main stakeholder categories involved in the studied system (Figure 1.5). The most relevant stakeholder categories are workers, users, and customers, ergo these are included in the analysis.

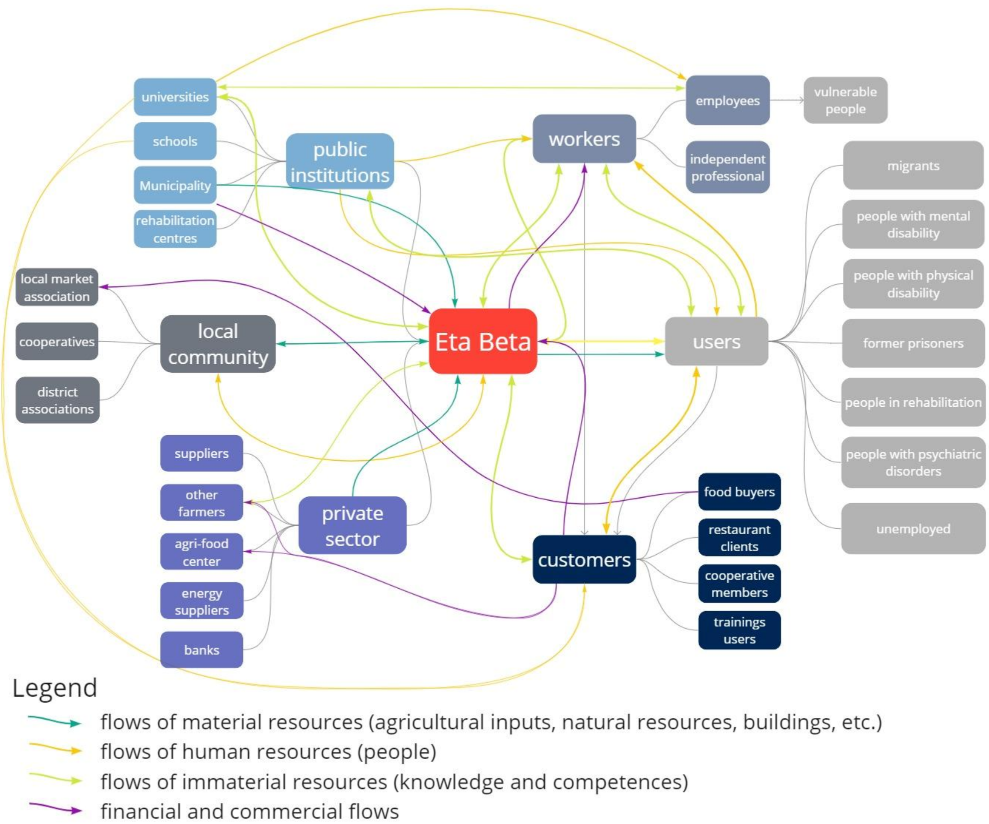

Figure 1.5: Stakeholder mapping of the Eta Beta cooperative.

Users are people from vulnerable groups benefiting from the social services provided by the cooperative, including gardening, and food-related training activities (horticultural production, food processing, cookery), while customers are considered as people paying for a provided service, which includes fresh and processed food products, catering services (during events such as conferences or job meetings), and educational activities such as workshops and trainings on food-related activities (e.g., regenerative agriculture cultivation techniques). In this sense, customers also include beneficiaries such as schools and citizens. Interactions among stakeholders include material (agricultural inputs, natural resources, buildings), immaterial (knowledge and skills), human, and financial flows of resources.

Life Cycle Inventory

Data was collected according to the stakeholders involved in the identified activities and the related flows of resources within the scope of the analysis. The detailed inventory of the data flows is presented in Table g in A-C1, while Table 1.4 presents the data collection for the case study. Data are presented on an aggregated basis in Table 1.4, however, data is analysed disaggregated (i.e. for each actor involved) for the impact assessment. It must be noted that production rates are significantly affected by seasonality: the months between October and January and between May and July produce 80% of the yearly production, which amounts to 9500 kg on average. Also, the amount of food being served at events can vary considerably throughout the year: an average number of 480 kg per month is considered. Finally, especially in the catering service, there is a large trainees' turnover, that varies from 0 to 10 depending on the period, hence an average number of 5 is considered for the Eta Beta Kitchen and 4 for the Eta Beta Garden, based on the last 3 years of activity.

Table 1.4: Data collected for the Eta Beta case study.

Description	Unit/year	Data
Number of workers (total)	N	7
Number of vulnerable workers (total)	N	3
Employee wages including benefits (average)	€	14976,57
Number of female workers paid equally to male workers (total)	N	3
Number of workers trained (total)	N	7
Number of vulnerable users in traineeship (total)	N	9
Number of participants to events in one year (total)	N	20000
Number of weekly working hours per worker (average)	h/week	22
Number of weekly hours trained per user (average)	h/week	22
Number of paid annual leave days (average)	days	27,5
Kg of organic and locally produced fruits and vegetables sold	kg	9500
Kg of organic and locally produced fruits and vegetables processed and sold	kg	2100
Kg of organic, plant-based, and locally produced food served at events	kg	5760
Kg of organic plant-based food served at the canteen	kg	1200
Hours spent per person in gardening activity	h/week	18
Number of users working with other people during training activities	N	9

Life Cycle Impact Assessment

The social handprint in terms of person-eq was calculated analysing data from the Life Cycle Inventory and converting it into person-eq through the characterisation model as proposed in Table 1.2. Results of the impact assessment are presented in Table 1.5, providing a measure of the impacts in person-eq per outcome indicator and impact category. In the analysed system, 7 workers are directly involved in the horticultural production and catering service activities, three of which are ex-users from vulnerable groups hired by the cooperative. Two workers are self-employed consultants and one worker is part-time employed, whose wage is generated by different sources including other entities outside Eta Beta, which are not considered in the assessment. For this reason, the direct impact of the case study on living wage for a typical family (Vionnet and Sacayon, 2023) accounts for 4 person-eq. All workers, including the three female ones, are equally paid according to their contract typology. Three workers were trained within the cooperative on organic agricultural production and four workers on food safety standards. The Italian collective labour agreement (Contratto Collettivo Nazionale di Lavoro, CCNL) for agricultural workers and catering services is adopted for the impact assessment, setting the paid annual leave at 30 days and 4 working weeks (corresponding to 20 days with 5 days working weeks) respectively. At the cooperative, fair annual leave days are guaranteed for all workers, while the working hours never exceed 35 hours per week for any worker. During their traineeships, vulnerable users are involved either in organic horticultural production or food preparation, cooking, and serving activities in the catering service. During training activities, users create their professional skills: the kitchen trainees spend an average of 5,5 hours per day in catering activities, whereas the agricultural trainees spend an average of 18,5 hours per week in gardening activities. Gardening activity is considered as a proxy of moderate physical activity contributing to health for 7 person-eq, as indicated by the WHO global recommendation and the Italian guidelines for a healthy lifestyle setting the threshold on "at least 2,5 hours per week" (CREA, 2019; WHO, 2010). In both cases, users spend the whole training time in the cooperative interacting with other people, both workers, supporting them in the training, and other users, ergo creating relational skills.

Table 1.5: Impact assessment for the Eta Beta case study.

Thematic area	Stakeholder categories	Outcome indicator	Pers-eq	AV	Weighted pers-eq	Impact categories	AV	Weighted pers-eq
Job quality	Workers	Living wage	4	0,083	0,33	Basic material for life	0,25	0,83
		Job opportunities for vulnerable people	3	0,083	0,25			
		Gender equality	3	0,083	0,25			
Education and skill development	Workers	Professional skills development	7	0,05	0,35	Freedom of choice and action	0,25	20,68
	Users	Professional skills creation	9	0,05	0,45			
	Consumers	Raised awareness	384,6	0,05	19,23			
Work-life balance	Workers	Fair working hours	6	0,05	0,30			
		Fair annual leave	7	0,05	0,35			
Food security and quality	Consumers	Recommended nutritional intake (fresh food)	65,1	0,125	15,89	Health	0,25	16,76
		Recommended nutritional	14,4					

		intake (processed food)						
		Recommended nutritional intake (served meals)	39,5					
	Workers and users	Recommended nutritional intake (served meals)	8,2					
Physical health	Workers and users	Recommended hours of physical activity per week	7	0,125	0,88			
Social support	Users	Relational skills creation	9	0,25	2,25	Good social relations	0,25	2,25
Total					40,53			40,53

The food is produced, processed, and sold to customers through both farmers' markets (fresh food) and on-site shop (processed food), and it is prepared and served to customers during events, and to workers and users in the Eta Beta canteen every week. The recommended nutritional intake for fruits and vegetables was assumed as 400 g per day (CREA, 2019). In the table, data for the consumers category include organic fruits and vegetables a) produced by the cooperative and sold, b) processed by the cooperative and sold, and c) served at events. A remarkable impact is generated on raised awareness by the participation of consumers to events (around 20.000 throughout the year), accounting for about 19,23 person-eq, followed by the organic fruits and vegetables produced and sold, accounting for 15,89 person-eq. Overall, the Eta Beta cooperative generates a social handprint on stakeholders' well-being equal to 40,53 person-eq. Nevertheless, findings from the interviews' qualitative analysis revealed that the case study can generate impacts on the stakeholder categories of the local community and society, which are not considered in the scope of the assessment framework.

Interpretation

The highest social handprint is generated by knowledge-sharing events aimed at raising awareness among consumers, which is part of the channels in the BMC (see Figure 4). Events connect all the activities of the cooperative, including the activities not considered within the scope of the analysis. Indeed, during training courses and awareness-raising events, a "circular" approach is adopted:

organic plant-based food is produced by the Eta Beta Garden subsystem and processed or prepared, cooked, and served by the Eta Beta Catering subsystem, whereas tables, chairs, dishes, and tableware are created by the woodworking and handcraft subsystems (not included in the assessment). The 80% of food prepared and served by the catering service during events comes from the Eta Beta Garden subsystem. This is a qualitative aspect that unveils the circular economy aims of the cooperative. Considering the social handprint on the health impact category (see Table 5), the organic plant-based food production is the most contributing activity, which are at the core of the value proposition of the BM and are delivered to consumers via farmers' market and restaurants, representing the channels in the BMC. The stakeholder category mostly benefiting from the CRFSi is the consumers one, mostly due to the selling of organic production and the involvement in knowledge-sharing events. This means that in the BMC the revenue streams are generating not only economic benefits but also social handprints. The stakeholder category of workers and users, which are part of the key human resources in the BMC, are less affected by the CRFSi social handprint. This might be related to the relationships with key partners such as public institutions, which play a vital role in the management of the cooperative users and can thus influence the availability of resources. Overall, the social handprint of the system could be improved by scaling up the activities to allow the employment of more people, both workers and vulnerable ex-users and to generate more revenue streams to cover the costs of wages. The interpretation of results shows that business owners might improve the management of key resources and the relationships with key partners to maximise the BM potential of generating social handprints.

Limitations and future outlooks

During the iterative process of methodological development and application of the assessment framework, some limitations and potential future developments were encountered. The assumptions made by authors for the goal and scope definition have a great influence on the entity of the assessment results, meaning that other assumptions and choices in the goal and scope definition might provide different findings. The analysed case study entails a high degree of complexity among different subsystems involved beyond the food-related ones, which were not included in the current study. The considered system boundaries may have led to an underestimation of the social handprint generated by the CRFSi, since only food-related activities were assessed while additional social handprint might be generated by other activities, e.g. artistic pottery and woodworking. Also, the adoption of an organisation-based FU implies that the size of the organisation's activities can substantially compromise the overall impact. To allow comparability among different CRFSi, results in person-eq might be normalised by the organisation size, e.g. dividing the number in person-eq by the number of (non-vulnerable) employed people or by the economic turnover, to provide an adapted version of social return on investment. However, in this case, the issue does not affect the isolated interpretation of the case study results. For future research development, potential complementary FUs (e.g. economic-based) may be used to communicate the results to compare their performance with similar CRFSi. The specific entity of the case study allowed a high degree of data granularity; yet such a granularity might not be available in other contexts. Accordingly, authors propose to analyse aggregated data to enhance the replicability of the assessment framework. Further research developments could focus on the development of an impact pathway relying on statistical correlation as a characterisation model, starting with the proposed conceptual background to assess causal links leading to the improvement of stakeholders' well-being. To this scope, the authors advise validating the proposed assessment framework through expert consultation. To ensure the framework's replicability, the authors recommend the testing of the assessment framework on a representative sample of CRFSi. Lastly, the proposed assessment framework should be integrated into a holistic Life Cycle Sustainability Assessment through further methodological development exploring the interactions of environmental and economic impacts on well-being and unveiling potential synergies and trade-offs. On a policy perspective, the framework can be further refined for the sustainable finance attempt to define and assess economic activities potentially having positive social impacts (EC, 2022), to support the allocation of public funding and public procurements.

1.4. Conclusions

The assessment of positive impacts is still under development in the S-LCA literature and there are various interpretations of the concept. The study provides a pragmatic conceptualisation and methodological framework for the assessment of positive impacts on stakeholders' well-being to be applied to social businesses in CRFS. The methodological framework was applied to a real case study representing a CRFSi as defined by Cirone et al. (2023). The main novelty of the study refers to the methodological development of a qualitative impact pathway leading to the evaluation of impacts on well-being in person-eq as a comprehensive measure entailing social handprints on the considered constituents of well-being. Many qualitative aspects were not converted into a quantitative measure by the proposed assessment framework, such as the circularity aspects and short food supply chain approach and further methodological developments are needed to unravel intercorrelations among different constituents of well-being. However, the assessment framework demonstrates to be directly applicable to a real-life BM in CRFSi, with average data availability and provides an easily understandable measure of people directly benefiting from the CRFSi activities. This enhances the assessment framework replicability and the communicability of results, which can be exploited by business owners and different stakeholders in CRFS contexts. This represents an added value of the research since it provides a ready-to-use framework for local decision-makers to assess social handprints in CRFSi BM. On a European Union level, the framework can pave the way for the systematic evaluation of CRFSi positive impacts on stakeholders' well-being, therefore supporting policy-makers in defining and evaluating economic activities that may have positive impacts, for sustainable finance and public procurements purposes, inter alia.

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Chapter 2 : Unravelling business models sustainability opportunities: the case of horticultural farmers in Cartago, Costa Rica

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Abstract

In Latin America, the agricultural sector plays a key role in shaping transition towards more sustainable food systems. However, agricultural producers face a dual pressure deriving from market dynamics and regulatory frameworks: to mitigate environmental burdens by implementing sustainable practices, while simultaneously ensuring financial viability to generate added value within their businesses. Based on a case study on a horticultural farmers' cooperative in Costa Rica, the current research sets out to investigate the environmental and economic implications of implementing agroecological practices, and identify market barriers and opportunities for sustainable business models for horticultural smallholders.

A case study is performed to investigate the main agroecological practices implemented in a horticultural farmers' cooperative in Costa Rica. The Agroecology Criteria Tool allowed to select the most promising producer for an in-depth analysis. An Environmental Life Cycle Costing (E-LCC) is performed to compare cost performances in the cooperative with the business-as-usual scenario. The environmental externalities in the E-LCC are internalised through the monetisation of carbon and water footprints. A market analysis facilitates the grounding of the business in the current commercial context and determine potential strengths and weaknesses in the business model. The Business Model Canvas is used to co-design a tailored business model with the cooperative's farmers to foster the business sustainability and competitiveness.

The results provide insights into the main challenges and barriers encountered by Costa Rican farmers in improving their sustainability performances. By identifying drivers and opportunities, the current paper proposes recommendations to boost horticultural farmers' BM sustainability in Costa Rica. Ultimately, this research provides a science-based BM proposal tailored for horticultural farmers in the Central America region, facilitating their transition towards more sustainable food systems.

Results show the potential of Life Cycle Thinking in presenting the main focal points in a particular production model, that can be exploited in a BMC design process. Findings can be used as an input for further attempts of sustainable BM development for Central American farmers. Data availability issues were encountered as main limitations in the study. Future studies should investigate additional socio-economic and environmental aspects for a deeper understanding of the business competitivity and sustainability.

Keywords: Environmental Life Cycle Costing; Sustainable Business Model; agroecology; small farmer; cooperative; Latin America.

2.1. Introduction

Food production stands among the key challenges in global sustainability seeing the contribution of conventional agriculture to environmental degradation, food unaffordability, and socio-economic inequity (FAO, 2023). In recent decades there has been a growing demand not only to produce larger quantities, but also to improve agricultural sustainability through environmentally friendly, socially just, and economically beneficial production systems (Wezel et al., 2014). In this context, the region of Latin America and the Caribbean (LAC) is a major protagonist, representing the 13% of the net value of global agriculture and fish production, with exports accounting for the 70% of total production value (OECD-FAO, 2024). Recent studies shed light on the complex interaction between food, energy, and water resources in this particularly vulnerable region (Kondash et al., 2021), where the intensive use of pesticides for agri-food production causes concerns on its alarming repercussions on soil and groundwater health (Anselmi and Vignola, 2022; Galt, 2008; Grondona et al., 2023). To this scope, sustainable agricultural production is addressed as key activity to achieve food security and fair livelihoods in the LAC region (FAO, 2015).

To restore ecological health in agricultural systems, farmers can be the pathbreaker, by adopting the most innovative solutions for a sustainable farming system combining traditional knowledge with multi-disciplinary science (FAO, 2018a; Jhariya et al., 2021). The 60% of the food produced globally comes from small farmers and in LAC smallholder agriculture accounts for 16,6 million farms and provide for the 70% of food consumed in the region (FAO, 2014; Loukos and Arathoon, 2020). Notwithstanding their crucial role in income distribution, food provision, and sustainable farming, most small farmers remain poor and, ironically, they often experience food insecurity (OCDE-FAO, 2023). Small farmers' production and incomes are severely affected by price volatility for inputs (increasing) and food products (decreasing), unbalanced market access, and climate change effects (OCDE-FAO, 2023; Viguera et al., 2019). In parallel, they need to transform their production systems, aligning with sustainable agriculture principles including the circular use of organic inputs, biodiversity preservation on-farm, water conservation, and soil health regeneration, inter alia. In this sense, studies have shown that sustainable agricultural practices can enhance farm productivity and resilience, making them a viable strategy for long-term success (Altieri and Nicholls, 2017; Gliessman, 2014).

Agroecology (Altieri, 1995) represents an agroecosystem management approach that integrate ecological and social sustainability into agri-food systems to achieve ecosystems' regeneration and socio-economic resilience for farmers (FAO, 2018b; Mouratiadou et al., 2024; Palomo-Campesino et al., 2022). Farmers' knowledge on local agrobiodiversity and management experiences are key to foster the implementation of agroecological practices (FAO, 2018a), which can in turn enhance small farmers' livelihood and promote food sovereignty and food justice (Chappell et al., 2018). The introduction of agroecological elements in smallholder groups, such as cooperatives and associations, aims to bring holistic sustainability within food systems while undertaking the ecology of traditional farming systems (Gliessman, 2018; Méndez et al., 2013). In the LAC region, agroecological practices based on traditional small farmers' knowledge are gaining momentum as crucial strategies to improve food security and sovereignty through community empowerment (Altieri and Nicholls, 2008; Altieri and Toledo, 2011; McCune et al., 2017). To this scope, deeper understanding is needed on the (socio-)economic outcomes of agroecological practices and the circumstances under which these practices are implemented (Mouratiadou et al., 2024), to avoid misinterpreting agricultural production indicators, such as yield, in contrast to overall agricultural costs, when evaluating agroecological performances (Mondal and Palit, 2020).

Nevertheless, grounding agroecological practices into market competitiveness remains a colossal challenge for small farmers in developing countries (Ríos-Fuentes et al., 2022). To this scope, sustainable business models (SBM) are a promising approach to support entrepreneurs to explore the opportunities for competitive businesses with sustainability orientation (Aagaard and Ritzén, 2020; Boons and Lüdeke-Freund, 2013; Evans et al., 2017). New BM involving nature-positive production systems and internalising environmental externalities to understand the true cost of food are key for the food system transition (Colston and Jessica, 2021). In LAC agricultural sectors, innovative SBM often address social inclusion, grassroots movements, and smallholders (Molina-Maturano et al., 2020). In this context, BM complementing technical needs with social and solidary economy models, such as cooperativism, can play an interesting role, especially in the rural and agricultural scene (Huaylupo Alcázar, 2003; IICA, 2010). However, studies highlighted a lack of investigation in the field of SBM in LAC (Danse et al., 2020).

The current study seeks to evaluate the implications of agroecological practices for small farmers in Costa Rica, to provide reliable insights on possibilities for SBM developments and implementations. In doing so, the aim of the current study is multiple: a) to compare the overall economic and environmental costs encountered by organisations applying agroecological practices compared to the baseline (conventional) scenario, b) to investigate market status to identify barriers and opportunities for SBM, and c) to co-design a SBM for a case study cooperative of small farmers in Costa Rica. To achieve them, the study combines Life Cycle Thinking, to compare economic and environmental costs throughout the life cycle of alternative scenarios, with Business Model Thinking, to support the development of a SBM through a participatory approach.

2.2. Methods

Case study

Among LAC countries, Costa Rica stands out for its commitment in safeguarding biodiversity and ecosystems. The main challenges identified for family agriculture in Costa Rica consist in the improvement of soil and water quality through the application of sustainable, agroecological, and organic production practices (MAG, 2020). In parallel, many family farmers in Costa Rica rely on growing horticultural crops as an income source (IICE, 2021), facing many challenges including high costs for agricultural inputs and low prices for final products. The Cartago region represents the area with most farms in Costa Rica, mainly oriented to horticultural products such as onions, potatoes, tomatoes, and carrots (OECD, 2017). In this area, a collaborative project was launched in 2017 between the university Tecnológico de Costa Rica, and the horticultural farmers' cooperative CoopeHorti Irazú R.L., located in the Cartago region, to improve its competitiveness strategies and sustainability objectives. In response, a BM was proposed to add value to the final products and ensure traceability, leading to the constitution of a cooperative in 2019, comprising 55 founding members and 43 local producers.

Before the current study, a face-to-face questionnaire was applied to 20 cooperative members to identify the key aspects in their production systems and management strategies. Alongside, several Living Lab sessions allowed to identify the key challenges faced by farmers and define the thematic areas to be investigated, i.e. production costs, added value, and marketing in the horticultural market. All the interviewed farmers are smallholders (less than 4 ha), most of them are part of a family farming unit, while decisions usually rely on males aged 35 and over. Besides, all of them have been farmers for the past 10 years at least. They mention important price and profit variability and management skill gaps, such as weak accounting and planning practices and scarce information systems on-farm. Despite their awareness on environmental management, they hardly apply formal monitoring systems, except for farmers certified with the "Bandera Azul Ecológica" programme (i.e. a voluntary certification released by Costa Rican public institutions) (PBAE, 2022). CoopeHorti Irazú

R.L. farmers commonly use synthetic fertilisers and pest control inputs, with an increasing trend in the use of organic inputs and innovative technologies such as precision irrigation systems.

A subgroup of the cooperative farmers, implementing agroecological practices, is engaged in a focus group aimed at a) identifying the agroecological practices applied within the cooperative, and b) verifying available secondary data on conventional production in Costa Rica. The Agroecology Criteria Tool (ACT) (Biovision, 2019) is adopted for the screening of agroecological practices which builds upon the 10 agroecological principles presented by FAO (2018b). The ACT relies on 11 elements of transition, namely efficiency, recycling, regulation and balance, synergies, diversity, resilience, circular and solidarity economy, culture and food traditions, co-creation and sharing of knowledge, human and social value, responsible governance. Findings from the focus group were used to feed into the ACT to identify the main agroecological hotspots in the production systems and to select the farmer reaching the highest score in ACT. Results from the ACT analysis can be found in Annex Chapter 2 (A-C2). The case study represents a mix of agroecological approaches including organic farming, circular use of resources, and precision agriculture, inter alia. Primary data from the case study was collected through semi-structured interviews.

Compared Environmental Life Cycle Costing

To assess agroecological performances, the Environmental Life Cycle Costing (E-LCC) is selected (Hunkeler et al., 2008), which differs from conventional LCC for the internalisation of environmental externalities, allowing to compare environmental impacts to the economic outcomes generated by the organisations (Eidelwein et al., 2018). To perform the E-LCC, the methodological steps as described by Rodrigues and da Silva (2024) are followed to define the perspective and the goal of the assessment, organise the scope, define and calculate internal cost categories, and select and calculate environmental externality cost. The current study adopts a producer perspective, and the goal of the assessment is to analyse the current economic and environmental cost performance of the case studies compared to a baseline scenario. The baseline scenario is defined as the business-as-usual (BAU) in the horticultural production in Costa Rica, considered as conventional agricultural production and based on secondary data on production costs in Costa Rica. Specifically, data on infrastructure and machineries from FAO (2016) and Arce Quesada (2020) is used, while data on production inputs for potato, carrot, and onion is derived from the Ministry of Agriculture and Livestock farming of Costa Rica (MAG, 2021) and actualised according to the inflation of Consumer Price Index in Costa Rica between 2021 and 2023 (INEC, 2024). Data from the two alternative scenarios are validated through expert consultation. Table 2.1 displays the alternative scenarios and their main features.

Table 2.1: Case study general info compared to the BAU scenario.

Item (unit)	CoopeHorti Irazú R.L. farmer	BAU
Location	Cartago, Costa Rica	Costa Rica, central-east Region (including Cartago)
Agricultural area (hectares)	0,2 ha	1 ha
Annual production (tons)	31,5 t	73,3 t
Annual production (dollars)	$ 25.426,54	$ 84.971,44
Main products	Onion Potato Carrot Garlic	Onion Potato Carrot
Main cultivation method	Precision and regenerative agriculture	Conventional agriculture
Reference year	2023	2023

The functional unit is set relying on an economic-based reference flow and consists in the unitary revenue from selling horticultural products by the product system, i.e. 1$ of business revenues. Time coverage is set on one year of activity. The study included the annual operations and inputs for the year 2023. System boundaries are defined based on a cradle-to-gate approach and include the following subsystems: 1) establishment (seed, nursery, and plant growth), (2) production at farm level, (3) initial processing (cleaning and drying), (4) transport to the cooperative (Figure 1). The horticultural produce is both processed in loco and sold fresh to customers via farmer's markets, large-scale distribution, public catering, and restaurants. The E-LCC provide impacts in monetary units (Costa Rican colons converted in United States dollars currency, USD, according to SEPSA (2023)) of the relevant costs (inputs, energy, fuels, labour, transport) according to each life cycle stage. The study employs the following cost categories: infrastructure, materials, energy, labour, maintenance, and environmental costs (Bradley et al., 2018; Hunkeler et al., 2008; Kambanou and Sakao, 2020).

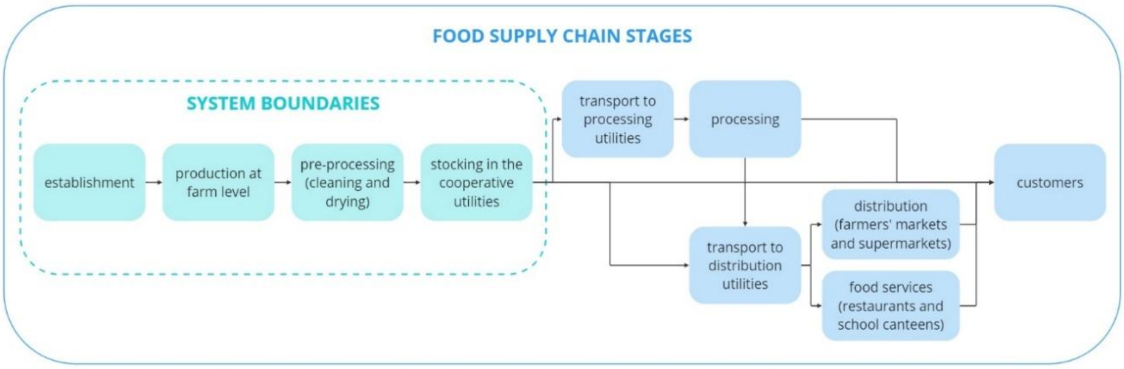

Figure 2.1: Food supply chain stages and system boundaries of the current study.

For the internalisation of environmental externalities, the carbon footprint (CF) and water footprint (WF) were selected as the most relevant externalities considering the local context, which were calculated relying on the YVY© app (Plan21, 2024), which employs the Greenhouse Gas protocol, and the global warming potential factors as stated by the IPCC; the quantification of blue and green water footprint derived data on precipitations from Meteostat. To monetise the CF and WF, the damage cost approach was followed (Amadei et al., 2021), and monetisation factors provided by True Price Foundation (Galgani et al., 2023) were actualised according to the inflation of Consumer Price Index in Costa Rica between 2022 and 2023 (INEC, 2024). Data was collected relying on in-person interviews and the inventory was built in Microsoft Excel ®. Assumptions included a lifespan of 10 years for most of fixed assets following (Edwards, 2015), except for greenhouse structures for which 15 years were considered for the depreciation, relying on Torrellas et al. (2012) and bio-inputs laboratories for which 25 years were considered for depreciation (IRS, 2021).

Market analysis

Relevant sources of grey and scientific literature were scrutinised to collect information on the current market of horticultural products in Costa Rica. The scoping review allowed to identify the main hotspots and challenges for the horticultural producers to maximise the competitivity of their BM in the Costa Rican market. The main findings serve to ensure that the sustainable transition efforts of the producers can match with the actual socio-economic context. This step is essential for the co-design of a SBM for the cooperative, since it allows the SBM to be context-based and consistent with the current market scenario.

Co-design of a Sustainable Business Model for the cooperative

Two participatory workshops and a focus group were held to co-design the SBM for the cooperative, integrating the findings from the E-LCC combined with the market analysis. The workshops followed the Metaplan methodology (Aloy-Duch et al., 2023; Veiga-Seijo et al., 2020) to drive the discussion within the group of participating farmers. Findings from previous Living Labs stand for the introductive step for the workshop. Following the Sustainable BMC template (Threebility, 2024) and adapting the possible questions for each block to the Metaplan technique, farmers are involved in three steps: 1) questions presentation, 2) teamwork, and 3) teams' presentation of their proposals for sustainable value proposition. This proposal is meant to undertake the detected hotspots in the E-LCC and their context, including internal cooperative conditions and market challenges and opportunities. Results from the first workshop were verified and further detailed with farmers during the second workshop, aimed at the finalisation of the co-designed BMC. Finally, a focus group is conducted to validate results together with the Board of Directors of the cooperative.

2.3. Results and discussion

Compared E-LCC

The results of the E-LCC analysis refer to the functional unit defined as 1$ of business revenues and are displayed in Figure 2.2. The BAU scenario shows a total cost impact of 0,70 on 1$ of business revenues. The main hotspot is represented by material costs, which include fertilisers, plant protection products, and seeds, amounting to a total of 0,26, due to the conventional production system. The intensive crop rotation (2-3 cycles per year for each crop) increases the nutritional demands of the crops and the pressure from pathogens, increasing the need for the use of large quantities of synthetic inputs (Bennett et al., 2012). The second hotspot is the cost of environmental externalities, amounting to 0,21 (30,4% of the total cost), which is also attributable to the conventional production system of the BAU scenario. Specifically, the monetisation of the CF and WF reveals that the latter accounts for approximately 80% of the total external cost, and the authors identified as main driver the intensification of crop rotations, which accelerates the growth rate of crops thereby increasing water needs. It must be stressed that the BAU scenario represents conventional and intensive crop rotation according to secondary data on national averages in Costa Rica, hence the calculated WF may be affected by the assumptions made during the scenario building phase. In addition, the YVY © app does not include the impact of phytosanitary products in terms of CO_2-eq emissions, potentially underestimating the quantification of CF.

CoopeHorti Irazú R.L. farmer shows a cost impact lower than the baseline scenario, amounting to 0,53. The main cost items refer to the variable production factors. Labour costs are the largest cost item amounting to 0,21, i.e. 39,1% of the unitary cost. This cost exceeds the BAU's one (0,15) due to a lower mechanisation degree. Material costs amount to 0,16 which represents a saving of 0,1 compared to BAU (0,26). The lower incidence of material costs on the functional unit is explained by the low-input production model, which employs organic fertilisers and phytosanitary products, as described in Section 2.3. It must be highlighted that, in relative terms, this cost item still represents 30,3% of the farmer's costs impact. The farmer shows an environmental cost of 0,08, which is 62% lower compared to the BAU, thanks to a 10-times lower CF (0,004 for the farmer versus 0,05 for BAU).

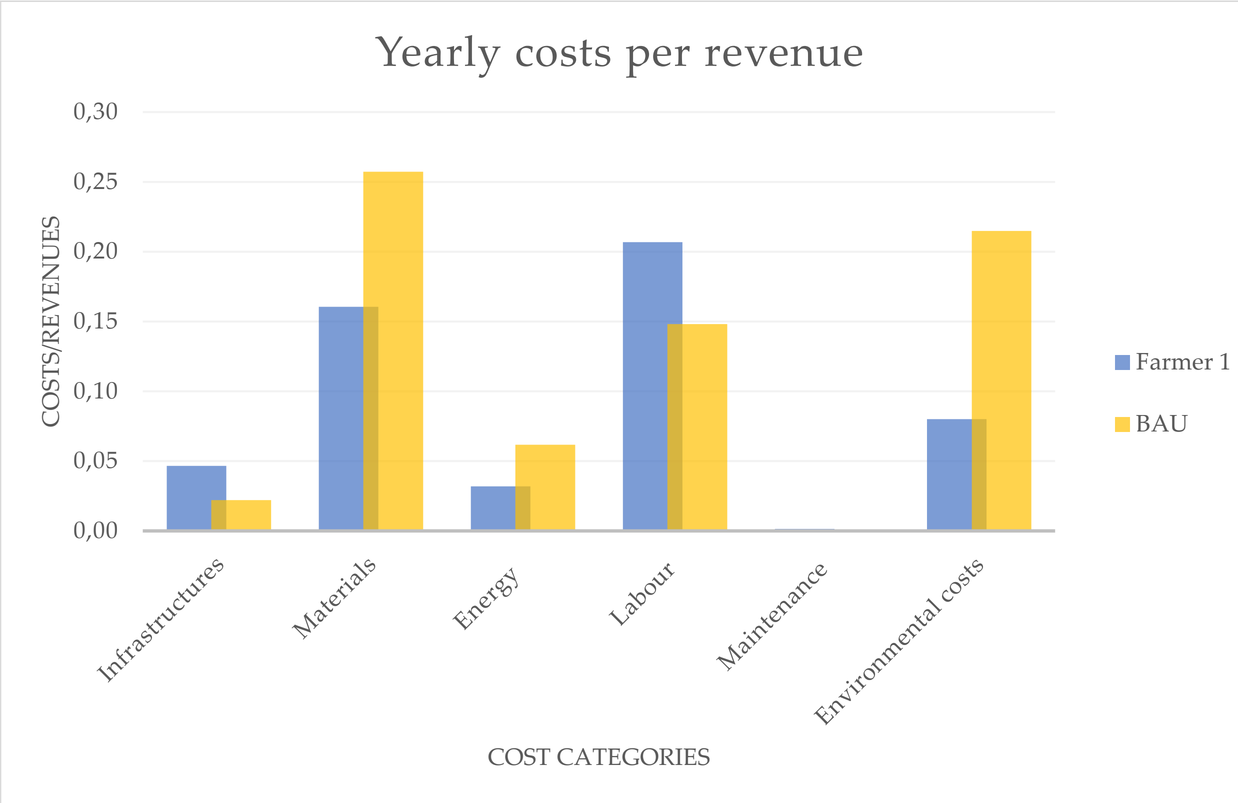

Figure 2.2: Compared results of the E-LCC for the BAU scenario and CoopeHorti Irazú R.L. farmer.

The E-LCC results highlight that the production system employed by CoopeHorti Irazú R.L. farmer generates higher unit profits and lower external costs, mainly thanks to the use of organic inputs. Reduced machinery equipment is identified as the main driver of the hotspot on "Labour cost" for the farmer, view that agricultural operations are performed manually. Indeed, the incidence of the machinery cost on the overall 'Infrastructure and Machinery' category amounts to 1,25% versus 7,5% of the BAU. On the other hand, the farmer's lower level of mechanisation can support the local community by creating employment opportunities through increased demand for manual labour. To this scope, investments in machinery can help address the cost hotspot without compromising the positive implication of employment creation, by improving working hours' efficiency thanks to increased productivity. In this case, the higher costs associated with the investment for infrastructures and maintenance would be compensated by the increase in production and revenues. In addition, this approach would reduce labour costs per dollar revenue without affecting the number of jobs or workers' wage. Furthermore, it is important to note that the infrastructure costs for the farmer are also influenced by the presence of a seed bank at the farm. The purpose of this facility is to collect seeds from local varieties of horticultural products that are well-adapted to the area's soil and climate conditions. This activity helps protect and conserve local biodiversity, improving resilience and hence creating an additional social benefit for the community. Therefore, to capture all the impacts of CoopeHorti Irazú R.L. farmer's activities from an agroecological perspective, social impacts should be included in the analysis. By incorporating the social dimension into e.g. a cost-benefit analysis, the farmer could take advantage of a decision-making tool to identify the optimal level of investment maximising both cost reduction and the positive societal impacts.

Market analysis

Costa Rica is distinguished by a robust economy and a stable political landscape, with an increasing focus on sustainable development (Ivankovich and Martínez, 2020). The agricultural sector is integral to both the economy and society, as evidenced by its contributions to GDP, exports, and employment, which simultaneously improve the socio-economic conditions of rural populations and enhance food production. This sector reflects a disparity among different producers, especially between family farms and larger agricultural enterprises, exacerbated by technological deficiencies in agricultural inputs and market monopolisation. In 2021, agriculture accounted for 9.6% of Costa Rica's GDP, with notable contributions from diverse agricultural undertakings (Ministry of Agriculture and Livestock of Costa Rica, 2023). To tackle the main challenges identified for the agricultural sector, four strategic action pillars were proposed by the Ministry of Agriculture and Livestock of Costa Rica (2023), namely modernisation of agricultural institutions, enhancement of competitiveness, productivity and sustainability, value addition and marketing strategies.

In terms of international trade, Costa Rica is part of the Free Trade Agreement between the Dominican Republic, Central America and the United States of America, which delineates tariff schedules, inter alia (CAFTA-DR, 2007). This agreement encompasses a series of quotas with taxes applied to the importation of specified products, which may fluctuate based on domestic supply. Data from international trade in 2021 underscores the agricultural sector's substantial contribution to the economy, with exports reaching USD 5,610.9 million and a trade surplus of USD 2,454 million, while also accounting for 11.7% of the labour force (Subdireccion General de Relaciones Internacionales y Asuntos Comunitarios, 2021). However, the Monthly Index of Economic Activity (IMAGRO) reveals concerning negative trends in the sector, indicating a decline in performance since early 2022 (Ministry of Agriculture and Livestock of Costa Rica, 2023).

The potato crop is cultivated by 1160 producers in Costa Rica, mostly small and medium-sized, i.e. with agricultural areas of less than 5 ha (Serrano Bulakar, 2021). In 2023, the Cartago province accounted for 74% of Costa Rica's potato production, with significant contributions from the regions of Oreamuno and Alvarado (Caravaca Vega, 2023). In the last five years, the domestic production of potatoes remained quite stable (Zeledón García et al., 2024), as reported in Table 2.2, and supplies for 100% of the national annual consumption, reaching 80.000 t (14,7 kg per capita) on average (Serrano Bulakar, 2021). Also in the case of onion the production remained stable in the last years, amounting to 46.789 t in 2023, whereas the production of carrots increased by 15,5% in 2023 compared to the previous year and amounts to 34.220 t (Zeledón García et al., 2024).

Table 2.2: Annual production areas and volumes in Costa Rica, 2020-2023 (Zeledón García et al., 2024).

Crop	**Area (ha)**				**Production (t)**				**Variation (%)**
	2020	2021	2022	2023	2020	2021	2022	2023	
Potato	2880	3081	2963	3104	76084	83410	77784	81272	4,5
Onion	1277	1231	1276	1447	41472	41863	45392	46789	3,1
Carrot	N/A	N/A	N/A	N/A	N/A	30513	29600	34220	15,5

Vegetable consumption in Costa Rica reflects a strong preference for fresh and minimally processed products, driven by growing health awareness and the search for high nutritional value (Castro-Urbina et al., 2023). According to the most up-to-date statistics from the Integral Program for Agricultural Marketing, potatoes, carrots, tomatoes, and lettuce were the most consumed vegetables in 2015, a trend that has continued in recent years (Programa Integral de Mercadeo Agropecuario, 2016). However, challenges remain, particularly in relation to farm prices, which ranged from 1,50 $/kg to 2,13 $/kg. Supermarket prices showed even greater variation, from 1,856/kg in March to 2,384/kg in May, highlighting the disparity in the distribution of profits across different sales channels. Despite the growing interest in organic products, farmers in Latin America face challenges, including consequences from the COVID-19 pandemic, financial difficulties, and lack of training in organic practices (Mamani-Flores et al., 2022). There are also gaps in certification procedures and management tools for urban agriculture, though local markets play a crucial role in promoting sustainable practices (Ministry of Environment and Energy, 2023).

The Costa Rican horticultural market presents both challenges and opportunities. On top of addressing environmental issues related to the use of agrochemicals, the sector must navigate significant barriers in the national and international trade. The disparity between small family farms and larger enterprises hinders equitable growth, as small farmers often lack access to technology and modern agricultural inputs. Market monopolisation by larger players further restricts small farmers' competitiveness and profitability, while price disparities along the value chain disadvantage them with low farm-gate prices. However, Costa Rica's political and economic stability creates a favourable environment for long-term investments in sustainable practices. Additionally, growing consumer demand for fresh, minimally processed, and organic products presents significant opportunities for farmers (Villalobos Monge, 2024). In this context, local markets and urban agriculture also hold potential for promoting sustainable production and consumption patterns. Moreover, Costa Rica's established agricultural export markets and trade surplus provide opportunities for value-added products and niche markets, particularly in organic and processed goods. By addressing barriers through innovation, technology investment, and policy support, the horticultural sector can develop sustainable and resilient BM that capitalise on growing demand for healthier and environmentally friendly products.

Sustainable business model proposal

Through the BMC development, CoopeHorti Irazú R.L. seeks to improve its vision of how the business works, and its ability to generate value, along with new opportunities and value propositions. The sustainability of the BM can be achieved through the follow-up of the proposed blocks with adequate support from the general management to achieve what is proposed, emphasising the cooperative's operational efficiency.

The customers targeted by the cooperative are distribution centres and retailers, independent producers, restaurants and hotels, educational institutions, and other cooperatives, that prioritise both social responsibility and food quality. The cooperative aims to penetrate new markets, such as supermarkets, educational institutions, hotels, and self-service stores. The customer service is designed to be capable of meeting customer expectations, reflecting the cooperative's stability, and therefore maintaining customer loyalty. In addition, the cooperative intends to export its products, posing new opportunities for both domestic and international growth through strategic partnerships. The distribution strategy is based on both direct and indirect channels, using the cooperative transports and collection centres to ensure the delivery of fresh high-quality produce. As part of the customer relationship, it is structured to be long-lasting, seeking to collaborate with entities that align with the cooperative's principles. Efforts to improve personalised service and transparency with customers include increasing visits to production sites, facilitating pre-sales, and arranging meetings with clients. This collaborative approach reinforces mutual commitment to sustainability and ensures that products meet the highest standards in terms of quality, safety, and traceability. Finally, for the product end-of-life the cooperative foresees plans to valorise organic waste through, e.g., compost, vermicompost, and anaerobic digestion (Bokashi) to minimise environmental impact. The cooperative is also committed to innovation in sustainable waste management.

The sustainable value proposition consists in the supply of healthy and high-quality food produced through sustainable agriculture. The cooperative members seek to distinguish their products in a competitive market thanks to high quality and traceability. This can be achieved checking compliance with quality standard protocols and stipulating sanctions for deviations from the prescribed guidelines. This framework is reinforced with production process certifications such as good manufacturing practices and in the future will even opt for certifications on e.g. smart agriculture or food safety compliance, to meet customer expectations. A purchasing and sales department is supposed to be created to improve technological innovation, accurate record keeping, and effective planning and management systems.

The creation of sustainable value relies on the adoption of innovative technologies, resource use optimisation, and the application of advanced agricultural practices, like automation of the production processes. Voluntary certification systems can reinforce the efforts in sustainable value creation. To foster the cooperative identity, considered crucial for marketing purposes, farmers aim to strengthen the direct relationship with customers through the organisation of visits during which the production process can be observed and final products can be tasted. The integration of sustainable production practices not only satisfies market demands, but also enhances the value proposition matching the growing demand for more sustainable products. The main sustainable resources employed within the cooperative are agricultural equipment for crop management, such as tractors and tools that are adapted to facilitate planting, weed management, fertilisation and harvesting; processing facilities and sanitising tools; and competent human resources with technical knowledge in agricultural processes for the development of the work. As sustainable partners, the cooperative has the support of key institutions such as the Ministry of Agriculture and the Tecnológico de Costa Rica, as well as partnerships with other cooperatives.

As for the cooperative's cost structure, technological innovation contributes to cost reduction, through automation of production processes and is essential to ensure both traceability and compliance with good agricultural practices. Also, innovative marketing strategies potentially benefit the cooperative, especially technology platforms, which can promote greater visibility. On top of selling horticultural products, the cooperative expanded its sources of income through a) agreements with institutions that provide financial support, b) the rental of facilities, and c) the provision of complementary services. Regarding the rental of facilities, the board has recognised the potential for income generation through this avenue and now organises recreational activities such as social events for the local community. Lastly, the cooperative agricultural area is an additional asset for members who wish to use it for their crops. This diversification strengthens the BM by reducing dependence on a single source of income, thereby mitigating risks and pursuing new opportunities. Also, the cooperative status improves farmers' credibility, thereby facilitating government support. The support received from various institutions allows to implement initiatives that promote farmers' economic development and well-being, fostering a sustainable transition without compromising its operational capacity.

Overall, the development of the BMC allowed CoopeHorti Irazú R.L. to visualise and structure its BM, and to promote innovation and adaptability of the cooperative. Customer segments, value proposition, channels and other key areas were clearly identified, and an in-depth understanding of the opportunities and challenges facing the cooperative was obtained. The BMC should be implemented through a dynamic approach, constantly reviewing and adjusting the model according to market changes and customer needs. This will enable the cooperative to have a scientific foundation for strategic decision-making to foster the transition of the BM towards sustainability in a competitive environment.

2.4. Conclusions

The current study combines different methods and tools to investigate the economic and environmental performance of agroecological practices and propose a more sustainable and competitive BM to be grounded on the contextual market trends. Findings show the potential of Life Cycle Thinking in disclosing the main strengths and weaknesses of a particular production model, to be then exploited in a BM design process supported by the BMC. However, limitations were detected during the research work. The major challenge encountered within the current research is related to the lack of primary and secondary data. Data availability issues concern weak monitoring systems both among farmers and in national statistics, which hardly include comprehensive and up-to-date data. Poor data availability and reliability might have harnessed the work in several stages, namely the compared E-LCC in which two case studies were excluded from the assessment due to inconsistent or unreliable data, and the market analysis in which authors struggled to find up-to-date information on horticultural production and market trends in Costa Rica. Also, the low participation of the cooperative members in stakeholder engagement (about one third of the total members) activities hindered a representative overview of the cooperative members' perceptions and needs.

Accordingly, it is recommended that future investigations broaden the participant pool and diversify the methodologies employed in data collection. For instance, an increased number of focus groups could be performed with the assistance of the cooperative to enhance contributor engagement and acquire a more comprehensive viewpoint. Also, future investigations should include the evaluation of additional aspects, such as job creation, within sustainability assessments, to encounter relevant considerations for the development of SBM, which were not considered in the scope of the current study. In this sense, E-LCC is unable to entangle competitivity issues in the assessment of the business sustainability. Besides, a more in-depth analysis is considered pertinent on the implementation of certifications at the cooperative level, thereby motivating producers to adopt these sustainability certifications and assessing the potential advantages that could arise for the cooperative. Finally, in relation to sustainability, it is proposed to incorporate quantitative metrics in future research to gauge the environmental and social impact of the practices adopted, thus encouraging greater transparency and improving external communication.

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Chapter 3 : Social assessment of sustainable practices in coffee production: unveiling impact pathways towards farmers’ perceived well-being

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Abstract

Coffee is a cornerstone of local value creation in many developing countries, with its production stage entailing major environmental and economic burdens. From a social perspective, coffee smallholders living conditions are addressed as key challenge in the sustainability of the coffee sector. Insights from the Social Life Cycle Assessment (S-LCA) highlight the need for developing social impact pathways for a deeper understanding of correlation chains in the coffee sector social sustainability. Drawing upon this context, the current study aims to unveil the impact pathway that unfolds from psychosocial and behavioural factors influencing the adoption of sustainable agricultural practices (SAP), towards their potential effects on farmers’ well-being.

The study integrates different approaches to a) model the correlations among driving factors for adopting SAP, and b) unveil the ensuing impact pathway towards perceived well-being. To do so, the Theory of Planned Behaviour guides the identification of factors influencing farmers’ adoption of SAP, whereas the S-LCA is employed as a methodological foundation for developing an impact pathway. Data is collected through a structured questionnaire targeting Costa Rican coffee farmers and the Structural Equation Model allows to test a modified version of the Theory of Planned Behaviour and unfold the S-LCA impact pathway. Finally, an expert consultation guides the results validation and interpretation according to the local context.

This exploratory study unveils an impact pathway from psychosocial and behavioural factors driving coffee farmers’ adoption of SAP towards perceived impacts on well-being. The proposed model shows that attitude and perceived behavioural control are positively related to the adoption of SAP and positive impact on well-being as perceived by farmers. Socio-demographic factors are also correlated to behaviour and impact on well-being, and socio-cultural considerations emerged from the expert consultations to explain specific correlations. Findings hold promise for informing decision-making, future capacity building, and SAP adoption in sustainable coffee production, enlightening trade-offs in socio-ecological sustainability within the sector.

The integration of behaviours and perceptions into social impact pathways through statistical modelling paves the way for methodological advancements in the field of S-LCA unravelling their role in fostering the transition towards more sustainable agricultural systems. This exploratory study emphasises the need for integrated approaches and concerted efforts to address the complexity of sustainability within the agricultural sector. The results of this study provide a solid basis for coffee cooperatives and policymakers to promote the adoption of SAP to ultimately maximise positive impacts on farmers’ well-being.

Keywords: social life cycle assessment, impact pathway, small farmers, coffee production, well-being

3.1. Introduction

The coffee sector is one of the most prominent value chains globally (Potts, 2003; Wright et al., 2024). Coffee ranks among the top ten traded commodities worldwide, with 25 million small farmers from low-income countries relying on it as a source of income (ICO, 2024, 2019a, 2019b). However, the sector faces a "sustainability crisis" (Sachs et al., 2019) driven by climate change, market imbalances, and income distribution disparities (Babin, 2015; Barreto Peixoto et al., 2023; Wright et al., 2024). Coffee is extremely vulnerable to climate change due to its temperature and humidity requirements (Barreto Peixoto et al., 2023; Pham et al., 2019). As a result, reducing environmental impacts in the coffee sector is widely addressed in the literature (Hadi et al., 2022). Scientists also document the vulnerability of small farmers to socio-environmental changes, including price volatility, supply chain disruptions, market conditions, and climate change (Bacon, 2005; Guido et al., 2020; ICO, 2021; Rodriguez-Camayo et al., 2024). However, the social dynamics associated with coffee production have received relatively limited investigation (Rahmah et al., 2023).

Improving coffee farmers' living conditions and well-being is a major challenge for the social sustainability of the coffee sector (Potts, 2003). The Social Life Cycle Assessment (S-LCA) is acknowledged among the most promising methods to assess social sustainability in the food value chains (Arcese et al., 2023; Desiderio et al., 2022; Sala et al., 2013) and more precisely in coffee production (Brenes-Peralta et al., 2021). S-LCA considers human well-being as its main Area of Protection (Lindkvist and Ekener, 2023; Schaubroeck and Rugani, 2017; Soltanpour et al., 2019), and comprises two main methods to assess impacts: Type I Reference Scale, and Type II impact pathway (IP) (UNEP, 2020). The latter is still under development and is less commonly adopted (UNEP, 2020). Among the several S-LCA Type II IP studies reviewed by Sureau et al. (2020), few explore the root causes of potential social impacts, and none specifically address coffee farmers' well-being and related drivers. To this scope, researchers call for methodological developments in S-LCA to uncover social dynamics and their effects on well-being through IP (de Araujo et al., 2021; Sureau et al., 2020; Zamagni et al., 2021a).

Sustainable coffee farming can significantly enhance farmers' well-being. Sustainable Agricultural Practices (SAP) ranging from agroforestry to organic coffee farming, show potential for achieving sustainability goals in coffee farming (Brenes-Peralta et al., 2022; Martinez et al., 2024). Recent studies indicate that SAP tend to have overall positive impact on stakeholders' livelihoods and well-being (Milheiras et al., 2022). Still, scholars advocate for deeper investigation on the relation between

SAP and human well-being to provide empirical evidence, especially in tropical landscapes (Miller et al., 2020). To evaluate the potential benefits of SAP on coffee farmers' well-being, it is crucial to understand the social dynamics influencing their adoption. For which reason, experts suggest combining S-LCA with other methods (Zamagni et al., 2021b) to better understand the interactions among social variables and their impacts on well-being. Among behavioural approaches, the Theory of Planned Behaviour (TPB) (Ajzen, 1991) addresses psychosocial factors driving decisions made by rational actors, such the adoption of SAP by coffee farmers (Savari et al., 2023; Tabe-Ojong et al., 2024).

This research intends to combine S-LCA with TPB to understand which factors influence farmers in adopting SAP and how these impact on their well-being. In doing so, the study aims to develop a S-LCA Type II IP, which allows to unveil correlations between inventory indicators and potential impacts on stakeholders' well-being (UNEP, 2020). The proposed IP explores correlations between psychosocial factors, the adoption of SAP, and perceived impacts on farmers' well-being. By examining Costa Rican coffee farmers, this research sheds light on social dynamics related to SAP and farmers' well-being in Coffee Belt countries. It offers a scientific foundation for developing policies to promote sustainable coffee farming in Costa Rica and other coffee-producing nations. In this sense, this study's objective is twofold: a) to contribute methodologically to the burgeoning field of S-LCA by integrating insights from behavioural sciences, and b) to lay the groundwork for evidence-based interventions empowering resilient coffee farming communities.

3.2. Methods

Contextual aspects

Among the Coffee Belt countries, Costa Rica serves as an illustrative case, due to its tradition of coffee production (ICO, 2019b). Coffee cultivation in Costa Rica is predominantly managed through a community-based approach with most production undertaken by smallholders (OECD, 2017; UNDP, 2024). Despite Costa Rica's longstanding commitment to sustainability, coffee farmers heavily depend on chemical pesticides and fertilisers, contributing to greenhouse gas emissions and other externalities (Anselmi and Vignola, 2022; Noponen et al., 2012). Furthermore, social concerns persist on coffee farmers' well-being due to low and variable coffee prices (USDA, 2022). Therefore, the coffee production stage is widely addressed in literature for its impacts on Costa Rican food system sustainability (Brenes-Peralta et al., 2022; Campos Trigoso et al., 2021; Santos et al., 2023). Research indicates that coffee cooperatives, comprising 24% of all cooperatives in Costa Rica (OECD, 2017), have the potential to enhance the livelihoods of smallholders by providing fair opportunities (Brenes-Peralta et al., 2021). As a case study, a sample of coffee farmers is analysed, located in Tarrazu, Costa Rica, the main canton of high-quality coffee production in Costa Rica (ICAFE, 2021a; Valenciano-Salazar et al., 2023).

Theoretical background

An exploratory study is performed to investigate the psychosocial and behavioural factors influencing the adoption of SAP in coffee production and the consequent perceived impact on farmers' well-being. The primary hypothesis of this study relies on the fact that SAP are likely to improve stakeholders' livelihoods and well-being (Milheiras et al., 2022). Among SAP for coffee production, this study addresses bio-fertiliser application, shaded coffee cultivation, agroforestry, soil conservation and regeneration, and water use optimisation. Considering agroecosystems as the arena where human-nature interactions take place in the shape of ecosystem services, human well-being is defined according to the Millennium Ecosystem Assessment (MEA 2003), a framework linking drivers, ecosystem services and human well-being (Gari et al., 2015). The constituents of well-being are defined as basic materials for life, health, security, social relationships, and freedom of choice and action (MEA, 2003). It should be stressed that the current study is intended to delineate the IP from driving factors for adopting SAP towards perceived well-being, rather than providing a measure of the impacts on farmers' well-being.

The S-LCA is used as theoretical approach to develop a Type II IP (UNEP, 2020). Considering the goal and scope of the study, farmers are targeted as main stakeholder category and human well-being is selected as main Area of Protection, or endpoint impact category (Jørgensen et al., 2010; Lindkvist and Ekener, 2023; Schaubroeck and Rugani, 2017; Soltanpour et al., 2019). The definition of a functional unit and system boundaries fall out of the scope of the current study, which aims to propose a model to track the causal chains between psychosocial factors, the organisation activities and potential implications for farmers' well-being, rather than performing an overall S-LCA. The inventory data serving as starting point for the impact pathway refer to farmers' perceptions and sociodemographic characteristics. The TPB is selected among the main behavioural approaches considering its ability to specifically address key drivers shaping decisions in rational subjects, such as farmers' adoption of SAP, isolating them from external factors such as the economic and policy context. TPB provides the theoretical framework to investigate the social factors - grouped in three main theoretical constructs, namely attitude, subjective norms and perceived behavioural control -

influencing the intention and resulting in a determined behaviour (Figure 3.1), such as the adoption of SAP in coffee production (Buyinza et al., 2020a, 2020b; Kirungi et al., 2023; Nguyen and Drakou, 2021).

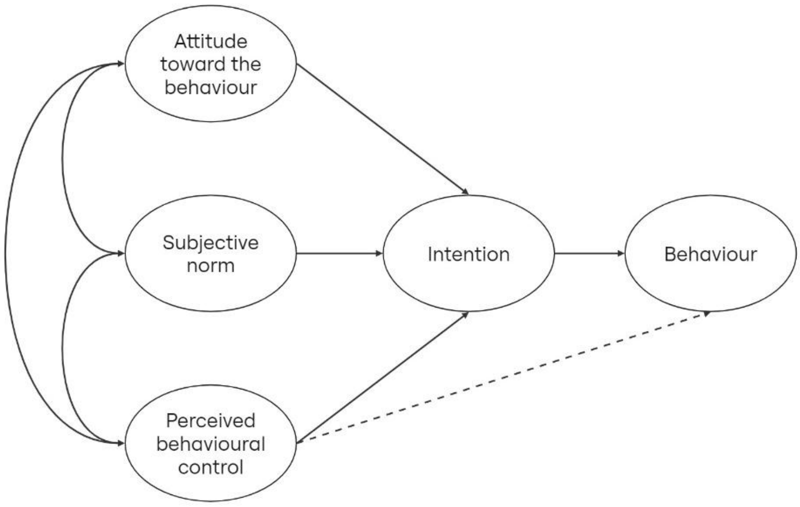

Figure 3.1: Theory of Planned Behaviour.

In the current study, a modified TPB is proposed to encompass the most relevant aspect to be included as theoretical constructs influencing the behaviour of SAP adoption. Hypotheses for the model are formulated based on a non-systematic literature review and theoretical underpinnings. Specifically, hypotheses are developed to test the relationships between psychosocial and behavioural factors, the adoption of SAP, and its impact on farmers' well-being:

- H1: The adoption of SAP influences farmers' perceived well-being.
- H2: Socio-demographic characteristics of farmers influence the adoption of SAP
- H3: Farmers' attitude influences the intention to adopt SAP
- H4: Social norms influence the intention to adopt SAP
- H5: Farmers' perceived behavioural control influences the intention to adopt SAP
- H6: Intention influences the adoption of SAP

Hypotheses are then tested and confirmed or rejected according to statistical analysis results.

Questionnaire development for data collection

To collect data, an online farmer-level survey is designed according to the selected theoretical constructs. The main psychosocial and behavioural factors influencing the adoption of SAP in coffee production are identified according to the non-systematic literature review. Theoretical constructs (latent variables) from the TPB are composed of multiple indicators (observation variables) derived by the literature (Table 3.1). Observation variables are deducted from statements on a 5-Likert scale in which farmers stated their level of agreement/disagreement. Also, information on farmers' socio-demographic characteristics is collected.

Table 3.1: Latent and observation variables of the model and related references.

Latent variables	Observation variables	Reference
Attitude towards sustainable Farming Behaviour (AFB)	Environmental concerns (AFB1)	(Bravo-Monroy et al., 2016; Brenes-Peralta et al., 2022; Nguyen and Drakou, 2021; Rodríguez-Barillas et al., 2024; Sebuliba et al., 2023)
	Coffee productivity (AFB2)	(Bravo-Monroy et al., 2016; Buyinza et al., 2020b; Malik et al., 2019; Putri Handayani et al., 2024; Rodríguez-Barillas et al., 2024; Sebuliba et al., 2023)
	Production costs (AFB3)	(Bravo-Monroy et al., 2016; Brenes-Peralta et al., 2022; Harvey et al., 2021; Malik et al., 2019; Sebuliba et al., 2023)
	Health concerns (AFB4, AFB5)	(Huzenko and Kononenko, 2024; Phung and Dao, 2024; Rajasree and Sharma, 2019; Rehman et al., 2022; Yan et al., 2022; Zheng et al., 2024)
Social-Norm Influence on Sustainable Farming Behaviour (SFB)	Affiliation to cooperative schemes (SFB1)	(Brenes-Peralta et al., 2022; Putri Handayani et al., 2024)
	Injunctive norms from different stakeholder categories (other farmers, workers, local community, children, etc.) (SFB2, SFB3, SFB4, SFB5, SFB6)	(Buyinza et al., 2020b; Nguyen and Drakou, 2021; Rodríguez-Barillas et al., 2024; Sebuliba et al., 2023)
Perceived Behavioural Control of Farmers (PBF)	Technical control /availability of technology (PBF1)	(Bravo-Monroy et al., 2016; Buyinza et al., 2020b; Nguyen and Drakou, 2021)
	Knowledge or learning on sustainable agricultural practices (PBF2, PBF4)	(Brenes-Peralta et al., 2022; Buyinza et al., 2020b; Malik et al., 2019; Putri Handayani et al., 2024; Rodríguez-Barillas et al., 2024; Sebuliba et al., 2023)
	Financial control/cost management (PBF3)	(Bravo-Monroy et al., 2016; Brenes-Peralta et al., 2022; Harvey et al., 2021; Malik et al., 2019; Nguyen and Drakou, 2021)
	Easiness of adoption of sustainable cropping practices (PBF5)	(Brenes-Peralta et al., 2022; Rodríguez-Barillas et al., 2024; Sebuliba et al., 2023)
Farmers' socio-demographic information	Age (AGE)	(Harvey et al., 2021; Kirungi et al., 2023; Rodríguez-Barillas et al., 2024; Sebuliba et al., 2023)
	Gender (GND)	(Rodríguez-Barillas et al., 2024; Sebuliba et al., 2023)
	Years of formal education (EDU)	(Bravo-Monroy et al., 2016; Kirungi et al., 2023; Rodríguez-Barillas et al., 2024; Sebuliba et al., 2023)
	Coffee farming experience (EXP)	(Hasibuan et al., 2022; Kirungi et al., 2023; Rodríguez-Barillas et al., 2024; Sebuliba et al., 2023)
	Land ownership and decision-making (OWN, DEC)	(Bravo-Monroy et al., 2016; Kirungi et al., 2023; Rodríguez-Barillas et al., 2024)
	Farm size and coffee plot numbers (SIZ, VOL)	(Bravo-Monroy et al., 2016; Hasibuan et al., 2022; Kirungi et al., 2023; Malik et al., 2019; Rodríguez-Barillas et al., 2024)

Then, the intention to adopt SAP is examined along with the actual behaviour of farmers in SAP adoption. Finally, farmers' perceptions are investigated concerning changes in four constituents of well-being, namely basic materials for a good life, health, good social relations, and freedom of choice and action (MEA, 2003). The questionnaire is distributed to a sample of 167 coffee farmers in the Tarrazu canton in Costa Rica (link available in Annex-Chapter 3 (A-C3)).

Data analysis and validation

Data collected through the survey is analysed in two steps. First, descriptive statistics is calculated for dataset exploration. Then, a Structural Equation Model (SEM) is applied to confirm the theoretical model, and thereby quantify the relationship between declared SAP adoption, its determinants (TPB constructs and socio-demographic information), and the perceived impacts on well-being. The SEM is chosen as the estimation technique due to its ability to analyse relationships among multiple variables simultaneously, including latent constructs such as psychosocial factors (Hair et al., 2010; Mazzocchi, 2008). The SEM integrates two main models: a measurement model allowing to generate of the latent variables (i.e. the theoretical constructs) as a function of the observed variables, and a structural model (or path analysis) quantifying the interactions among latent variables (Buyinza et al., 2020a). SEM also allows to investigate of complex causal pathways (Sureau et al., 2020; Wu et al., 2015) and provides insights into the direct and indirect effects of psychosocial factors on the adoption of SAP and farmers' well-being. SEM is used as a confirmatory technique, and data is used to test the effectiveness of the model (Johnson, 1999). The parameters of the model are estimated through maximum likelihood, and as goodness-of-fit measures RMSEA, CFI, TLI, and SRMR are computed using the Satorra–Bentler scaled chi-squared statistic to obtain standard errors that are robust to non-normality (Byrne, 1994; Hu and Bentler, 1999). All the analyses are performed using Stata 18 software (StataCorp, 2023).

Results from statistical analysis are validated through expert consultations during two online meetings with a total of ten participants, four of which came from Costa Rican coffee production cooperatives (first consultation), and six representatives from Costa Rican agricultural institutions, namely the Ministry of Agriculture and Livestock and the ICAFE (second consultation). During the consultations, the participants are introduced to the main characteristics of the survey sample, along with the main results of the statistical analysis, including descriptive statistics, exploratory factors, and SEM results. Then, a debate tackles ten main discussion items to interpret the main outcomes of the study, encompassing the perspective from diverse actors. The structure of the expert consultations can be consulted in A-C3.

3.3. Results and discussion

Sample characterisation

The sample is composed of 85% of men and 14% of women (1% did not declare their gender), in line with the national population of coffee farmers in the year 2014 (ICAFE, 2021b), with an average age of 45,6 years (see Table 3.2). Concerning the educational level, half of the sample has a primary school degree. The respondents have on average 27,68 years of experience in coffee farming. Within the sample, 98,8% of the respondents own the land and 71% declare to be the decision-makers in the activity. 71% of the respondents cultivate coffee in less than 5 ha, while on a national level 92% of coffee farmers have an agricultural area within 5 ha (ICAFE, 2024).

Table 3.2: Description of socio-demographic characteristics of the analysed sample.

Label	Socio-demographic information		unit	data
AGE	Age (average)		years	45,59
GND	Gender	Male	%	85
		Female	%	14
		Not declared	%	1
EDU	Educational level	Primary school	%	50
		Secondary school	%	28
		University level	%	21
EXP	Years of experience		years	27,68
OWN	Owned land		%	99
DEC	Decision-maker		%	71
SIZ	Agricultural area	≤5 ha	%	71
		5 ha<x≤10 ha	%	14
		10 ha<x≤20 ha	%	10
		>20 ha	%	4
VOL	Production volume (total)	≤5 t	%	19
		5 t<x≤20 t	%	39
		20 t<x≤50 t	%	20
		>50 t	%	21
	Yield (average)		t/ha	6,95

Relevant socio-demographic information from the survey responses is included within the developed structural model as proposed in Section 3.2. However, information on gender, agricultural area, and production volumes is excluded from the overall model due to weak overall fit indicators. The next step of the analysis consists of the definition of the SEM to investigate the correlations among observed and latent variables to identify potential relations between psychosocial factors and the adoption of SAP and their impacts on perceived well-being.

Structural equation model

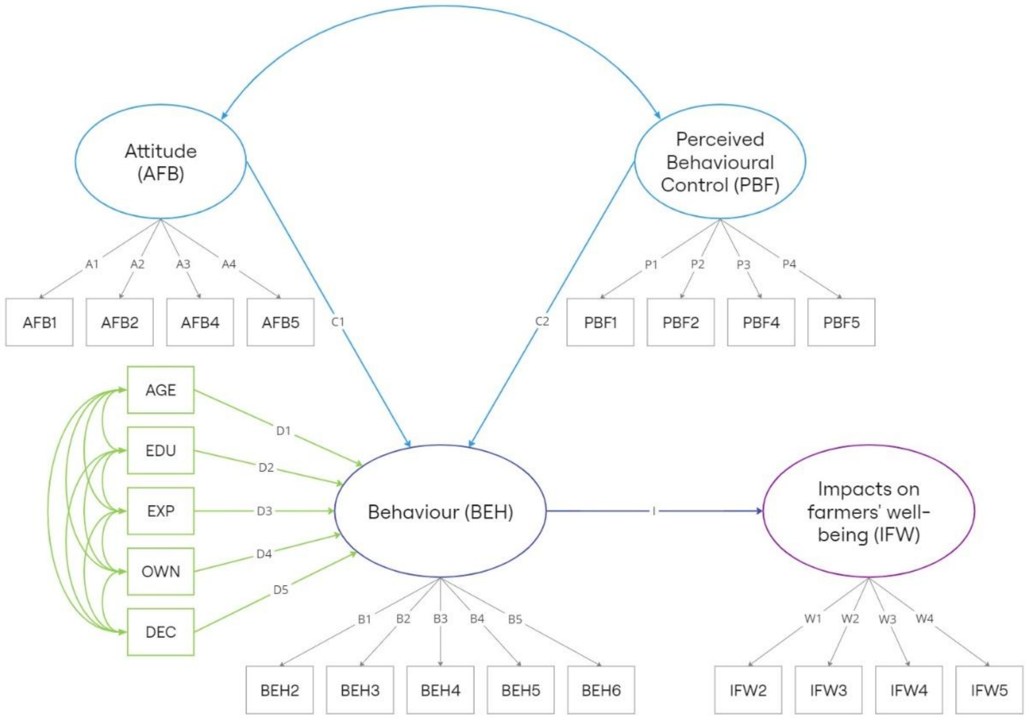

Figure 3.2: The proposed model.

The model displayed in Figure 2 represents the version of the model with the best overall fit for the analysed data, ensured by the following value for indicators (Byrne, 1994; Hu and Bentler, 1999):

- RMSEA_SB = 0,063
- CFI_SB = 0,910
- TLI_SB = 0,898
- SRMR_SB = 0,099

The model relies on a modified version of the TPB, as the latent variable of intention is excluded from the proposed model due to weak overall fit indicators (which rejected H6). This inconsistency may be attributed to the specific characteristics of the sample, where most respondents have already adopted SAP to a certain degree, therefore intentions might not correlate with actual behaviour. The latent variable of social norms is also excluded because of weak values of the overall fit of the model, rejecting H4. On the other hand, the significance of the direct correlations between socio-demographic characteristics, behaviour and positive impacts on perceived well-being can be confirmed, thereby confirming H1 and H2. Even though H3 and H5 were rejected due to the exclusion of the intention variable, data demonstrated a direct correlation between attitudes, perceived behavioural control, and behaviour, and the model generated relevant insights for discussion.

First, the latent variables of the model were investigated, i.e. attitude towards sustainable farming behaviour (AFB), perceived behavioural control of farmers (PBF), behaviour (BEH) and perceived impacts on farmers' well-being (IFW), to select the relevant observable variables as contributing factors to the latent variables. Cronbach's alpha coefficients confirmed reliability for attitude (0,89), perceived behavioural control (0,75), behaviour (0,83) and impacts on well-being (0,89). Table 3.3 describes the direct effect of each observed variable. All observed variables are positively related to the adoption of SAP and the perceived impact on well-being, confirming the first hypothesis of the model (H1). Also, all observed variables are significant at a 1% level.

Table 3.3: Variables direct effects.

Label	Variable	Direct effect	Coefficient	S.E.
AFB1	Environmental concern	A1	1	(constrained)
AFB2	Productivity	A2	0,75***	0,10
AFB4	Health – farmers and families	A3	1,12***	0,06
AFB5	Health – consumers	A4	1,07***	0,05
PBF1	Technical availability	P1	1	(constrained)
PBF2	Knowledge	P2	1,20***	0,14
PBF4	Employee management	P3	0,91***	0,13
PBF5	Easiness of adoption	P4	0,72***	0,15
BEH2	Bio-fertiliser application	B1	1	(constrained)
BEH3	Shaded coffee cultivation	B2	0,91***	0,12
BEH4	Soil conservation and regeneration	B3	1,17***	0,11
BEH5	Water use optimisation	B4	0,82***	0,10
BEH6	Labour rights	B5	0,91***	0,16
IFW2	Income	W1	1	(constrained)
IFW3	Health	W2	0,81***	0,07
IFW4	Security	W3	0,92***	0,06
IFW5	Freedom of choice and action	W4	1,02***	0,07

AFB is significantly influenced by positive perceptions about the impact of these practices on productivity and health, both for farmers and consumers. The observed variable having the highest direct effect is related to the health of farmers and their families, suggesting that those who consider SAP as beneficial for personal and family health have a very positive attitude towards these practices. This could be related to the fact that coffee in Costa Rica is often a family activity, meaning that farmers often engage their families and communities working in cooperatives, where people and families know each other. This highlights that perceived benefits, especially in terms of physical

*** p-value < 0,001

and environmental well-being, are key to fostering positive attitudes towards sustainable practices. PBF reflects the extent to which farmers feel they have the capacity or resources necessary to adopt SAP and is strongly influenced by the availability of technical resources and knowledge. Farmers who feel they have access to technology and the necessary knowledge feel more secure when adopting SAP. Knowledge represents the most relevant factor while easiness of adoption is relatively less influencing. BEH consists of the adoption of specific SAP in coffee farming. The SAP mostly adopted by farmers is soil conservation and regeneration, followed by bio-fertiliser application. This highlights that farmers value practices that are not only sustainable but also protect natural resources in the long term. In addition, social justice is an important value that influences the adoption of these practices.

IFW represent farmers' perceptions of the impact of SAP on their overall well-being. Perceived well-being, especially in terms of income, health and safety, is a key motivation for SAP adoption. Farmers who believe that these practices will improve their economic situation, health, sense of security and freedom, tend to adopt them. Variables show that adopting SAP not only improves productivity and sustainability, but also the well-being of farmers in terms of health, safety, and autonomy in decision-making. The most relevant factor for farmers is related to freedom of choice and action, meaning that farmers adopting SAP feel more comfortable with their livelihood and are able to make free decisions. Also, the analysis suggests that the adoption of SAP improves farmers' health, which could be related to safer working conditions and the use of less health-damaging methods. Lastly, attitudes and perceived control are positively correlated. This indicates that a positive attitude towards SAP is also related to a greater perception of control over the ability to adopt these practices. This suggests that there is a positive relationship between farmers' AFB and PFB, although it is less significant compared to other outcomes. Table 3.4 describes the SEM coefficients and p values for all the variables analysed within the model.

Table 3.4: SEM coefficients.

Label	**Variable (BEH)**		**Coefficient**	**S.E.**
AGE	Age	D1	-0,00	0,01
EDU	Educational level	D2	-0,07**	0,03
EXP	Years of experience	D3	-0,00	0,00
OWN	Ownership	D4	1,09***	0,12

*** p-value < 0,001
** p-value < 0,05
* p-value < 0,1

DEC	Decision-making	D5	$0,14^{*}$	0,08
AFB	Attitude	C1	$0,28^{***}$	0,07
PBF	Perceived behavioural control	C2	$0,62^{***}$	0,12
Label	**Variable (IFW)**		**Coefficient**	**S.E.**
BEH	Adoption of SAP	I	$0,40^{***}$	0,08

Age does not show a significant relationship with the adoption of SAP, suggesting that farmers' age does not affect the adoption of these practices. There is a significant negative relationship between the educational level and the adoption of SAP. This may indicate that farmers with a higher level of education may be less likely to adopt SAP, although this may be counterintuitive according to literature, stating that people with higher education degrees are usually more receptive to innovations and sustainable practices (Comer et al., 1999). This aspect is further discussed in Section 4. according to the expert consultations. First, the questionnaire did not address explicitly whether the educational degree was in the field of coffee cultivation. Besides, only in recent years, agricultural sustainability arose as a core issue within educational programs, therefore the survey respondents might have received training focused more on other topics such as productivity and profitability rather than the sustainability of production systems. Several experts also adverted that training for coffee farmers is often delivered in elementary forms to ensure accessibility at all educational levels, resulting in unattractive for higher-educated producers as a side-effect. Lastly, higher-educated farmers tend to provide higher formal education for their children, expecting them to reach a higher livelihood or social status, therefore not investing in SAP adoption for the future of the farm. Experience in agriculture also shows no significant relationship with the adoption of SAP, suggesting that years of experience are not a determining factor in adopting these practices. Land ownership has a very significant positive effect on the adoption of SAP, suggesting that farmers who own their land are more likely to adopt sustainable practices. Being the decision-maker within the farm also showed a positive relationship with SAP adoption and impacts on perceived well-being, although this relationship is marginally significant.

S-LCA impact pathway

From an S-LCA perspective, findings allow to identify the main aspects to be addressed to maximise positive impacts on the well-being perceived by farmers when adopting SAP. The proposed model aligns with S-LCA in posing human well-being as the main Area of Protection, i.e. the endpoint impact of the IP. Considering farmers as the target stakeholder category, farmers’ well-being is defined as the main endpoint category in the model. The farmer’s behaviour (i.e. SAP adoption) is considered a midpoint impact in the model and is supposed to be influenced by farmers' psychosocial factors and socio-demographic features as inventory data, and influence well-being as perceived by farmers (see Figure 3.3). The study used SEM to quantify correlations between unobservable social aspects for a type II IP in S-LCA at a micro scale (case study). The unobservable impact category of well-being was viewed as a latent construct. An IP was tested using confirmatory SEM and was established between psychosocial and behavioural factors and well-being improvement, with the mediating effect of adopting SAP in the IP. The confirmatory model showed the direct causal links from psychosocial and behavioural factors to the adoption of SAP as a mediating effect and to perceived well-being outcome were supported and statistically significant.

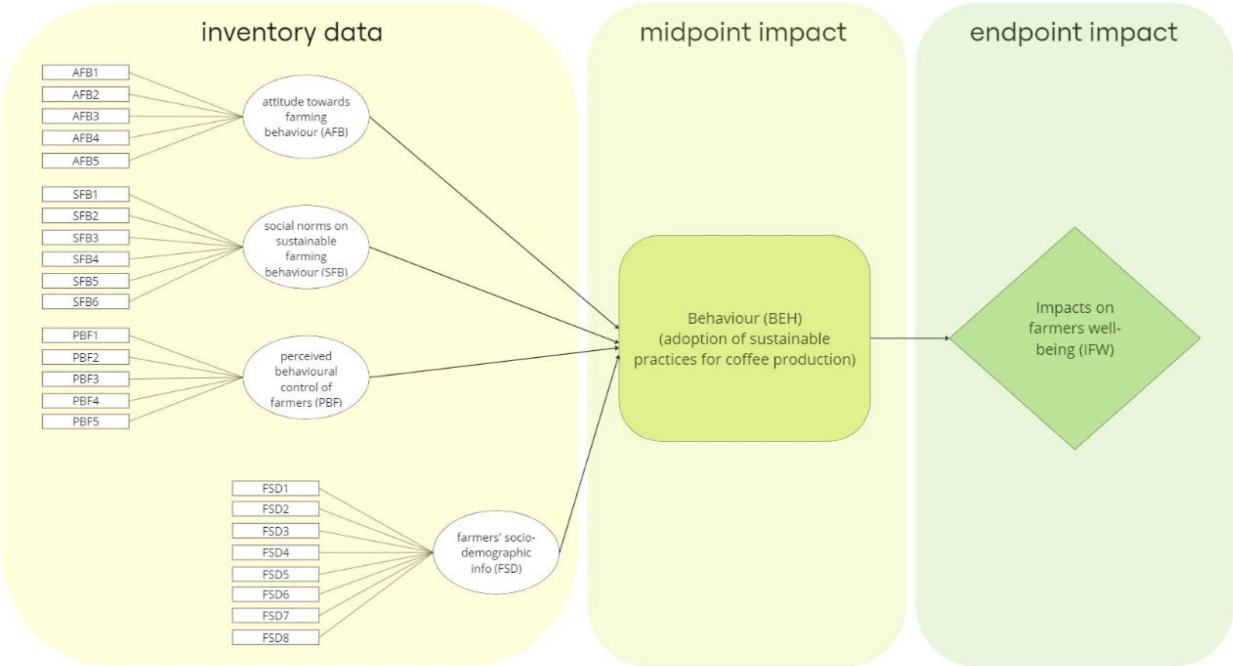

Figure 3.3: S-LCA impact pathway proposal.

Discussion

In general, small farmers aim at improving the farm's productivity and profitability, rather than enhancing their sustainability commitment. In other words, economic sustainability takes precedence over environmental and social ones. Coffee producers usually assume a short-term perspective instead of long one due to their focus on satisfying basic needs. Basic needs are considered as the main target of well-being; however, additional lifestyle needs are associated with well-being, according to the yearly farm's performance, i.e. based on the annual revenues, farmers aim to improve their well-being beyond basic need satisfaction. Experts state that well-being for coffee farmers is more related to revenues, which allow them to provide for their family's livelihood and ensure them a better future, rather than educational level. However, producers with higher educational levels might have higher expectations in terms of the farm's productivity and profitability, which might lead to disappointment if the business does not reach the expected performance. Overall, highly educated professionals aim at businesses which can be more profitable than coffee production, due to low profit margins, although margins are not fully or formally analysed by farmers. Besides, trainings to improve SAP capacities are designed to be accessible to farmers with a wide range of educational backgrounds. As a result, the shape in which training is proposed to farmers might not be as attractive to those with higher education, resulting in too basic compared to their expertise, resulting in this case in a negative relationship between education and SAP adoption.

Although gender was not among the highly correlated variables in the model, an observation regarding gender imbalances emerges from the descriptive statistics of the (predominantly male) respondents, and the expert consultations: very few women have the chance for ownership and decision-making in this area of coffee production. However, consulted experts point out a general openness for training and innovation among female farmers who under certain circumstances make decisions on their farms. The main reason for this gender imbalance is related to land ownership and inheritance, according to experts. Coffee farms are more often inherited by male heirs rather than females, hence fewer women have the chance to be landowners. Then, there is a leadership issue that is hardly recognised to women, implying a greater effort for women to be decision-makers in the context of coffee production. This is certainly also linked to historical and cultural issues, but it represents a crucial target to be addressed in international and local policy environments aiming at promoting SAP adoption.

Given the aim of the IP approach in S-LCA regarding the assessment and modelling of a causal link from social factors (stressors) and the effect they bring into the endpoint impact category (well-being) (UNEP, 2020), the present study poses an opportunity through the integration of TPB and SEM as proven methods. In this regard, TPB serves as the theoretical background and SEM as a robust statistical mechanism to explain the social dynamics knitting under the effect we can see of adopting SAP into farmers' well-being. The IP assessment is known to be still at a developing stage, but it is well recognised that from both qualitative and quantitative methods, it can move from indicators to the definition of a model that explains the followed path, traced until an impact after characterisation mechanisms. A specific comparison can be drawn with the Psychosocial Risk Factor

Impact Pathway proposed by Iofrida et al. (2019), which explores causal relationships between psychosocial risks and social sustainability outcomes. Notwithstanding the common goal of unveiling correlations between psychosocial factors and well-being in agricultural contexts, they differ significantly. The approach followed by Iofrida et al. (2019) is risk-oriented, seeking to identify the psychosocial stressors and their pathway towards potential social impacts or challenges. In contrast, the current study adopts a behavioural and solution-oriented perspective, focusing on the psychosocial drivers that influence farmers' decisions in the adoption of SAP, and how these decisions ultimately impact perceived well-being. Rather than assessing social risks, this research investigates context-specific positive pathways, emphasising factors such as attitudes, perceived behavioural control, and socio-demographics, which enable or hinder SAP adoption and contribute to well-being improvements.

In this context, understanding the implications and limitations regarding attitude, socio-demographics, and perceived behavioural control towards the adoption of SAP, as well as the impacts on different dimensions of well-being as perceived by the studied sample of farmers, is considered by the authors and the sectoral experts as an advancement in this discipline. By integrating behavioural science into S-LCA Type II, this study bridges a gap in social sustainability assessments, shifting the focus from risk identification to understanding and enabling positive behavioural change. To promote a wider social handprint (like in this case for coffee production), the use of the proposed methods adds clarity to the IP approach and potential goals of S-LCA and its usefulness in improved sustainability in agri-food chains such as coffee. Future research could further explore the interplay between psychosocial risks and drivers, combining different existing approaches to develop more comprehensive impact assessment models.

3.4. Conclusions

The study proposes a model unveiling correlations underlying the IP identified between psychosocial, behavioural, and demographic factors, the adoption of SAP, and perceived impacts on well-being. The model combines different theoretical approaches, i.e. TPB and S-LCA, and was tested through SEM. Results allow to identify the main factors driving the adoption of SAP for coffee farmers, namely land ownership and perceived behavioural control. TPB proved to be an effective theoretical approach to identify relevant factors influencing the adoption of SAP in coffee production, complementing S-LCA in the examination of behavioural aspects. SEM showed potential in describing correlations underlying the unfolding of an S-LCA Type II IP, therefore providing opportunities for S-LCA practitioners for future social impact assessments. To our knowledge, this is the first study employing SEM to delineate quantitative IP on a micro-scale (case study). Furthermore, the current study represents a first step in the definition of pathways to estimate or predict actual or future impacts according to the relative weighting of individual drivers.

Several limitations were encountered within this research. First, the form in which the online questionnaire was distributed may have limited the pool of respondents, representing a barrier for local coffee farmers who are not familiar with online or technological tools. Second, confirmatory analysis of data from a small sample size (<200) could generate non-robust results (Schumacker and Lomax, 2010). Accordingly, the authors suggest testing the model on a larger sample to improve the sample's statistical representativeness and increase the model's reliability. Third, the selection of the indicators to investigate the drivers for the adoption of SAP and represent the latent variables within this study are subject to criticism as they refer to a specific micro-scale context, i.e. small coffee farmers adopting SAP in Costa Rica. Last, the IP was tested at the micro-scale, therefore further efforts are needed to utilise the proposed IP on a meso- or macro-scale. Also, the authors suggest further investigations addressing perceived well-being before and after adopting SAP to quantify the delta between perceived well-being and therefore integrating the time effect within the model.

The results of this study provide a solid basis for coffee cooperatives and policymakers to promote the adoption of SAP to ultimately maximise positive impacts on farmers' well-being. To strengthen drivers of SAP adoption, it is essential to provide farmers with technical resources and accessible training to improve their control over production practices. Cooperatives can facilitate access to technology and finance, while policies should focus on supporting land ownership and autonomous decision-making. Autonomy in decision-making allows farmers to choose and implement sustainable practices according to their own needs, without relying excessively on external factors such as lack of information or resources. Addressing these factors will improve agricultural sustainability and producer welfare, contributing to more equitable and sustainable global food systems (Blackstone et al., 2024). Lastly, the learnings of this work could be used for future research in the context of social and environmental due diligence, new regulations related to the European Union's Green Deal initiative, and the certification and verification processes related to fair trade and ESG (Environmental. Social and Governance) models to assess the sustainability performance of coffee cooperatives according to evaluation and traceability criteria.

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Conclusions

The thesis explores the socio-economic issues connected to agri-food sustainability to understand the drivers and potential impacts of sustainable BM in food production, thereby contributing to methodological and scientific advancements in BM sustainability assessment. The concept of sustainable BM gained momentum in the last decades as potentially contributing to the transition towards more sustainable food systems worldwide. Nonetheless, existing approaches lack in providing practitioners and decision-makers with the effective tools to understand existing opportunities and barriers to ultimately improve stakeholders' well-being within agri-food systems. In this sense, the LCT methodologies prove to play a critical role in assessing BM sustainability and supporting evidence-based decision-making for BM improvements. The three chapters present distinct but complementary methodological approaches contributing to a comprehensive understanding of BM sustainability within the food systems of diverse geographical and sociocultural contexts, precisely in the EU and LAC. Also, the different case studies and purposes in which LCT was applied proved its versatility and effectiveness in assessing various sustainability dimensions supporting the design process for sustainable BM. The thesis findings finally underscore the relevance of contextual factors in shaping BM sustainability, providing significant insights to inform region-specific sustainability strategies.

The first aim of this research was to apply LCT to assess the sustainability performance of BM in food production. In Chapter 1, a novel methodological framework was proposed based on SO-LCA to assess social handprints (or positive social impacts) on stakeholders' well-being generated by BM in CRFSi; in Chapter 2, the E-LCC served to analyse the economic and environmental trade-offs of agroecological practices and provide insights on the related strengths and weaknesses, barriers and opportunities, to improve BM sustainability; in Chapter 3, a Type II impact pathway was developed to advance the S-LCA methodology through statistical analysis. These attempts confirmed the capability of the LCT methodologies in identifying hotspots in positive and negative impacts potentially generated by BM. Then, combining LCT results with the BM structure analysis allows to highlight the main shortcomings to be overcome and the potentialities to be exploited to enhance BM sustainability in agri-food systems.

The second aim was to understand how a BM can be designed so as to foster sustainable practices in agricultural production. Chapter 1 identified the main positive impacts generated by a BM providing a measure in person-equivalent benefiting from the BM; Chapter 2 proposed a co-designed sustainable BM for a horticultural farmers' cooperative; while Chapter 3 identified the main psychosocial and behavioural drivers for the adoption of SAP in coffee production, providing relevant insights to be considered when addressing BM sustainability. To this scope, the BMC supported a swift visualisation of the main components of a BM allowing to disclose the interactions between BM components and positive impacts (Chapter 1) and to co-design together with farmers' a novel BM for their cooperative (Chapter 2). The integration between BMC and LCT represented a successful example of interaction between different scientific disciplines and methodological approaches and demonstrated to be a promising approach towards BM improved sustainability.

The third aim was to identify the main socio-economic factors connected to BM sustainability in different regional contexts. Chapter 1 quantifies positive impacts generated by BM on stakeholders' well-being, providing a measure of social handprint in person-equivalent; Chapter 2 unveils the economic and environmental costs of agroecological practices and their potential for improving BM sustainability; Chapter 3 identifies psychosocial and behavioural factors driving the adoption of SAP and unravels the impact pathway towards perceived impacts on farmers' well-being. The research shed light on deep and structural differences between the EU and the LAC contexts, not only on a technical sphere in terms of existing food production systems, but also on a socio-cultural perspective, for the features of the involved stakeholders. Although the case studies were not aimed to be compared, insights from the research suggest that LCT could support comparative studies between different local contexts to highlight the main challenges faced by stakeholders and opportunities for sustainable BM.

Further developments

The thesis relies on three case studies seeking for different purposes of methodological developments and applications. The methodological framework proposed in Chapter 1 and applied on a CRFSi case study could be applied on a representative sample of CRFSi in the EU to entangle the variety of CRFS functions and goals. Also, additional qualitative aspects, such as circularity and short food supply chains, which were not encountered in the proposed assessment framework, could be further explored to be able to include them in the quantification of social handprint and achieve a comprehensive and reliable measure of BM social performances. The *modus operandi* used to improve BM sustainability in Chapter 2 could be replicated on different case studies to find potential shortcomings and improvements in the methodological process and therefore establish useful guidelines for business-owners to inform sustainable BM according to their own specificities.

Lastly, the social impact pathway unveiled in Chapter 3 could be exploited by not only business owners and cooperatives, but also policymakers, to predict potential impacts generated by the adoption of SAP, according to specific local context characteristics, empower autonomous decision-making, and ultimately maximise farmers' well-being.

Limitations and future research

The thesis revealed both strengths and weaknesses in the application of diverse approaches towards the understanding of agri-food BM sustainability. The integration between LCT methods remains a challenge in sustainability assessment debates, with methodological interoperability representing the main barrier to overcome. The complex nature of social phenomena, and especially with respect to well-being, posed challenges in the retrieval of comprehensive and reliable data that could adequately represent the studied topic and provide relevant results. Particularly in the Costa Rican context, data availability represents a major issue for contextual analysis and monitoring of sustainability performances, and broader scientific research. To this scope, the thesis highlights the need for improved data collection systems and wider stakeholder involvement to ensure a more accurate and inclusive representation of sustainability performance in future research. Also, the conceptualisation of well-being requires combined efforts to better capture its interrelated dimensions and understand the mutual implications between sustainability and human well-being. Although valuable insights are provided on stakeholders' well-being on a micro-scale level, future research could extend the analysis to larger scales and embed longitudinal data to better capture changes in well-being over time. By addressing these limitations, future research can be built upon this work to combine the LCT approaches integrating social, economic and environmental assessments and ensuring data comparability to identify sustainability trade-offs in food systems. Also, future studies should aim at testing the proposed methodologies to verify their adaptability across different socio-economic contexts and enable their comparison. The thesis highlights the need for expanding the outreach of the sustainability assessment findings to inform policy and practice in the transition towards sustainable food systems from an environmental, economic, and social perspective.

Research to policy

On the international agenda, agri-food system sustainability stands out among the most urgent challenges to be tackled, while sustainable BM in agri-food systems can potentially unlock great opportunities. On one side, a set of policies and regulations, such as the EU Common Agricultural Policy (CAP), supports farmers by ensuring a fair standard of living for the agricultural community and providing consumers with safe and high-quality food at reasonable prices. On the other side, proposed measures, such as the EU Green Deal, aim to make the global economy sustainable through climate-neutrality, biodiversity preservation and restoration, and pollution reduction, inter alia. However, to fully understand the effects of these policies on specific regions, quantitative and qualitative frameworks and metrics are needed. This dissertation aims to contribute to the ongoing discourse on sustainable BM in agri-food systems by providing evidence-based recommendations for policymakers at both EU and LAC levels.

The social handprint assessment framework proposed in Chapter 1 provides a science-based support tool for decision-makers and policy planners in the CRFS context. The quantification in person-equivalent allows practitioners and non-practitioners to have a swift and simple measure to understand the social performance of BM in CRFSi in influencing stakeholders' well-being. In addition, it can provide a solid basic tool to collect data on food initiatives which operate across several agricultural sectors and can allow comparing trade-offs between initiatives in different geographical contexts. The combination of methods used in Chapter 2 to co-design a sustainable BM for a horticultural farmers' cooperative can be a support tool for policy in evaluating and forecasting agricultural scenarios in vulnerable contexts such as developing countries. Also, it can help identify and discuss the distribution of responsibilities among stakeholders along the value chain and across societal sectors, including policymakers, to promote cooperation and the definition of shared targets for long-term intervention scenarios. Finally, knowledge exchange is needed between research and policy on the drivers and implications of adopting sustainable agriculture (as explored in Chapter 3) both in developed and developing countries, starting a multi-actor participation process to share diverse viewpoints in the development of effective and appropriate policy responses for a more inclusive and sustainable global food system.

Annexes

Annex – Chapter 1 (A-C1)

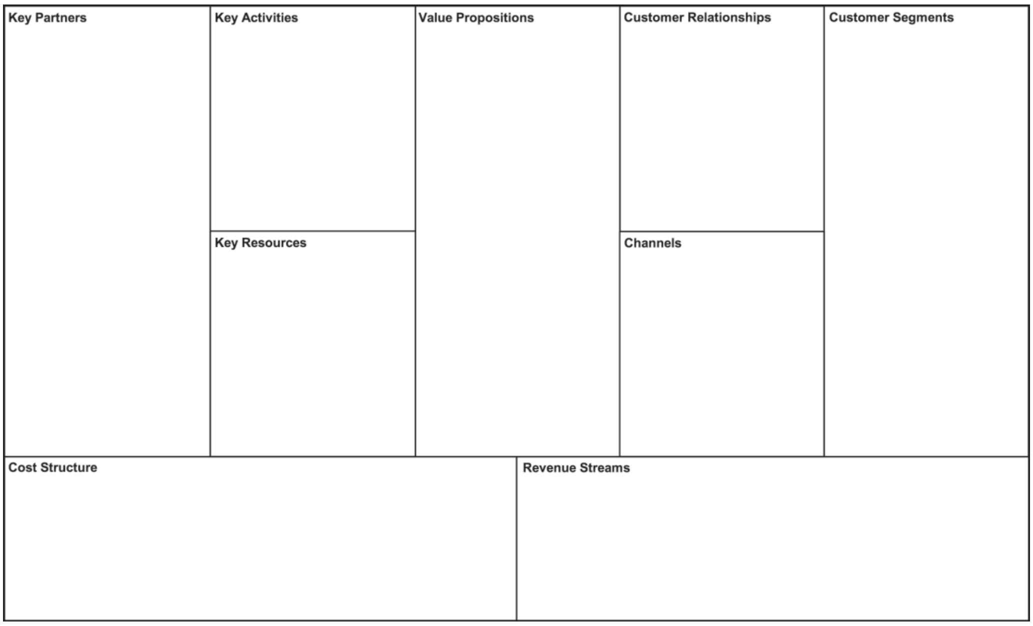
A-C1 Table a: Definitional framework adopted in the current study.

Concept	Definition	Reference
Activities	"Actions, or tasks, that are performed in support of specific impact objectives"	IMWG (2014)
Basic material for life	Ability to access resources to earn income and gain a livelihood	MEA (2003)
City Region Food System	The complex network of actors, processes, relationships to do with food production, processing marketing and consumption in a given geographical region which includes a more or less concentrated urban centre and its surrounding peri-urban and rural hinterland, a regional landscape across which flows of people, goods and ecosystem services are managed.	(Jennings et al., 2015)
City Region Food System initiatives	"CRFSI can be defined as profit or non-profit entities involved in the food system in strong connection with their territorial context and being in one or more of the following activities: agriculture & fishing, food processing (e.g., transformation of agricultural products into food), food distribution (e.g., wholesale, retail, community supported agriculture), food service and consumption (e.g., catering, cooking, restauration), food waste management, education and services. Their workforce is often composed of less than 10 employees, with volunteers involved in several cases. They are located in, or nearby cities or consumption centres and they bond mutual relationships with their final users, enabling the creation of rural-urban linkages. This working definition has been used as a unit for the sustainability scoring system development."	(Cirone et al., 2023)
Constituents of well-being	The constituents of well-being, as experienced and perceived by people, are situation-dependent, reflecting local geography, culture, and ecological circumstances.	MEA (2003)
Determinants of well-being	Inputs into the production of well-being, such as food, clothing, potable water, and access to knowledge and information.	MEA (2003)
Framework	"The rationale and the structure for the integration of concepts, methodologies, methods and tools"	Sala et al. (2013a)
Good social relations	Social cohesion, mutual respect, good gender and family relations, and the ability to help others and provide for children.	MEA (2003)
Health	Strength, feeling well, and having a good functional capacity. Health, in popular idiom, also connotes an absence of disease. The health of a whole community or population is reflected in measurements of disease incidence and prevalence, age-specific death rates, and life expectancy	MEA (2003)
Impact categories	"The impact categories and subcategories assessed in S-LCA are those that may directly affect stakeholders positively or negatively during the life cycle of a product" *Here the concept is used in place of "endpoint" impact categories	UNEP (2020)
Impact pathway	"Impact pathway S-LCIA assesses potential or actual social impacts by using causal or correlation/regression-based directional relationships between the organisations' activities and the resulting potential social impacts"	UNEP (2020)
Impacts	"Changes, or effects, on society or the environment that follow from outcomes that have been achieved"	IMWG (2014)
Indicators	Information based on measured data used to represent a particular attribute, characteristic, or property of a system.	MEA (2003)
Outcomes	"Changes, or effects, on individuals or the environment that follow from the delivery of products and services"	IMWG (2014)

Outcome indicators	Indicators representing the effects that follow from the delivery of products and services.	Authors elaboration
Outputs	"Tangible, immediate practices, products and services that result from the activities that are undertaken"	IMWG (2014)
Output indicators	Indicators representing the tangible practices, products and services that result from the activities that are undertaken.	Authors elaboration
Positive impacts	"Positive impacts are benefits accruing through the product life cycle that make a positive contribution to the improvement of human well-being, i.e. beneficial impacts (as opposed to negative impacts, which are detrimental). They can be assessed by looking at positive effects experienced by affected stakeholders or through potentially positive proxies, such as positive social performance. An example of this would be the changes made by businesses that result in improvements of social conditions beyond mere minimal compliance conditions."	UNEP (2020)
Social handprint	"The results of changes to business as usual that create positive outcomes or impacts"	UNEP (2020)
Social impact indicators	"Social impact indicators are evidences (…) collected to facilitate concise, comprehensive and balanced judgements about the condition of specific social aspects with respect to a set of values and goals"	Di Cesare et al. (2018)
Stakeholder categories	"The stakeholder categories are at the basis of an S-LCA assessment because they are the items on which the justification of inclusion or exclusion in the scope needs to be provided"	UNEP (2020)
Thematic areas	Thematic areas represent the topics in which the BM can generate impacts in relation to the key dimensions of current well-being presented by the OECD Well-being framework (OECD, 2020) .	Authors elaboration
Well-being	A context- and situation-dependent state, comprising basic material for a good life, freedom and choice, health, good social relations, and security. Wellbeing is at the opposite end of a continuum from poverty, which has been defined as a "pronounced deprivation in well-being."	MEA (2003)

A-C1 Table b: Methodological inputs derived from literature on food business model social impact assessment.

Authors and date	Aim	Method	Main methodological input
(Böckin et al., 2022)	Methodological development for environmental sustainability assessment of BM	LCA	Use of LCT to assess BM; goal and scope definition in 2 phases
(Corvo et al., 2021)	Experimental tool development to assess social impacts of short food supply chains	SIA	Methodological development assessing impacts through the measurement of outcomes, and testing on short food supply chains
(Doernberg et al., 2022)	Sustainability assessment tool for short food supply chains	SIA	Participatory assessment in case study city regions
(Lüdeke-Freund et al., 2017)	Development of a sustainability-oriented Business Models Assessment framework	SUST-BMA	Theoretical background
(Michelini et al., 2020)	Understand impacts from food business models	-	Theory of change approach
(Rauter et al., 2019)	Conceptual framework for sustainable BM impact assessment	-	Methodological steps to be followed to assess sustainability in BM
(Ribeiro et al., 2018)	Holistic sustainability assessment of a food waste prevention BM	LCT and SROI	Sustainability assessment of a food-related BM, combining BMC, LCT and SROI
(Siegerink and Shinwell, 2022)	Methodological framework to assess firms' non-financial performances with respect to human well-being	-	Thematic areas for the development of the assessment framework, to ensure comprehensiveness for the assessment of BM impacts on well-being.



A-C1 Figure d: The Business Model Canvas (Osterwalder and Pigneur, 2010).

A-C1 Table c: FoodE project S-LCA indicators from impact categories to inventory data.

Stakeholder category	**Subsystem**	**Element**	**Data needed**
Workers and producers	Job creation & quality and skills development	Jobs creation	N of jobs created every year
		Contract typology	N of non-fixed term contracts
		Income level	Euros of average gross monthly salary per employee
		Trainings	Hours of training
		Gender Balance	N female waged employees
		Social inclusion	N people belonging to vulnerable categories
Consumers	Food security	Online platform usage	Annual euros of products sold through online platform
		Presence across the CRFS measured via	Annual euros of products sold in the city
		Purchase frequency	N purchses per week
		Average expenditure	Average sale amount
	Food quality	Customers return rate	N of customers per year coming back after the first time
		Tend to increase the total expenditure	N of customers per year increasing their total expenditure after the first time
		Availability of products information	N of certified food products
Local community	Community outreach, education & development	Digital channels for activity dissemination	N of channels
		Frequency of events for local community	N of events per year
		Participation rate	N of people participating per event (average)

		Educational events	N of events specifically targeting education on food system per year
		Volunteering activities in the community	N of activities per year
		Local collaborations	N of collaboration with other local CRFSIs and actors
		Collaborations with activities and projects	N of research activities and projects collaborating with the initiative
	Local economic development	Local selling	Euros of local products sold (bought from other local producers)
		Provenance of employees	N of local employees
Society		Raw materials traceability	N of food labels indicating the origin of products
		Ethical purchases	N of fair-trade certified products

A-C1 Figure b: Map of the area of Bologna including the "Pilastro" district and the case study area of agricultural activity.

A-C1 Figure c: Eta Beta horticultural gardens

A-C1 Figure d: Eta Beta restaurant.

A-C1 Table d: Semi-structured interviews with the Eta Beta staff.

1. What are the main goals of the Eta Beta cooperative and how is Eta Beta working to reach these goals?
2. Which are the main benefits that users are receiving from the Eta Beta activities?
3. Which are the most important aspects for the users' well-being and both personal and professional development?
4. Could you describe the Eta Beta working structure?
5. Which are the main actors involved in the Eta Beta activities?
6. Which are the main customer segments of the Eta Beta business model?
7. What is the value proposition of the Eta Beta business model?
8. Which are the relationships between Eta Beta and its customers?
9. Which are the main channels exploited to deliver value to customers?
10. Which are the main activities performed to create value in the Eta Beta business model?
11. Which are the main resources used to create value in the Eta Beta business model?
12. Which are the main partners of Eta Beta?

A-C1 Table e: Indicators selected from literature on social impact assessment.

Indicator	Reference
Wage and benefits	(Manning and Soon, 2016; Siegerink and Shinwell, 2022)
Employment for vulnerable people	(Corvo et al., 2021)
Gender equal pay	(Corvo et al., 2021)
Skills development for workers	(Manning and Soon, 2016)
Skills development for vulnerable people	(Siegerink and Shinwell, 2022)
Knowledge sharing in local community	(Cirone et al., 2023)
Working hours**Errore. L'origine riferimento non è stata trovata.**	(Falcone et al., 2019; Siegerink and Shinwell, 2022)
Annual leave	(Siegerink and Shinwell, 2022)
Parental leave	(Siegerink and Shinwell, 2022)
Quantity of food produced	(MEA, 2003)
Physical activity	(Wang et al., 2023)
Social relationships	(Siegerink and Shinwell, 2022)

A-C1 Table f: Extensive description of the Eta Beta case study Business Model Canvas.

Key partners:
The Municipality of Bologna plays a key role by assigning the Spazio Battirame for the Eta Beta activities with a 17-years long concession contract, which will be compensated by the restoration works of the whole area (estimated around 600.0000 euros). Furthermore, the Municipality of Bologna contributed to the funding of the restoration of the area through a grant allocated to the cooperative as initiative for social inclusion (Case Zanardi project). The Foundation ENELCUORE also funded part of the work related to the creation and running of the community and social gardens. Eta Beta cooperates with a wide network of local public and private actors. For what concerns activities such as training and job placement for vulnerable adults and minors (migrants, drug addicted in rehabilitation, former prisoners, disabled people, etc.), the main partners are: Bologna municipality (Social services office), San Vitale district; Mental Health dept. of the local health service, migration centres, rehabilitation centres, etc. Eta Beta cooperates with the University of Bologna and in particular the RESCUE AB (Research Centre in Urban Environment for Agriculture and Biodiversity - http://rescue-ab.unibo.it/), which are key actors for the design and development of the garden area, both from technical and social perspective. Among private actors, Eta Beta works with both architects and planners (mainly involved in the restauration and spatial planning of the area), and SMEs, Associations and NGOs for the fundraising and development of specific projects and events.
Key activities:
The main activity focus on the organic production and selling of fruit, vegetables and aromatic herbs in the peri-urban area of Bologna (Spazio Battirame), along with food processing, cooking and serving in the restaurant/catering services. Strategic activities allow to develop the framework for the social inclusion of vulnerable people for professional and interpersonal skills development.
Key resources:
Flows pf physical, human, and intellectual resources are considered as key to the cooperative. Among physical resources, land, buildings, agricultural inputs and machineries, fuel and electricity, water, etc. are identified. Human resources are constituted by the workers, vulnerable users and trainees involved in the main activities (food production, processing, distribution, serving), and the intellectual resource is mainly represented by the trainings for the users.
Value proposition:
Eta Beta project at Spazio Battirame included the revitalisation of an abandoned industrial area in the city of Bologna through innovative actions for social inclusion, health and sustainability including organic agricultural production, food processing and distribution in a short food supply chain. Social inclusion activities for vulnerable people consist in training/job placement and therapeutic/rehabilitative programs for their professional and interpersonal skills development. In all its activities and products Eta Beta promotes ethical values such as zero waste, re-use, health, link with nature and biodiversity. Therefore, Eta Beta offers to the consumers products and services that bear clear ethical and cultural added value.

Customer relationships:
Relation with consumers are either formal (selling of products) and informal (participation in activities and events), and take place through personal relationship with individuals and collaborations with associations, cooperatives, universities.
Channels:
The cooperative sells organic products through direct contact, either on site (both on-farm and in farmer market) and on-line, and to restaurants. Marketing communication is done partly through social media and partly at territorial level trough participation in other initiatives, links with associations and local authorities, etc.
Cost categories:
Being many activities based on self-production and re-use, most of the costs consist in staff wages.
Revenue sources:
The retail of organic vegetable and fruit is the main revenue source of Eta Beta. Eta Beta also earns revenues through the production of handmade jewellery, production of glassware and ceramic art, as well as restoration of antique furniture and woodwork, however these aspects are not included in the current study. 17 people work in the association as employees, 4 of which belong to the category A and 13 are disadvantaged belonging to the category B. No volunteers are involved in the activity of the association. Eta Beta receives support from the local authorities to activate rehabilitation activities in form of training and job inclusion of vulnerable persons in charge of social services.

A-C1 Table g: Inventory of the main data flows.

Element	Unit
Employees	N
Users (people from vulnerable groups)	N
Trainees	N
Wages	€
Working hours per week	h/week
Weeks worked per year	N
Leave days per year	days/year
Fresh food sold	kg
Food processed and sold	kg
Food served	kg
Hours of physical activity per week	h/week
Housing support	€
Components of the worker's family	N
Hours of training received	h/year

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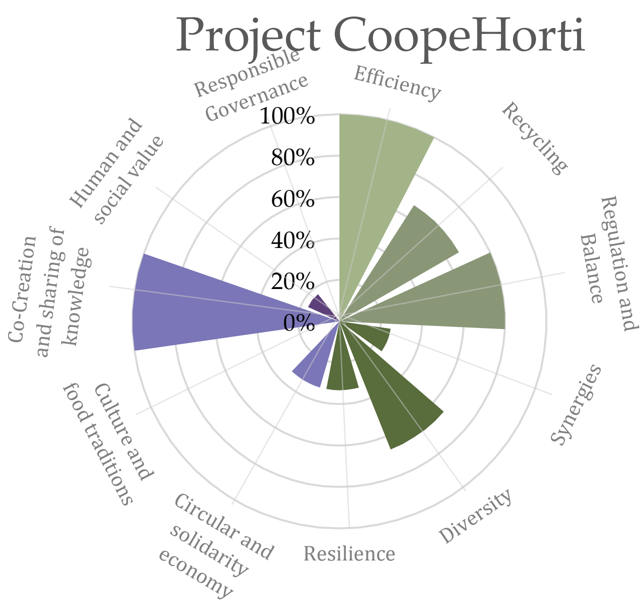
Annex – Chapter 2 (A-C2)

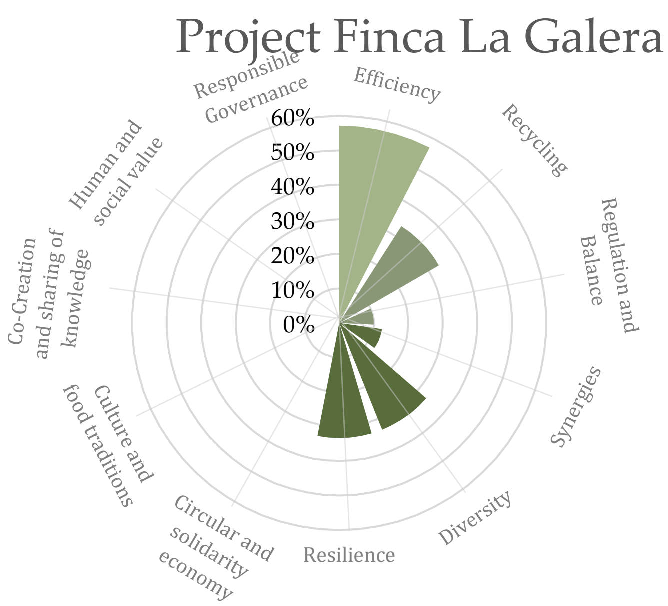
Agroecology Criteria Tool – CoopeHorti analysis

Project name	**Project CoopeHorti**	
Level of transition	**Element of transition**	**Score**
Level 1: Increase efficiency of industrial and conventional practices	**1.1. Efficiency**	**100%**
Level 2: Substitute industrial or conventional inputs with more sustainable alternatives	**2.1. Recycling**	**67%**
	2.2. Regulation and balance	**80%**
Level 3: Redesign whole agro-ecosystems	**3.1. Synergies**	**25%**
	3.2. Diversity	**67%**
	3.3. Resilience	**33%**
Level 4: Re-establish connections between growers and eaters, develop alternative food networks	**4.1. Circular and solidarity economy**	**33%**
	4.2. Culture and food traditions	**0%**
	4.3. Co-Creation and sharing of knowledge	**100%**
Level 5: Rebuild the global food system so that it is sustainable and equitable for all	**5.1. Human and social value**	**17%**
	5.2. Responsible governance	**0%**



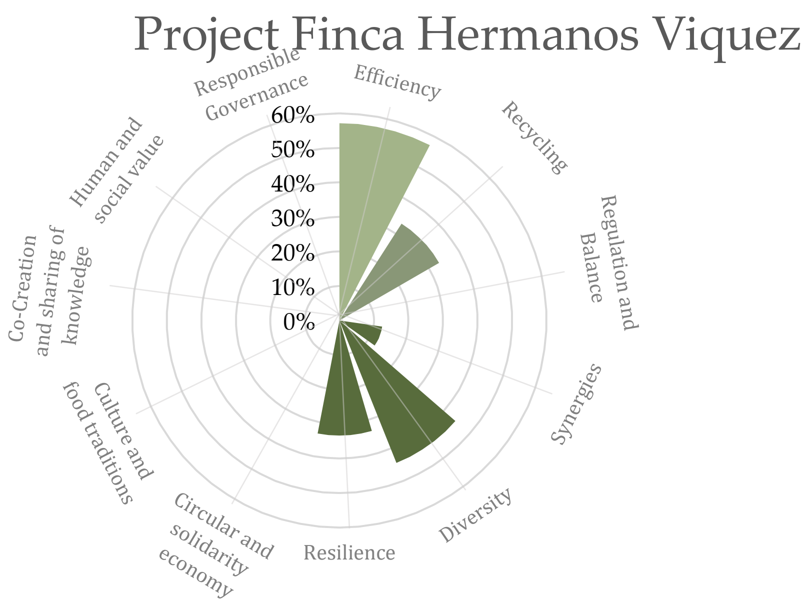
Agroecology Criteria Tool – Finca La Galera analysis

Project name	Project Finca La Galera	
Level of transition	Element of transition	Score
Level 1: Increase efficiency of industrial and conventional practices	1.1. Efficiency	57%
Level 2: Substitute industrial or conventional inputs with more sustainable alternatives	2.1. Recycling	33%
	2.2. Regulation and balance	10%
Level 3: Redesign whole agro-ecosystems	3.1. Synergies	13%
	3.2. Diversity	33%
	3.3. Resilience	33%
Level 4: Re-establish connections between growers and eaters, develop alternative food networks	4.1. Circular and solidarity economy	0%
	4.2. Culture and food traditions	0%
	4.3. Co-Creation and sharing of knowledge	0%
Level 5: Rebuild the global food system so that it is sustainable and equitable for all	5.1. Human and social value	0%
	5.2. Responsible governance	0%



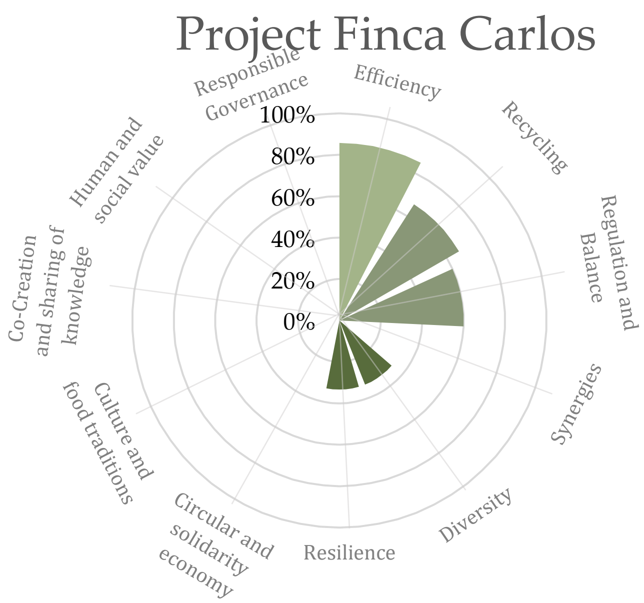
Agroecology Criteria Tool – **Finca Hermanos Viquez** analysis

Project name	**Project Finca Hermanos Viquez**	
Level of transition	**Element of transition**	**Score**
Level 1: Increase efficiency of industrial and conventional practices	**1.1. Efficiency**	**57%**
Level 2: Substitute industrial or conventional inputs with more sustainable alternatives	**2.1. Recycling**	**33%**
	2.2. Regulation and balance	**0%**
Level 3: Redesign whole agro-ecosystems	**3.1. Synergies**	**13%**
	3.2. Diversity	**44%**
	3.3. Resilience	**33%**
Level 4: Re-establish connections between growers and eaters, develop alternative food networks	**4.1. Circular and solidarity economy**	**0%**
	4.2. Culture and food traditions	**0%**
	4.3. Co-Creation and sharing of knowledge	**0%**
Level 5: Rebuild the global food system so that it is sustainable and equitable for all	**5.1. Human and social value**	**0%**
	5.2. Responsible governance	**0%**



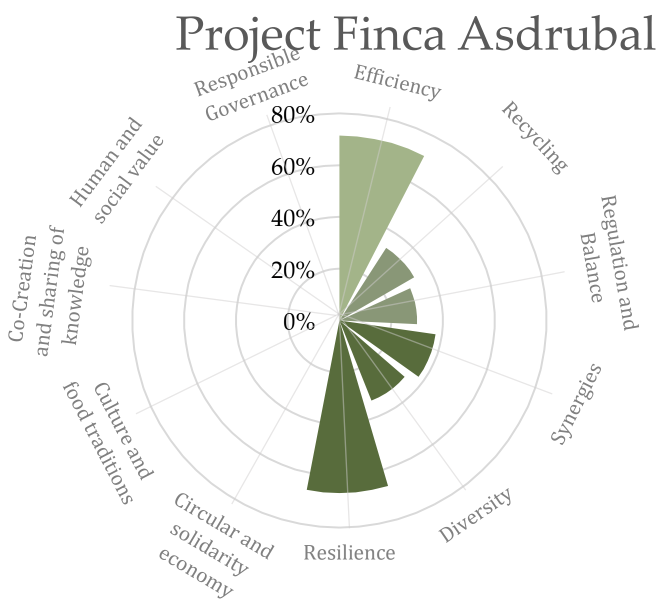
Agroecology Criteria Tool – **Finca Carlos analysis**

Project name	**Project Finca Carlos**	
Level of transition	**Element of transition**	**Score**
Level 1: Increase efficiency of industrial and conventional practices	**1.1. Efficiency**	**86%**
Level 2: Substitute industrial or conventional inputs with more sustainable alternatives	**2.1. Recycling**	**67%**
	2.2. Regulation and balance	**60%**
Level 3: Redesign whole agro-ecosystems	**3.1. Synergies**	**0%**
	3.2. Diversity	**33%**
	3.3. Resilience	**33%**
Level 4: Re-establish connections between growers and eaters, develop alternative food networks	**4.1. Circular and solidarity economy**	**0%**
	4.2. Culture and food traditions	**0%**
	4.3. Co-Creation and sharing of knowledge	**0%**
Level 5: Rebuild the global food system so that it is sustainable and equitable for all	**5.1. Human and social value**	**0%**
	5.2. Responsible governance	**0%**



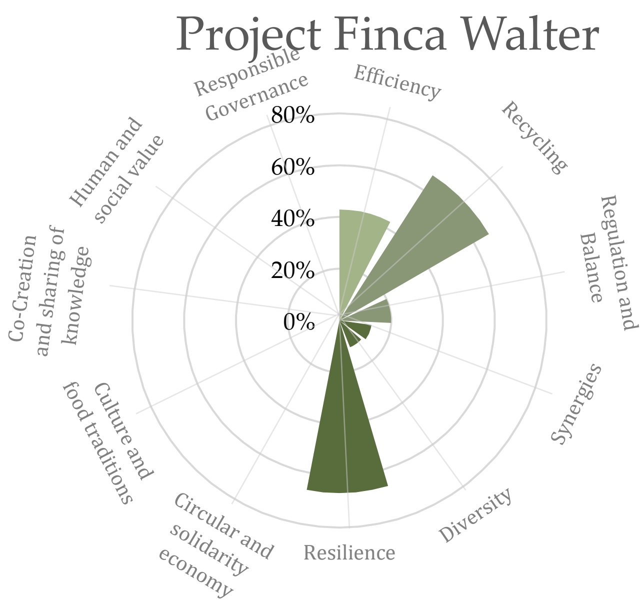
Agroecology Criteria Tool – Finca Asdrubal analysis

Project name	Project Finca Asdrubal	
Level of transition	Element of transition	Score
Level 1: Increase efficiency of industrial and conventional practices	1.1. Efficiency	71%
Level 2: Substitute industrial or conventional inputs with more sustainable alternatives	2.1. Recycling	33%
	2.2. Regulation and balance	30%
Level 3: Redesign whole agro-ecosystems	3.1. Synergies	38%
	3.2. Diversity	33%
	3.3. Resilience	67%
Level 4: Re-establish connections between growers and eaters, develop alternative food networks	4.1. Circular and solidarity economy	0%
	4.2. Culture and food traditions	0%
	4.3. Co-Creation and sharing of knowledge	0%
Level 5: Rebuild the global food system so that it is sustainable and equitable for all	5.1. Human and social value	0%
	5.2. Responsible governance	0%



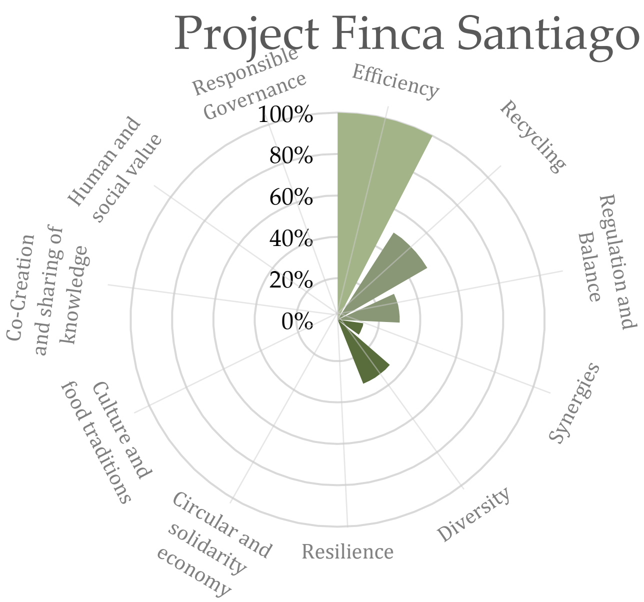
Agroecology Criteria Tool – Finca Walter analysis

Project name	Project Finca Walter	
Level of transition	**Element of transition**	**Score**
Level 1: Increase efficiency of industrial and conventional practices	1.1. Efficiency	43%
Level 2: Substitute industrial or conventional inputs with more sustainable alternatives	2.1. Recycling	67%
	2.2. Regulation and balance	20%
Level 3: Redesign whole agro-ecosystems	3.1. Synergies	13%
	3.2. Diversity	11%
	3.3. Resilience	67%
Level 4: Re-establish connections between growers and eaters, develop alternative food networks	4.1. Circular and solidarity economy	0%
	4.2. Culture and food traditions	0%
	4.3. Co-Creation and sharing of knowledge	0%
Level 5: Rebuild the global food system so that it is sustainable and equitable for all	5.1. Human and social value	0%
	5.2. Responsible governance	0%



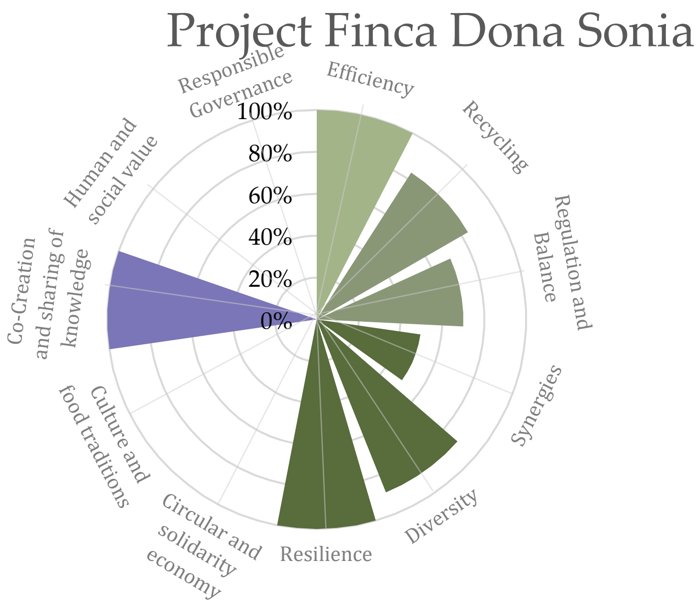
Agroecology Criteria Tool – Finca Santiago analysis

Project name	Project Finca Santiago	
Level of transition	**Element of transition**	**Score**
Level 1: Increase efficiency of industrial and conventional practices	**1.1. Efficiency**	**100%**
Level 2: Substitute industrial or conventional inputs with more sustainable alternatives	**2.1. Recycling**	**50%**
	2.2. Regulation and balance	**30%**
Level 3: Redesign whole agro-ecosystems	**3.1. Synergies**	**13%**
	3.2. Diversity	**33%**
	3.3. Resilience	**0%**
Level 4: Re-establish connections between growers and eaters, develop alternative food networks	**4.1. Circular and solidarity economy**	**0%**
	4.2. Culture and food traditions	**0%**
	4.3. Co-Creation and sharing of knowledge	**0%**
Level 5: Rebuild the global food system so that it is sustainable and equitable for all	**5.1. Human and social value**	**0%**
	5.2. Responsible governance	**0%**



Agroecology Criteria Tool – Finca Sonia analysis

Project name	Project Finca Dona Sonia	
Level of transition	Element of transition	Score
Level 1: Increase efficiency of industrial and conventional practices	1.1. Efficiency	100%
Level 2: Substitute industrial or conventional inputs with more sustainable alternatives	2.1. Recycling	83%
	2.2. Regulation and balance	70%
Level 3: Redesign whole agro-ecosystems	3.1. Synergies	50%
	3.2. Diversity	89%
	3.3. Resilience	100%
Level 4: Re-establish connections between growers and eaters, develop alternative food networks	4.1. Circular and solidarity economy	0%
	4.2. Culture and food traditions	0%
	4.3. Co-Creation and sharing of knowledge	100%
Level 5: Rebuild the global food system so that it is sustainable and equitable for all	5.1. Human and social value	0%
	5.2. Responsible governance	0%



Annex – Chapter 3 (A-C3)

1. Survey full text available at this link: https://forms.office.com/r/VQMteuGabp

QR code: 

2. **Experts consultation**

Questions and clarifications

Objective: SEM results validation to determine relationships among different variables, behaviour and well-being

Preguntas y aclaraciones por parte del equipo Academia:

1. Clarifications: model explications
2. In which elements should we ground our results?
3. Is farmers' decision-making constrained only to profitability? How do farmers consider their decision on a temporal basis (short term-profitability vs long term-sustainability)
4. Clarifications: explications on what sustainability refers to within the survey
5. When referring to well-being, what do farmers think about this concept?
6. On the negative relationship between educational level (of the farmer) and adoption of SAP: Is the farmers' perception connected to cultural aspects rather than educational level? How do you perceive it? What are the farmers missing to understand the actual outcomes of SAP? Can it be associated to higher expectations of farmers with higher educational degree?
7. Do you think that farmers with higher educational levels consider the trainings less attractive than the majority of farmers?
8. Is there any relevant issue related to the gender dimension in the coffee production sector to be highlighted? Is there any difference relatively to the adoption of SAP? Which are the main challenges related to gender?
9. Clarifications: coffee as a development means for the country (historical national context)
10. Clarifications: positive relationship between land ownership and adoption of SAP.