# FoodE

# D2.4

# Data inventory



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

| | |
|---|---|
| **Project Acronym and Name** | FoodE – Food Systems in European Cities |
| **Type of action** | IA – Innovation Action |
| **Grant Agreement No.** | 862663 |
| **Work package** | WP2 Methodological framework development and case studies sustainability assessment |
| **Dissemination level** | Public |
| **Document type** | Report |
| **Lead partner** | WR |
| **Authors** | Luuk Graamans, Martí Rufí-Salís, Mara Petruzzelli, Fabio De Menna, Francesco Cirone, Matteo Vittuari Antonella Samoggia, Kathrin Specht, Runrid Fox-Kämper, Agnès Lelièvre, Vèronique Saint-Ges, Josè Pascual-Fernández, Ilaria Braschi, Xavier Gabarrell Durany, Francesca Monticone |
| **Contributors** | Isabella Righini, Alexander van Tuyll, Emanuele Durante, Giuseppina Pennisi, Elisa Apolloni, Enrico Buscaroli, Ilaria Zauli, Laura Carotti, Ivan Paucek, Stefania Quaini, Giorgio Gianquinto, Nicola Michelon, Alberto Minelli, Giovanni Bazzocchi, Esther Sanyé-Mengual, Farhad Zulfiqar, Parada Felipe, Arcas-Pilz Veronica, Petit-Boix Anna, Villalba Gara, Paola Clerino |
| **Planned delivery date** | 31/01/2022 |
| **Actual delivery date** | 14/02/2022 |
| **Project website** | FoodE |
| **Project start date** | 01/02/2020 |
| **Duration** | 48 months |
| **Version** | 3 |

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 862663. The contents reflect the author's views. The Research Executive Agency (REA) is not liable for any use that may be made of the information contained therein.



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

# Project consortium

| No. | Institution Short name | Institution Full name | Country |
|---|---|---|---|
| 1 | UNIBO | ALMA MATER STUDIORUM – UNIVERSITÀ DI BOLOGNA | IT |
| 2 | APT<br><br>INRAE | INSTITUT DES SCIENCES ET INDUSTRIES DU VIVANT ET DE L'ENVIRONNEMENT - AGRO PARIS TECH<br>INSTITUT NATIONAL DE RECHERCE POUR L'AGRICULTURE, L'ALIMENTATION ET L'ENVIRONNEMENT | FR |
| 3 | RMN | COMMUNE DE ROMAINVILLE | FR |
| 4 | SWUAS | FACHHOCHSCHULE SUDWESTFALEN | DE |
| 5 | ILS | INSTITUT FUR LANDES- UND STADTENTWICKLUNGSFORSCHUNG gGMBH | DE |
| 6 | FLY | FLYTECH SRL | IT |
| 7 | NOL | NOLDE ERWIN | DE |
| 8 | BOL | COMUNE DI BOLOGNA | IT |
| 9 | NAP | COMUNE DI NAPOLI | IT |
| 10 | UNINA | UNIVERSITA DEGLI STUDI DI NAPOLI FEDERICO II | IT |
| 11 | HCA | HAGUE CORPORATE AFFAIRS BV | NL |
| 12 | LAN | GEMEENTE LANSINGERLAND | NL |
| 14 | WR | STICHTING WAGENINGEN RESEARCH | NL |
| 16 | POL | POLAR PERMACULTURE SOLUTIONS AS | NO |
| 17 | TAS | TASEN MICROGREENS AS | NO |
| 18 | MBI | ASOCIATIA MAI BINE | RO |
| 19 | ARC | ARCTUR RACUNALNISKI INZENIRING DOO | SI |
| 20 | BEE | DRUSTVO URBANI CEBELAR | SI |
| 21 | SBD | AJUNTAMENT DE SABADELL | ES |
| 22 | ISL | ORGANIZACION DE PRODUCTORES DE TUNIDOS Y PESCA FRESCA DE LA ISTA DE TENERIFE | ES |
| 23 | ULL | UNIVERSIDAD DE LA LAGUNA | ES |
| 24 | UAB | UNIVERSITAT AUTONOMA DE BARCELONA | ES |
| 25 | METAINST | STICHTING METABOLIC INSTITUTE | NL |
| 26 | NBL AS | NABOLAGSHAGER AS | NO |

# Document Control Sheet

| Version | Date | Summary of changes | Author(s) |
|---|---|---|---|
| 3 | February 2022 | Final | WR |
| 2 | January 2022 | Second draft | WR |
| 1 | November 2021 | First draft reviewed by WP2 and task leaders | WR |



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

# Table of contents





This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

## List of Tables



## List of Figures





This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

## List of Appendices





This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

# Glossary

| | |
|---|---|
| App | Application |
| CRFS | City Region Food System |
| CRFSI | City Region Food System Initiatives |
| D | Deliverables |
| KPI | Key Performance Indicator |
| LCA | Life Cycle Assessment |
| LCC | Life Cycle Costing |
| LCT | Life Cycle Thinking |
| E-LCC | Environmental Life Cycle Costing |
| S-LCC | Societal Life Cycle Costing |
| ST | SubTask |
| Task | T |
| WP | Work package |



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

# 1. Executive Summary

The current deliverable describes the developments and outputs of the FoodE (Food Systems in European Cities) European research project Task 2.3.

FoodE, funded by the Horizon 2020, was launched in 2020 and will last for 4 years. The consortium involves 24 partners from 8 European countries (France, Germany, Italy, Netherlands, Norway, Romania, Slovenia and Spain) and aims at accelerating the growth of citizen-led food system initiatives and creating related innovative and inclusive job opportunities at local level.

In this context, Task 2.3 collected, processed and analysed data from the City Region Food System (CRFS) and the different initiatives (CRFSI) across Europe, across scales and across industries. The data analysis allowed for a preliminary integrated sustainability assessment of the initiatives. To this end, the analysis adopts a life cycle thinking (LCT) approach, including the social, economic, and environmental pillars, and it consists of two main layers of assessment:

- an initial assessment, featuring a quali-quantitative perspective and limited data requirements, which was circulated to 600+ CRFSI. This assessment was used to generate an overview of the European CRFSI and serves as a basis for a synthetic and rapid appraisal of generic hotspots of impact;
- an extensive assessment, with a quantitative approach and increased data requirements, which was circulated to 100+ CRFSI. This assessment provided extensive quantitative data for life cycle assessments and a greater insight into the impacts of specific methodological choices across disciplines.

The presented data inventory (D2.4) will support the detailed evaluation and ranking of the sustainability performance of diverse operational CRFS initiatives at local and international level.



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

# 2. Background

## 2.1 Project objective: FoodE – Food Systems in European Cities

The main objective of FoodE is to involve European Union local initiatives in the design, implementation, and monitoring of environmentally, economically, and socially sustainable CRFS. The key challenge of the project is to improve food and nutrition security of European citizens by shaping a sustainable network, able to increase accessibility and availability of affordable, safe, and nutritious food. This challenge will be tackled by setting a co-created mechanism, based on Citizen Science and Responsible Research & Innovation principles, where public authorities, citizens, SMEs, and non-profit organisations can share ideas, tools, best practices, and new models, supporting cities and regions in developing innovative and sustainable food systems.

## 2.2 Work package objective: WP2

Considering and integrating all the recent advancements on sustainability assessment of CRFS, this WP aims at developing a methodological framework and an analytical decision support tool for the development of innovative business models and initiatives to enhance CRFS. More specifically, the WP2 roadmap (Figure 2) foresees to:

- Create an inventory of innovative and sustainable CRFS projects.
- Identify the sustainable and accessible KPI of the CRFSI and their replication
- Develop an integrated methodology for the interpretation and analysis of innovative business models and their suitability to apply in specific contexts.
- Apply, validate and refine the integrated methodology on case studies, including a sustainability assessment, also integrating revisions proposed by stakeholders during cross-pollination (WP3).
- Develop business case reports and carry out comparative analyses to identify barriers and key drivers of change.
- Develop an analytical decision support tool, based on the FoodE integrated methodology, to support decision-making of innovative business models and improve their performances and sustainability.



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663**.**


Figure 1 – Roadmap WP2

## 2.3 Task objective: T2.3

An LCT approach was adopted to assess both environmental (e.g.: carbon footprint, land use, etc.), economic (costs, net present value, value added, etc.), and social (labour, health, vitality of regions, innovation, etc.) impacts, in a cradle (biomass supply) to grave (final use) to cradle (re-use / recycle) perspective. This task aimed to collect information according to the methodological framework and the data collection protocol (T2.2). Primary data on technical, environmental, economic, and social aspects were collected. Data gaps were identified, and additional information was gathered through secondary data analysis. The data inventory (D2.4) includes data on material flows (products and valuable by-products yielded by the processes), inputs (materials, energy and costs), outputs (emissions, waste, health and other social indicators).

*Subtasks*

T2.3.1 - Food quality sampling and analyses
T2.3.2 - Growing systems
T2.3.3 - Social impacts
T2.3.4 - Consumer preferences and market potential
T2.3.5 - Life cycle inventory and economic aspects

Literature reviews in specific areas of CRFS conducted in T2.3.1-T2.3.4 were conducted to complement the primary data collected within the survey dissemination.

## 2.4 Deliverable objectives: D2.4 and D2.5

The integrated assessment framework is composed of two items collecting and processing the data from CRFSI and assessing their sustainability:

- **Data inventory (D2.4)**

  This deliverable focuses on presenting the primary data on social, environmental, technical, and economic aspects, including information on business structure, income



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

streams, costs, material flows, energy, emissions, waste production, organised activities, health, et cetera. For this inventory coherent and useful information was retrieved from the various CRFSI using the data collection protocol (D2.3). Data was collected in an exploratory and detailed survey for both the simplified and the extensive assessment of each CRFSI. To this end, standardised data was retrieved at an adequate level of detail for each assessment.

- **Life cycle assessment, life cycle costing and social LCA of 100+ CRFSI (D2.5)**

  This deliverable focuses on presenting the primary and secondary data integrated with economic information and describing the life cycle inventories that will constitute the basis for the assessment of case studies. This will form the basis for a comprehensive LCT study. The process follows the system boundaries defined in the framework (D2.2) to enable a comparative evaluation, standardise the data to be collected for the assessment, and select the appropriate indicators.

These two deliverables are linked but differ in the level of detail and level of processing required. Together they provide an overview of the sustainability of the CRFSI.

## 2.5 Linkages with other tasks in WP2

Synergies and/or potential risks of duplication/overlapping with other WP2 activities have been explored and discussed. The methodological framework development has two major collaboration hotspots:

- **Data collection and inventory (T2.2)**

  The assessment framework, methodology and data collection protocol were specified in T2.2. This was conducted in parallel with T2.3 to ensure adequate collaboration, correct timing and consistent participatory reviews. This collaborative approach ensured a recurrent and iterative dialogue as well as appropriate knowledge sharing.

- **Assessment of pilots and identification of best performances (T2.4)**

  Building on the data collection (D2.4) and a preliminary life cycle assessment of 100+ CRFS (D2.5), a complete LCT analysis is conducted on the FoodE pilots. The codesign and participatory approach described here is aimed at delivering sustainability assessments with an effective impact on pilots' decision-making and continuous improvement.

## 2.6 Linkages with other tasks in other WPs

The present contribution aimed to provide outputs to and receive inputs from several FoodE WPs. Linkages mostly refer to three areas:

- **WP3 – Cross pollination**

  The development of a framework of initiatives to foster **networking of CRFS stakeholders** (WP3). This step will develop (T3.2.2) and update (T3.2.3) the FoodE app, one of the major outcomes of the project. Apart from the mobile app aimed at improving the interaction between CRFS and citizens, a web app will be created to facilitate the data



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

introduction by the CRFSI owners. This data will be also used as basis of the calculations for the sustainability assessment of CRFSI. During the first stages of the app development, the link with WP2 will strictly be in terms of data collection and inventory processing (T2.3) to gain insight on the best way to proceed. Moreover, at later stages of project, the app will be one of the major tools to collect data from the CRFSI. Based on this data filled by CRFSI owners through the back-office web, key indicators identified in T2.2-T2.5 will be integrated in the app.

- **WP4 – Pilot implementation**

  The international challenge for the **co-design of innovative CRFS pilots** (on both established and newly implemented projects) (WP4) will use the data collected and presented in this report as a foundation. The FoodE Challenge (T4.1) in particular was developed on the same methodological framework and data collection protocol and therefore serves as a prime case for comparison.

- **WP5 – Business and validation of CRFS**

  The **business models and validation of CRFS** (WP5) will use the same methodology for the CRFSI assessment (D2.2) as a foundation for selecting relevant sustainability indicators. The data analysis on specific environmental, social and economic sustainability (D2.4-2.5) will be integrated within the business models of CRFSI to allow a greater understanding of their sustainability impacts. This integration will allow the development of BMs in line with the LCT methodology. Furthermore, activities of sustainability assessment in existing pilots (WP2) will allow for compiling the simplified dataset of indicators suitable for the online survey tool (T5.3) and certification standard (T5.4) and will also guide the elaboration of upscaling policies and tools in WP6.



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

# 3. Methodology

## 3.1 Methodology for data collection

### 3.1.1 Framework

The methodological framework for data collection has been explicated in D2.2 and D2.3 and supports the evaluation and ranking of the sustainability and Life Cycle of diverse existing CRFSI. In short, the framework adopts a Life Cycle Thinking (LCT) approach, integrating the social, economic, and environmental pillars. Additionally, it operationalizes the CRFS from a system to individual initiatives (CRFSI) within the system (i.e. integrated local supply chain with multiple services). The framework consists of two main layers of assessment: A simplified method (quali-quantitative) and an extensive method (quantitative). This document focuses on the data collection required for the simplified method.

Data is organised using the three pillars of sustainability: social impact (e.g., labour, health, innovation, etc.); economic impact (e.g., costs, net present value, value added, etc.); environmental impact (e.g., carbon footprint, land use, transport, etc.). Key Performance Indicators (KPIs) and specific indicators were formulated in D2.2 to translate the complexity of sustainability to clear and more manageable metrics.

### 3.1.2 Data collection protocol

Data collection was conducted in two individual surveys and this process is detailed in D2.3, the Data Collection Protocol (DCP). In short, the DCP is the operational interpretation of the framework described in Section 3.1.1 and shares the integrated Life Cycle Thinking (LCT) approach, the focus on CRFSI, and two levels of protocol: a simplified and an extensive one. The simplified DCP that was used for this document describes the process related to two surveys for the collection of quali-quantitative information on CRFSI and their subsequent sustainability scoring. The KPIs from D2.2 were translated to targeted questions. The data collection used two surveys that capture these targeted questions. The surveys collected data on innovative CRFS projects and initiatives all over Europe by means of an online survey. The first survey (DCP600+) was circulated to the set of 800+ CRFSI outlined in D2.1 and provided the initial overview of around **260** CRFSI, and the second survey (DCP100+) was circulated to all CRFSI and provided an initial assessment of **100** CRFSI. In the first case, questions addressed personal information, the type, main activities, size of the initiative, its relations to other key partners, its impact and the impact of the COVID-19 crisis. In the second case, questions were related to the sustainability of the CRFSI. The surveys utilised a range of response types including Likert scales, numerical information, predetermined choice options, binary options etc.

## 3.2 Additional processing of data

Qualitative data were analysed, categorised and standardised. All answers from initiatives were translated to points on the Likert scale (1-5 points), in accordance with the methodological framework (Deliverable 2.2, Section 4). For each question the highest score (5) was assigned to the most sustainable option, while the lowest score (1) was assigned to the least sustainable option.

The data format followed the type of data collected. Quantitative as well as qualitative data was collected and secondary data were used. The numerical or textual data were formatted as comma-separated values using Microsoft office. Additional processing of the data for statistical analysis also required comma-separated values using the software R-Studio. This document



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

presents an overview of the collected data. Further processing, interpretation and scoring of data is presented in D2.5.

## 3.3 Methodology of literature reviews

## 3.3.1 General methodology for literature reviews

### 3.3.1.1 Introduction

A critical literature review was carried out to integrate existing knowledge and projects in the field of CRFS, particularly in the following fields:

- Food quality sampling and analysis;
- Growing systems;
- Social impacts; and
- Economic impacts[1].

The main goal of this review was to identify **indicators** and **metrics** for measuring the sustainability impacts of CRFS. Scientific databases (Scopus and Web of Science) were used to derive an overview of current knowledge, possible indicators, assessment methods, etc. Only those papers that report on an empirical analysis of impacts and that use clear metrics were included in the final analyses.

### 3.3.1.2 The PRISMA method

The objectives of this review are the identification of the state of the art on key social, economic, and environmental aspects to be addressed when analysing CRFS. The literature reviews were based on the PRISMA method (Preferred Reporting Items for Systematic reviews and Meta-Analyses). The PRISMA method aims to help authors in improving the reporting of systematic reviews and meta-analyses on a specific topic[2]. The researchers relied on Web of Science and Scopus for the search:

- 2020-2010, Web of Science
- 2020-2010, Scopus

The PRISMA method was selected following its academic track record, clarity and usefulness. The documentation contains an example of good reporting, a rationale for its inclusion, and supporting evidence, including references, whenever possible. Furthermore, like any evidence-based endeavor, PRISMA is a living document which uses reader feedback to ensure PRISMA's continued development and relevance.

### 3.3.1.3 Setup of literature review

A first list of keywords was proposed by the research group leader of each sub-task, which was tested in sub-groups and complemented by the research teams in an iterative process. During

[1] The literature reviews on the economic and social impacts of CRFS were combined into a single study on socio-economic impacts (Section 3.3.4).

[2] Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Prisma Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS medicine*, *6*(7), e1000097.



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

this extensive pre-testing phase, the keywords and data collection protocol was adjusted and finalized.

The keywords typically crossed a list of different CRFS types with different factors pertaining to the specific scientific topic. If specific keywords turned out to lead to zero results during the pre-test phase, they were excluded from the search. If a combination resulted in an excessive number of results, an additional search string was applied to break down the records.

#### 3.3.1.4 Data processing

Only those papers that report on the analysis of specific impacts and that use clear metrics were included in the final analysis. Basic data on the searched papers and information on indicators and metrics were added into an excel table. Information was entered into the spreadsheet specifying the publication year, first authors name, doi number, database from which the paper was retrieved, country under investigation, indicators and metrics identified.

As a general rule, the research members divided the keywords within the team, so that the teams conducted the entire process from the first database entry until the final content analysis. In certain exceptions a first team conducted the first screening and collected the papers for analysis, while a second team analysed the papers.

#### 3.3.1.5 Additional literature reviews

Additional literature reviews were carried out in the FoodE project on the topics of multifunctional urban agriculture, production technologies and resource use. These reviews were not conducted within T2.3 and did not follow the same methodology, nor were they specifically aimed at providing KPIs for the simplified and extensive sustainability assessment of CRFSI. However, the reviews could provide additional insights into CRFS and were therefore partially included in the Appendices (Appendix A1-A6).

### 3.3.2 Specific methodology for food quality sampling and analyses

An analysis of various methods for food quality sampling and analysis is required to reach the main goals of the WP2. UniBO organised a literature review on key aspects of food quality sampling to be addressed when food products in CRFS. As a result, the authors produced:

- **a review of the potential food safety risks of CRFS; and**
- **a list of indicators and metrics to measure the food safety risks in CRFS food products.**

#### 3.3.2.1 Data collection

The data was collected by researchers from the FoodE team including researchers from UniBO, NAP, APT, WR and ILS. The participating researchers worked together as search terms and results were organized along nine main categories:

1. Foodborne pathogens and microorganisms
2. PTEs and heavy metals
3. Pesticides residues
4. Nitrate and nitrite
5. Microfauna and pluricellular parasites
6. POPs



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

7. Xenobiotics (organic compounds) and pharmaceuticals
8. Toxins
9. Hazardous materials

The members divided the keywords within the team and conducted the search process. The final content analysis was divided based on: 1) search engine (i.e., Scopus and Web of Science) and 2) time periods (I.e., before 2000, from 2000 to 2010, and from 2010 to 2020).

#### 3.3.2.2 Keywords used

The keywords search crossed a list of contexts (x) with different types of assessment (y).

Table 1 – Keywords for literature review on food quality and safety

| **X** | **CONTEXT** | **Y** | **ASSESSMENT** |
|---|---|---|---|
| **X01** | City region food systems | **Y01** | Food quality |
| **X02** | CRFS | **Y02** | Food safety |
| **X03** | Hydroponics | **Y03** | Pesticides |
| **X04** | Soilless system | **Y04** | Plant protection products |
| **X05** | Roof garden | **Y05** | PPP |
| **X06** | Aquaponics | **Y06** | Pesticide residues |
| **X07** | Food production | **Y07** | Heavy metals |
| **X08** | Rooftop greenhouse | **Y08** | Potentially toxic elements |
| **X09** | Controlled environment | **Y09** | PTE |
| **X10** | Indoor farming | **Y10** | Dioxins |
| **X11** | Urban farming | **Y11** | Dibenzofurans |
| **X12** | Leafy vegetables | **Y12** | Polychlorobiphenyls |
| **X13** | Fresh produce | **Y13** | PCB |
| **X14** | Hydroponic produce | **Y14** | Nitrates |
| **X15** | Nutrient film technique | **Y15** | *E. coli* |
| **X16** | NFT | **Y16** | *E. coli 0157:H7* |
| **X17** | Recirculating nutrient solution | **Y17** | Salmonella |



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

| | | | |
|---|---|---|---|
| **X18** | Recirculating aquaponic system | **Y18** | Listeria |
| **X19** | Irrigation water | **Y19** | Coliforms |
| **X20** | Urban soil | **Y20** | Foodborne illness |
| **X21** | Rural soil | **Y21** | Human health |
| **X22** | Zero km food | **Y22** | Community health |
| **X23** | Urban horticulture | **Y23** | Health risk evaluation |
| **X24** | Urban agriculture | **Y24** | Quantitative microbial risk assessment |
| **X25** | Vertical farming | **Y25** | QMRA |
| | | **Y26** | Ultraviolet treatment |
| | | **Y27** | Water disinfection treatment |
| | | **Y28** | Good agricultural practices |
| | | **Y29** | Gap |
| | | **Y30** | Agricultural practices |
| | | **Y31** | Polycyclic aromatic hydrocarbons |
| | | **Y32** | PAH |
| | | **Y33** | Persistent organic pollutants |
| | | **Y34** | POP |
| | | **Y35** | Postharvest handling |
| | | **Y36** | Processing practices |
| | | **Y37** | Consumer handling |
| | | **Y38** | Washing and sanitizing |
| | | **Y39** | Risk management |
| | | **Y40** | Risk assessment |
| | | **Y41** | Benefits in nutrition |
| | | **Y42** | Nutrient |
| | | **Y43** | Additives |



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

| | | | |
|---|---|---|---|
| | | **Y44** | Fortica* OR biofortifica* |
| | | **Y45** | Anti-nutrients |
| | | **Y46** | Food chain |
| | | **Y47** | Food composition |
| | | **Y48** | Government food standards |
| | | **Y49** | Bioactive non-nutrients |
| | | **Y50** | Food contaminants |
| | | **Y51** | Shelf-life |
| | | **Y52** | Nutraceuticals |
| | | **Y53** | Microplastics |
| | | **Y54** | Plastics |

#### 3.3.2.3 Data storage

The selected papers were indexed and stored in a joint online literature database hosted on Mendeley. The selected papers were also included in an excel table, named as “FoodE indicators summary_200714”.



This project has received funding from the European Union’s *Horizon 2020 research and innovation programme* under grant agreement No 862663.

#### 3.3.2.4 Data collection and processing: PRISMA

Table 2 – PRISMA documentation for literature review on food quality and safety, classification of papers on hazard treated.

| | **Papers identified** | **Duplicates elimination** | **Title and keyword screening** | **Abstract screening** | **Full text screening** | **Mendeley storage** |
|---|---|---|---|---|---|---|
| *Hazard class* | *Records identified through database searching ** | *Number of papers with full text available after duplicates removed** | *Records after title and keyword screening for excluding obvious errors** | *Records after abstract screening. Empirical research promising indicators* | *Records after full text check for indicators and metrics informing the result table* | *Number of papers with full text available stored in Mendeley* |
| **Foodborne pathogens** | NA | NA | NA | 102 | 102 | 102 |
| **PTEs and Heavy metals** | NA | NA | NA | 62 | 62 | 62 |
| **PPP residues** | NA | NA | NA | 23 | 23 | 23 |
| **Nitrate & nitrite** | NA | NA | NA | 29 | 29 | 29 |
| **Microfauna & parasites** | NA | NA | NA | 9 | 9 | 9 |
| **POPs** | NA | NA | NA | 11 | 11 | 11 |
| **Xenobiotics & pharmaceuticals** | NA | NA | NA | 5 | 5 | 5 |
| **Toxins** | NA | NA | NA | 2 | 2 | 2 |
| **Hazardous materials** | NA | NA | NA | 1 | 1 | 1 |
| **Total** | >120.000 | 895 | 665 | **217 | **217 | **217 |
| **Total after data cleaning** (merging of duplicates across groups; removal of non-peer-reviewed papers; removal of non-empirical papers) | | | | | | 217 |

NA = Not available.

* Classification was not performed at this level as it was not deemed necessary.

** Several papers discussed multiple hazards in the same paper. Therefore, the sum of class frequency is higher than the total number of papers selected.



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

### Analysed risk assessments among selected papers

In many cases, as multiple hazard classes are being dealt in the same paper, the statistics reported below is based on the total number of risk assessments performed within the 217 selected papers.

- **Foodborne pathogens and microorganisms:** 201 (50%)
- **Heavy metals and PTEs:** 84 (21%)
- **PPP residues:** 27 (6.8%)
- **Nitrate and nitrite:** 38 (9.**5%**)
- **Microfauna and pluricellular parasites:** 17 (4.3%)
- **POPs:** 17 (4.3%)
- **Xenobiotics and pharmaceuticals:** 12 (3%)
- **Toxins:** 2 (0.5%)
- **Hazardous materials:** 1 (0.3%)
- **Total number of papers selected:** 217
- **TOTAL number of assessments performed within the selected papers**: **399**

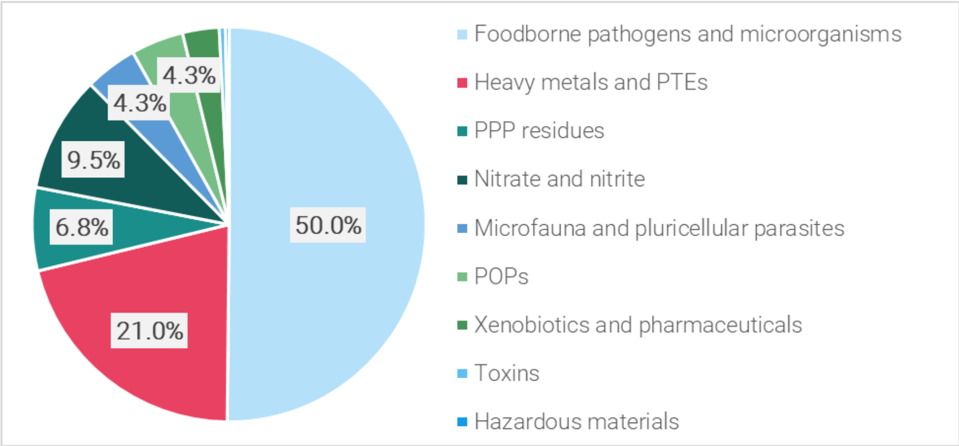



*Figure 2 –Food safety: spread of assessments per topic*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

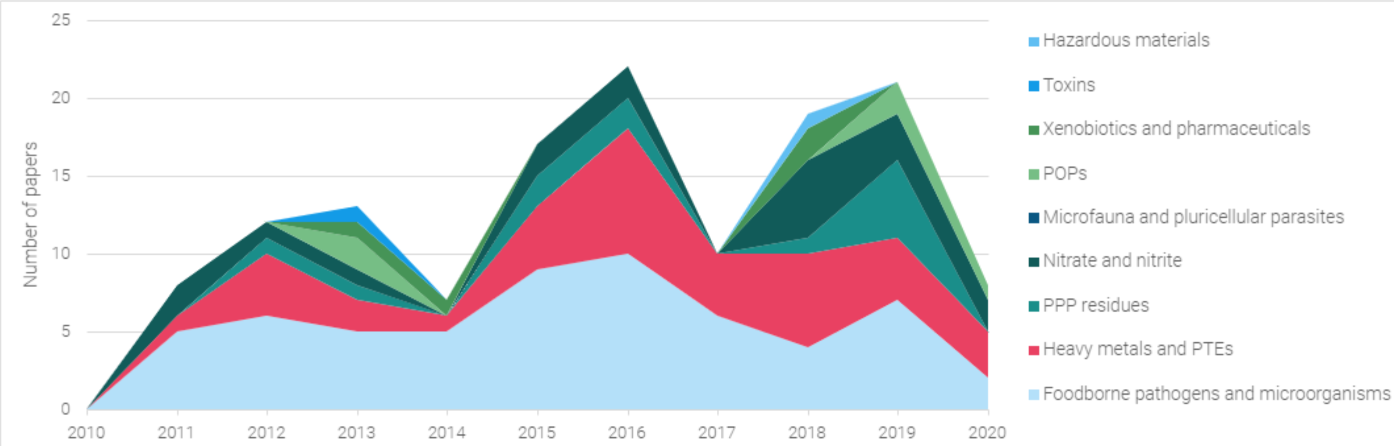



*Figure 3 – Food safety: Number of papers per hazard category per publication year*

### 3.3.3 Specific methodology for data collection on growing systems

An environmental impact analysis, in particular on production systems, is required to reach the main goals of the WP2. WR organized a literature review on key technical aspects of production systems to be addressed when analysing production systems in CRFS. As a result, the authors produced:

- **a review of the different production systems of CRFS; and**
- **a list of indicators and metrics to measure environmental impacts of CRFS production systems.**

#### 3.3.3.1 Data collection

The data was collected by 3 researchers from the FoodE team including researchers from WR. The participating researchers worked together as search terms and results were organized along two main categories:

1. Type of production system
2. Type of technology

The members divided the keywords within the team and conducted the search process. The final content analysis was divided based on the name of the lead author, in order to adequately distribute the workload.



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

### 3.3.3.2 Keywords used

The keywords search crossed a list of different analyses (x) with either different types of production typologies (z) or technologies (y). The additional search string (+) was applied from the beginning to narrow down the counts, as the initial search yielded a high number of rather disparate records.

Table 3 – Keywords for literature review on production systems

| **X** | **ANALYSIS** | **Y** | **TECHNOLOGY** | **+** | **ADDITIONAL** |
|---|---|---|---|---|---|
| **X1** | LCA | **Y01** | LED | +1 | Agriculture |
| **X2** | Life Cycle Analys*s | **Y02** | HPS | | |
| **X3** | Environmental impact* | **Y03** | heating | | |
| | | **Y04** | cooling | | |
| | | **Y05** | humidification | | |
| | | **Y06** | dehumidification | | |
| | | **Y07** | substrate* | | |
| | | **Y08** | pesticide* | | |
| | | **Y09** | herbicide* | | |
| | | **Y10** | fertilizer* | | |
| | | **Y11** | fertiliser* | | |
| | | **Z** | **PRODUCTION TYPOLOGY** | **+** | **ADDITIONAL** |
| | | **Z01** | agriculture | +2 | City |
| | | **Z02** | aquaculture | +3 | Urban |
| | | **Z03** | livestock | | |
| | | **Z04** | "open field*" | | |
| | | **Z05** | orchard* | | |
| | | **Z06** | greenhouse* | | |
| | | **Z07** | *tunnel* | | |
| | | **Z08** | glasshouse* | | |
| | | **Z09** | "glass house*" | | |
| | | **Z10** | "vertical farm*" | | |



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

| | | | | | |
|---|---|---|---|---|---|
| | | **Z11** | arable | | |
| | | **Z12** | hydroponic* | | |
| | | **Z13** | aquaponic* | | |
| | | **Z14** | aeroponic* | | |

### 3.3.3.3 Data storage

The selected papers were indexed and stored in the joint online literature database of Mendeley. The selected papers were also included in the excel table, named as "**First author name et al. year**" with "**doi**", for a basic overview of the literature search.

### 3.3.3.4 Data collection and processing: PRISMA

Table 4 – PRISMA documentation for literature review on production systems

| | **Papers identified** | **Duplicates elimination** | **Title and keyword screening** | **Abstract screening** | **Full text screening** | **Mendeley storage** |
|---|---|---|---|---|---|---|
| | *Records identified through database searching* | *Number of papers with full text available after duplicates removed* | *Records after title and keyword screening (n= ) for excluding obvious errors* | *Records after abstract screening (n= ) Empirical research promising indicators* | *Records after full text check for indicators and metrics informing the result table* | *Number of papers with full text available stored in Mendeley* |
| **Technology** | 6693 | 1571 | 184 | | 10 | 10 |
| **Production typology** | 2367 | | | | 29 | 29 |
| **Total** | 9060 | 1571 | 184 | | 39 | 39 |
| **Total after data cleaning** (merging of duplicates across groups; removal of non-peer-reviewed papers; removal of non-empirical papers) | | | | | | 39 |



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

**Analysed papers**

- **Technology:** 10 (26%)
- **Production typology:** 29 (74%)
- TOTAL of full papers analysed: **184**
- **TOTAL of full papers selected: 39**

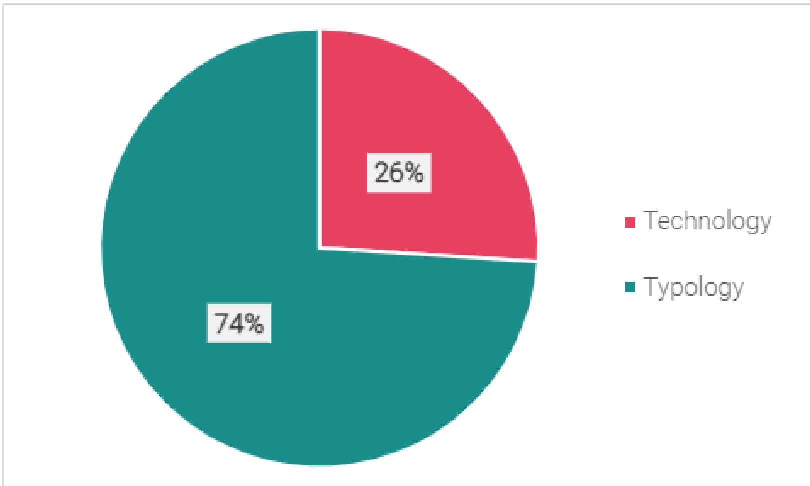



*Figure 4 – Production systems: spread of records per topic*

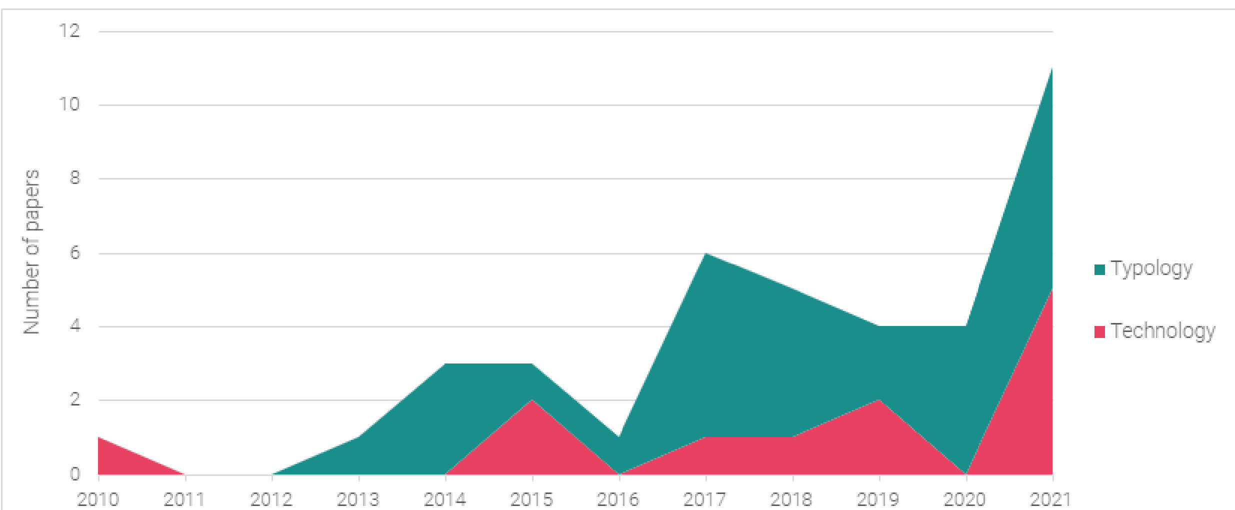



*Figure 5 – Social Impacts: spread of records per publication year*

### 3.3.4 Specific methodology for data collection on socio-economic impacts

A socio-economic impact analysis, together with the other tasks, is required to reach the main goals of the WP2. ILS organized a literature review on main social aspects to be addressed when analysing CRFS. As a final goal, the authors expected to produce:



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

- **a review on the social dimensions of CRFS; and**
- **a list of indicators and metrics to measure social impacts in CRFS.**

#### 3.3.4.1 Data collection

The data was collected by 19 researchers from the FoodE team including researchers from ILS, UNIBO, UAB, AGROPARISTECH, MAIBINE and SWUAS. The participating researchers split up in 4 teams, where impacts were organized along four main impact categories:

1. Education;
2. Health impacts;
3. Community development; and
4. Economic impacts.

In three out of four groups the members divided the keywords within the team and conducted the entire process from the first database entry until the final content analysis. In the case of one group (due to limited database access), one team within the groups did the first screening and collected the papers for analysis, while a second team analysed the papers.

#### 3.3.4.2 Keywords used

The keywords search crossed a list of different CRFS types (x) with different impacts (y). Due to the overall very high number of records, the "economic" subgroup applied the additional search string from the beginning to reduce the counts.

Table 5– Keywords for literature review on socio-economic impacts

| **X** | **WHERE** | **Y** | **WHAT** |
|---|---|---|---|
| **X1** | "city region food system*" | **Y1** | Education |
| **X2** | Aquaponic* | **Y2** | Knowledge |
| **X3** | Hydroponic* | **Y3** | Skill* |
| **X4** | "Roof garden*" | **Y4** | Workshop* |
| **X5** | "Rooftop greenhouse*" | **Y5** | School* |
| **X6** | "Indoor farm*" | **Y6** | Learning |
| **X7** | "zero km food" OR "zero mile food" | **Y7** | "policy making" OR "policymaking" OR "policy-making" |
| **X8** | "Urban horticulture" | **Y8** | "social interaction" |
| **X9** | "Urban agriculture" | **Y9** | Intercultural |
| **X10** | "Vertical farm*" | **Y10** | Gender |



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

| | | | |
|---|---|---|---|
| **X11** | “Urban farm*” | **Y11** | “social cohesion”[3] |
| **X12** | “Community garden*” | **Y12** | “civic engagement” |
| **X13** | “Urban food production” | **Y13** | “social diversity” |
| **X14** | “Allotment garden*” | **Y14** | “cultural heritage” |
| **X15** | “City farm*” | **Y15** | “social innovation*” |
| **X16** | “Rooftop farm*” | **Y16** | “human capital” |
| **X17** | “Civic agriculture” | **Y17** | “vulnerable group*” |
| **X18** | “Civic farm*” | **Y18** | “place-making” OR “placemaking” |
| **X19** | “Community supported agriculture” | **Y19** | health |
| **X20** | “Small scale fisher*” | **Y20** | "health risk*" |
| **X21** | “Farm* market*” | **Y21** | therapeutic* |
| **X22** | “food bank*” | **Y22** | “mental health” OR “mental illness” |
| **X23** | Canteen* | **Y23** | depression |
| **X24** | “Food donation” | **Y24** | "wellbeing" OR "well-being" |
| **X25** | “regional food production” | **Y25** | "physical health" |
| **X26** | “food cluster*” | **Y26** | "physical activit*" |
| **X27** | “Zero waste restaurant*” | **Y27** | “diabetes” OR “obesity” OR “high-blood pressure” OR “hypertension" |
| **X28** | “Carbon neutral restaurant*” | **Y28** | diet* |
| | | **Y29** | "malnutrition" OR "undernutrition" OR "nutrition" |
| | | **Y30** | "fruit and vegetable intake" |
| | | **Y31** | “food access” |
| | | **Y32** | Economic OR financ* |
| | | **Y33** | “Cost*” OR “profit*” OR revenue |
| | | **Y34** | “entrepreneur*” OR “business model*” |

[3] this term was excluded later on due to no results in search combinations with this y-word



This project has received funding from the European Union’s *Horizon 2020 research and innovation programme* under grant agreement No 862663.

| | | | |
|---|---|---|---|
| | | **Y35** | "external*" OR "sharing economy" OR "circular economy" |
| | | **Y36** | "funding" OR "subsid*" |
| | | **Y37** | "employment" OR "job*" OR "labour" OR "labor" |
| | | **Y38** | "affordab*" OR "fairness" |
| | | **Y39** | "purchas*" OR "sales" OR "price" |
| | | **Y40** | "consumer*" OR "prosumer*" |

### 3.3.4.3 Data storage

The selected papers were downloaded and stored in the joint online literature database ZOTERO, named as "**First name et al. year**". The selected papers were also included in the Excel table with "**doi**" and **abstract**, presenting the basic information and results of the search.



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

### 3.3.4.3 Data collection and processing: PRISMA

Table 6– PRISMA documentation for literature review on social impacts

| | Papers identified | Title and keyword screening | Abstract screening | Duplicates elimination | Full text screening | Zotero storage |
|---|---|---|---|---|---|---|
| | *Records identified through database searching* | *Records after title and keyword screening (n= ) for excluding obvious errors* | *Records after abstract screening (n= ) Empirical research promising indicators* | *Number of papers with full text available after duplicates removed* | *Records after full text check for indicators and metrics informing the result table* | *Number of papers with full text available stored in Zotero* |
| **Education** | 8486 | 2873 | 504 | 235 | 48 | 48 |
| **Health** | 7503 | 1072 | | 227 | (133)* | 117 |
| **Community** | 1299 | 370 | 189 | 147 | 53 | 40 |
| **Economic** | 471 | (246)* | 121 | 76 | 45 | 45 |
| **Total** | | | | | | 250 |
| **Total after data cleaning** (merging of duplicates across groups; removal of non-peer-reviewed papers; removal of non-empirical papers) | | | | | | 233 |

**this number is subject of uncertainty, due to a lack of documentation during the data collection process for this step.*

Analysed papers:

- **Education:** 48 (20%)
- **Health:** 117 (47%)
- **Community:** 40 (15%)
- **Economic:** 45 (18%)
- TOTAL of full papers analysed: **250**
- **TOTAL after merging** of duplicates across the 4 groups: **233**



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

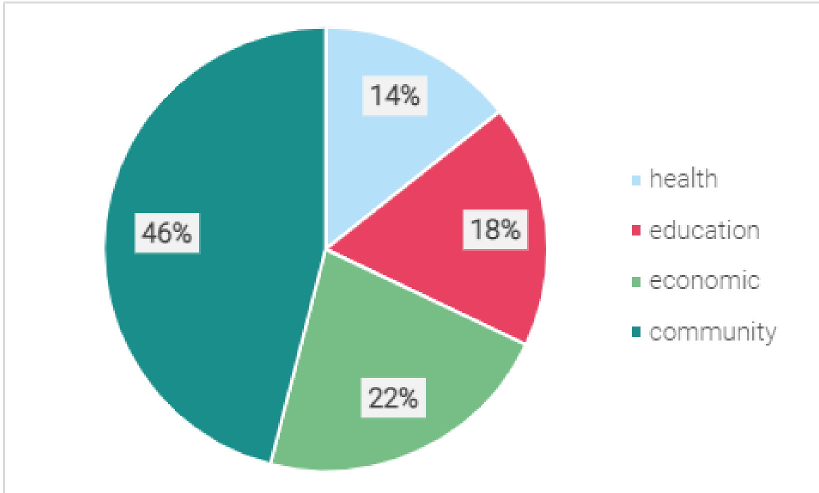



*Figure 6 – Socio-economic impacts: spread of records per topic*

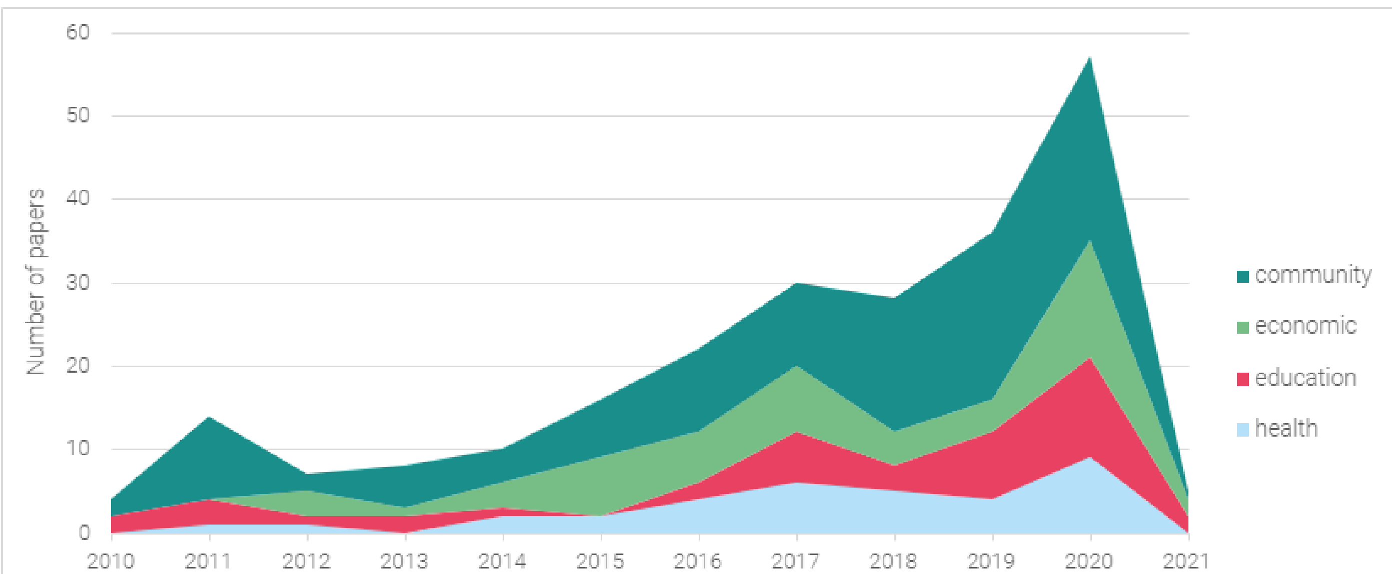



*Figure 7 – Socio-economic impacts: spread of records per publication year*

### 3.3.5 Results of literature reviews: KPI selection

The individual literature reviews will be published as scientific publications to provide an overview of the current body of knowledge of the food safety, production systems, and socio-economic aspects of CRFS.

Within FoodE and the future deliverables the literature reviews provide input on the Key Performance Indicators (KPIs) of CRFS. In each literature review, the following indicators were selected by the teams as most relevant and suitable to target the investigation of specific impacts of CRFS within FoodE. From the entire set of indicators and metrics collected during the reviews, those that were selected to be further used in the survey and the assessment of the pilots are presented below (Tables 7-9). While some of the items were already included into the survey of



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

the CRFS, others can be considered in the pilot assessment. If the topic is included in the CRFS surveys, but a higher level of detail is proposed, this is indicated using "proposed (in detail)".

The rationale for the selection the indicators was based on the following considerations:

- Choosing the most specific indicators, which are targeting a specific issue within the different dimensions of social, economic or environmental sustainability.
- Choosing indicators, which are clearly measurable based on specific metrics
- Choosing indicators, that are methodologically realistic to address, and that measure concrete impacts in one of the four dimensions of each sustainability pillar

Table 7– Key performance indicators proposed in social sustainability, based on the literature review on food quality and safety and socio-economic impacts.

| **Social indicators proposed from the literature review** | **Metrics** | Included in the **CRFS surveys** | Proposed for **pilot assessment** |
|---|---|---|---|
| **Social dimension 1: Community development** | | | |
| **Frequency of social activities** (and all related indicators on activities for local communities, educational offerings etc.) | - **No. of social activities and events/year** | | **proposed** |
| **Participation rate** (what rate of participants regularly participate etc.) | - **No. of participants total/year** | **included** | |
| **Social inclusion** (Involvement of disadvantaged groups of society) | - **No. of participants in activities by age group**<br>- **No. of disadvantaged participants**<br>- **No. of participants in activities by gender** | **included** | |
| **Participants living in the neighborhood** (connected with and all related indicators pointing out at the number of locals involved in the activities, the travel time of participants to get to the activities etc.) | - **No. of locals participating/year**<br>- **Travel time in h or distance in km of participants** | **included** | |
| **Networking** (Relations with other institutions) | - **No. of formal and informal exchanges with other projects, institutions/month**<br>- **No. and types of organizations partnering with the pilot** | | **proposed** |
| **Social dimension 2: Education** | | | |
| **Formal educational activities** (maintenance and transfer of knowledge) | - **No. of knowledge transfer events/year**<br>- **No. of participants in workshops or trainings** | | **proposed** |
| **Knowledge gain** (horticultural knowledge –hydroponic, aquaponic- sustainability and environmental knowledge, nutritional knowledge) | - **Likert scale evaluation after an experience in UA (workshop, internship, direct market) to evaluate the knowledge gain** | | **proposed** |
| **Skills development** (self-efficacy in terms of gardening skills and nutrition; confidence, emotional intelligence and prosocial behaviour) | - **Likert scale evaluation pre- and post-educational intervention in trainings** | | **proposed** |



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

| | | | |
|---|---|---|---|
| **School engagement** (grades and school attendance) | - **Likert scale evaluation pre- and post-educational intervention within the FoodE Kid-Science events** | | **proposed** |
| **Social dimension 3: Health** | | | |
| **Fruit and vegetable intake** (fruit and vegetable consumption of CRFS members/costumers) | - **Self-reported F&V intake (in portions (cups)/day)**<br>- **Self-reported F&V intake (in frequency)** | | **proposed** |
| **F&V-related attitudes and behaviour** (attitudes and behaviour of CRFS members/costumers) | - **No. of shopping trips to farmers market/month**<br>- **% of organic food consumed**<br>- **No. of meals prepared from scratch/week** | | **proposed** |
| **Risk of intake of toxic ingredients** (such as heavy metals) | - **Threshold values of potentially harming contaminants**<br>- **Distance of the CRFS production site from heavy traffic roads (in km)** | | **proposed** |
| **CRFS embeddedness in the food system** (food system situation in the spatial surrounding) | - **Distances to supermarkets, community gardens, and farmers' markets (in km)** | | **proposed** |
| **Social dimension 4: Food quality and safety** | | | |
| **Adoption of a quality management system** (HACCP, EUREPGAP, IFS, ISO 9000 family) | - **Certification maintained**<br>- **Newly achieved certifications**<br>- **Total number of certification obtained (or maintained) overall / company life in years** | | **proposed** |
| **Adoption of food labelling schemes** (Organic, fair trade, slow food, PDO) | - **Voluntary schemes adopted**<br>- **Third-party schemes adopted**<br>- **EU schemes adopted (PDO, PGI, TSG)** | | **proposed** |

Table 8– Key performance indicators proposed in environmental sustainability, based on the literature review on production systems

| **Environmental indicators proposed from the literature review** | **Metrics** | Included in the **CRFS surveys** | Proposed for **pilot assessment** |
|---|---|---|---|
| **Environmental dimension 1: Food production / supply** | | | |
| **Technologies used for cop production** (all related indicators on resource expenditure and environmental impact of these technologies) | - **Type of technologies and installations required for production** | **included** | **proposed (in detail)** |



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

| | | | |
|---|---|---|---|
| | - Resource expenditure of installations<br>- Environmental impact of installations | | |
| **Technology used for animal rearing** (all related indicators on resource expenditure and environmental impact of these technologies) | - Type of installations required for animal rearing<br>- Resource expenditure of installations<br>- Environmental impact of installations | included | proposed (in detail) |
| **Technology used for fishing or fish production** (all related indicators on resource expenditure and environmental impact of these technologies) | - Types of installations required for fish production<br>- Types of technology for fisheries (boats, netting, etc.) | included | |
| **Other Machinery and installations** (all related indicators on resource expenditure and environmental impact of these technologies) | - Specify technical characteristics of machinery or systems<br>- Specify fuel consumption of machinery or systems | | proposed |
| **Product characteristics** (specific negative and positive environmental impacts of the product, as well as its potential for reuse) | - Recyclability and compostability of product<br>- Direct environmental impact of product | | proposed |
| **Environmental dimension 2: Resource use efficiency** | | | |
| **Product produced/processed/sold** (maintenance and transfer of knowledge) | - Quantify units of product produced per type of product | included | |
| **Land use** (land area allocated to production or other activities) | - Quantify total land area in use for different activities<br>- Quantify direct impacts on soil | included | Proposed (in detail) |
| **Water use** (the amount of fresh water required by the initiative for production or processing) | - Quantify water use<br>- Commitment to water saving<br>- Commitment to reducing or reusing water | included | |
| **(Fossil) Energy use** (the amount of energy required by the initiative for production or processing, specified for renewable and fossil energy sources) | - Quantify energy use<br>- Quantify energy sources: renewable vs fossil<br>- Commitment to fossil energy saving<br>- Commitment to reducing or reusing energy | included | |
| **Fertilizer use** (the amount of fertilizers required by the initiative for production or processing) | - Quantify fertilizer usage of nitrogen, phosphorus and potassium | Included | Proposed (in detail) |



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

| | | | |
|---|---|---|---|
| | - **Specify manure management** | | |
| **Pesticide use**<br>(the amount of pesticides required by the initiative for food production or processing) | - **Specify total pesticide use** | **included** | **Proposed (in detail)** |
| **Animal/fish/insect feed**<br>(the amount of feed required by the initiative for animal rearing or fisheries) | - **Quantify total animal/fish feed use**<br>- **Specify feed composition** | | **proposed** |
| **Environmental dimension 3: Waste management** | | | |
| **Waste production**<br>(the amount of waste produced by the initiative as a by-product of food production or processing) | - **Quantify organic waste / production material / construction material / packaging materials** | **included** | |
| **Waste type**<br>(type of waste streams which relates to compostability, recyclability and reusability) | - **List types of waste production** | | **proposed** |
| **Waste reduction**<br>(level of income other than revenues) | - **Commitment to waste reduction**<br>- **Commitment to repurposing or reusing waste byproducts** | **included** | |
| **Environmental dimension 4: Transport** | | | |
| **Transport distances**<br>(distance from initiatives to their main suppliers and customers) | - **Distance for sourcing products**<br>- **Distance to primary customers** | **included** | |
| **Type of transport**<br>(mode of transport which relates to fuel use efficiency and units moved) | - **Types of transport used**<br>- **Efficiency of transport** | | **proposed** |
| **Fuel use**<br>(fuel use by selected mode of transport which relates to the kg km environmental impact of product) | - **Shares of fuel source used per type of transport** | **included** | |



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

Table 9 – Key performance indicators proposed in economic sustainability, based on the literature review on socio-economic impacts

| **Economic indicators proposed from the literature review** | **Metrics** | Included in the **CRFS surveys** | Proposed for **pilot assessment** |
|---|---|---|---|
| **Economic dimension 1: Employment** | | | |
| **Employment** (direct or indirect job creation) | - **No. of full-time/part-time/voluntary workers**<br>- **No. of female employees** | **included** | |
| **Economic dimension 2: Market** | | | |
| **Profits of sales** (net profits and revenues) | - **Annual revenues from product sales (in Euro/year)**<br>- **Annual revenues from other activities (in Euro/year)**<br>- **Annual net profit margin (in Euro/year)** | **included** | |
| **Funding rates** (level of income other than revenues) | - **Annual revenues from public funding (in Euro/year)**<br>- **Annual revenues from private funding (in Euro/year)** | **included** | |
| **Frequency of purchases** (how many customers are reached by the CRFS) | - **No. of end consumers sold to/month** | **included** | |
| **Affordability** (price of product compared to market prices) | - **End price (in Euro) compared to market prices** | | **proposed** |



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

# 4. General CRFS data overview- three pillars of sustainability

The first Section (4.1) provides a general overview of the CRFSI. In Sections 4.2-4.4 we present a general overview of data collected within each sustainability pillar. The main tools that have been developed in the past decades generally use the three sustainability pillars: the environmental performance (LCA), economical costs and value (LCC) and social impacts (S-LCA). When combined these pillars form a complete LCSA of a product or a system.

## 4.1 General overview

The data collection used two surveys to collect data on innovative CRFS projects and initiatives throughout Europe, following the data collection protocol from D2.3. The responses from the CRFSI provide an overview on the type, main activities, size, and the impact of the COVID-19 crisis, as well as the social, economic and environmental sustainability of the CRFSI. Selected datapoints from both surveys are presented in this report to provide an overview of the collected data. Further processing, analysis and interpretation of this data was conducted and presented in Deliverable 2.5. The overview of the typology and location of respondents is presented below, in Figures 8-10. Both surveys yielded responses from 7 different CRFS typologies from 10 European countries, ensuring a spread across Europe. Several distinguishing technical features of these initiatives are also presented in this section (Figures 11-12)

### 4.1.1 Locations of the CRFSI

The initial survey (DCP600+) saw responses from Belgium (BE), Bulgaria (BG), Catalunya (CA), France (FR), Germany (DE), Hungary (HU), Iceland (IS), Ireland (IR), Italy (IT), Luxembourg (LX), Malta (MA), Montenegro (MN), Norway (NO), Portugal (PO), Romania (RO), Slovenia (SL), Spain (ES) and the Netherlands (NL) (see Figure 8). For the second, detailed survey (DCP100+) a smaller number of responses was received from a smaller number of countries (see Figure 9). The responses were predominantly from urban or peri-urban areas, befitting the CRFS boundary conditions (see Figure 10).

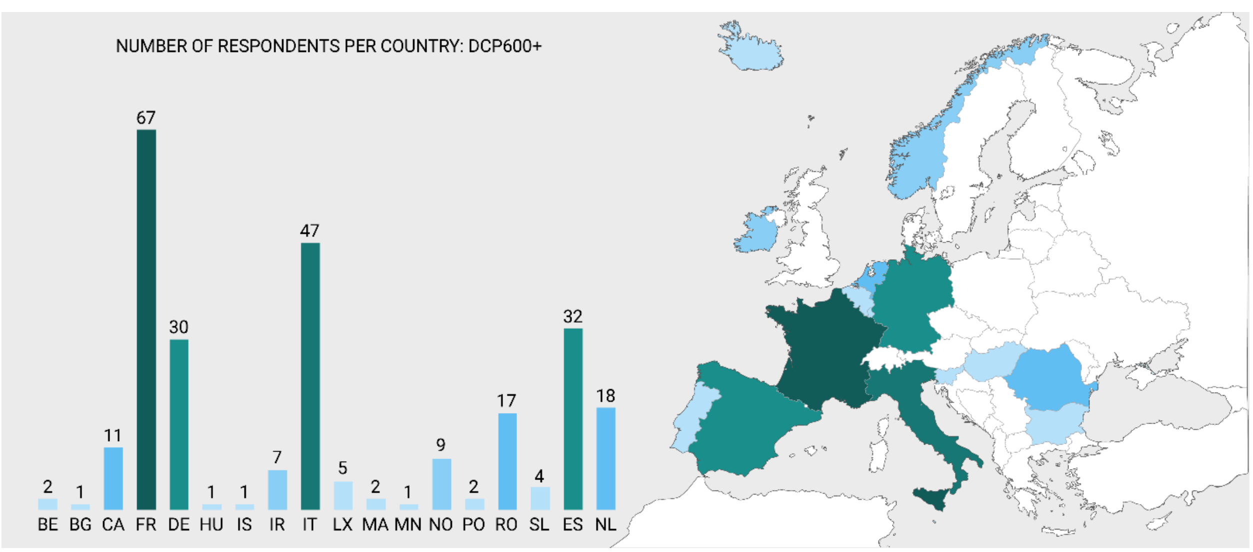



*Figure 8 – Number of respondents to the initial survey, per country. Datapoints were collected in the questions pertaining to general information in DCP600+.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

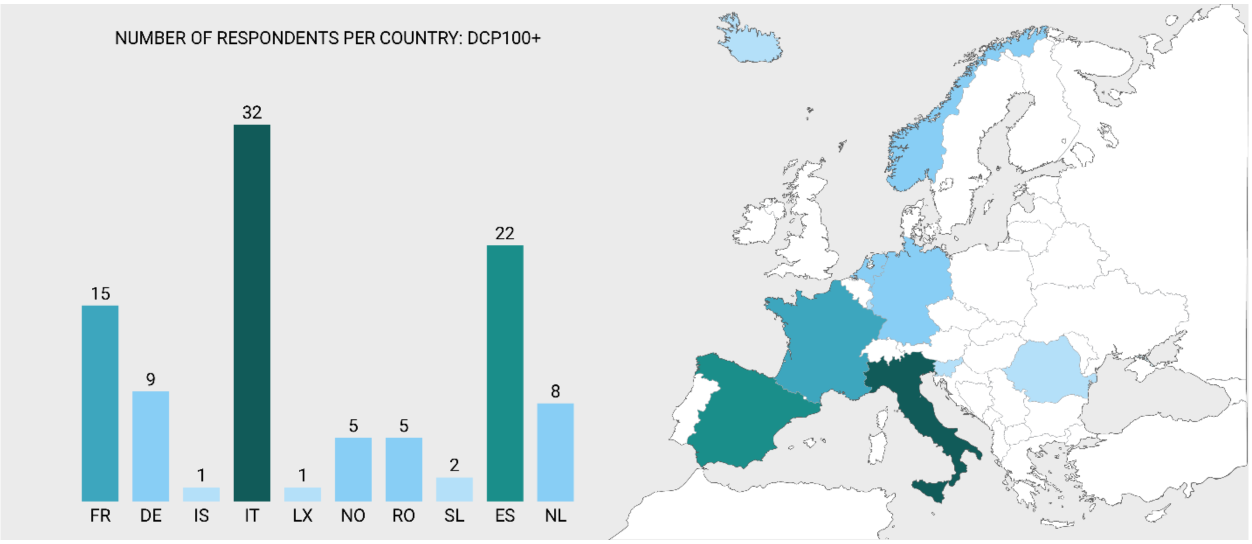



*Figure 9 – Number of respondents to the detailed survey, per country. Datapoints were collected in Q2.2 in DCP100+.*

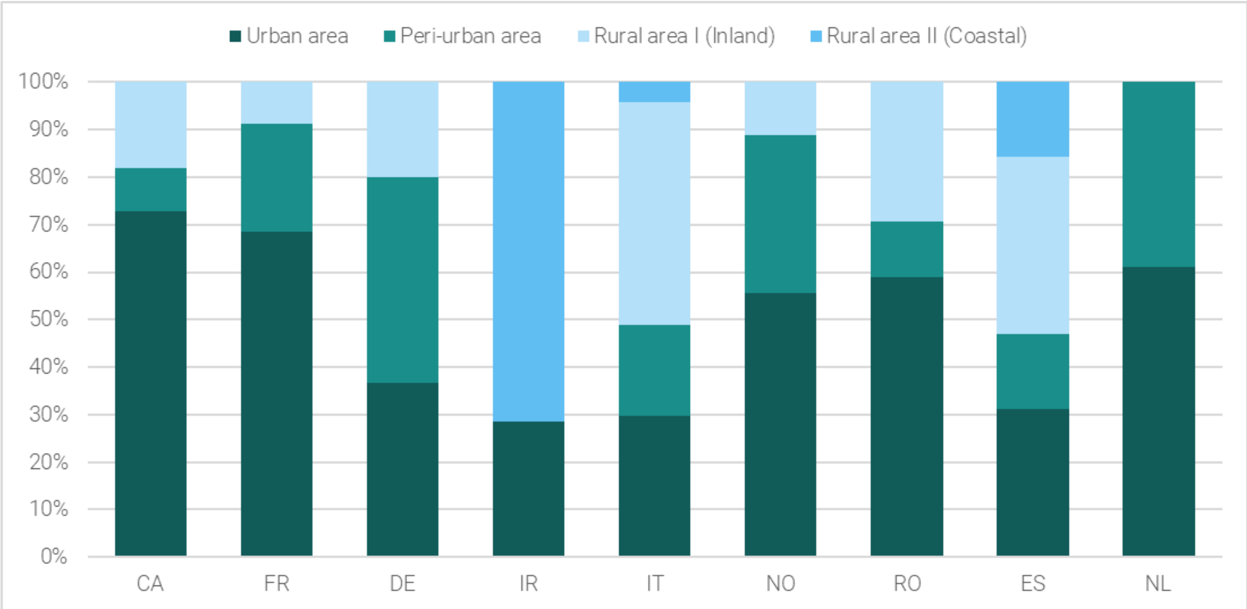



*Figure 10 – Location of the respondent CRFSI in Catalunya, France, Germany, Ireland, Italy, Norway, Romania, Spain and the Netherlands, relative to the city. Datapoints were collected in Q3 in DCP600+.*

## 4.1.2 Primary characteristics of the respondent CRFSI

Numerous questions were posed to form an overview of the general characteristics of the CRFSI. These characteristics included, but were not limited to their scale, innovative character, individual focus on sustainability and data collection. A selection is presented in Figures 11-13.



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663**.**

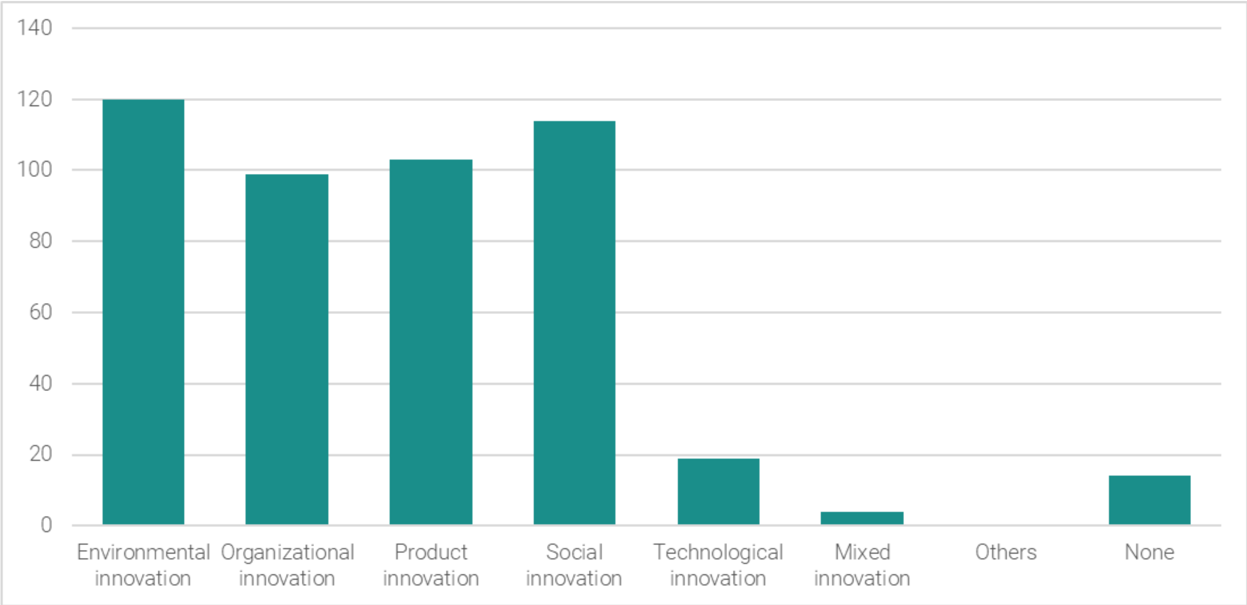



*Figure 11 – Number of reported instances of innovation by the respondents to the initial survey. The CRFSI could submit multiple fields for innovation. Datapoints were collected in Q16 in DCP600+.*

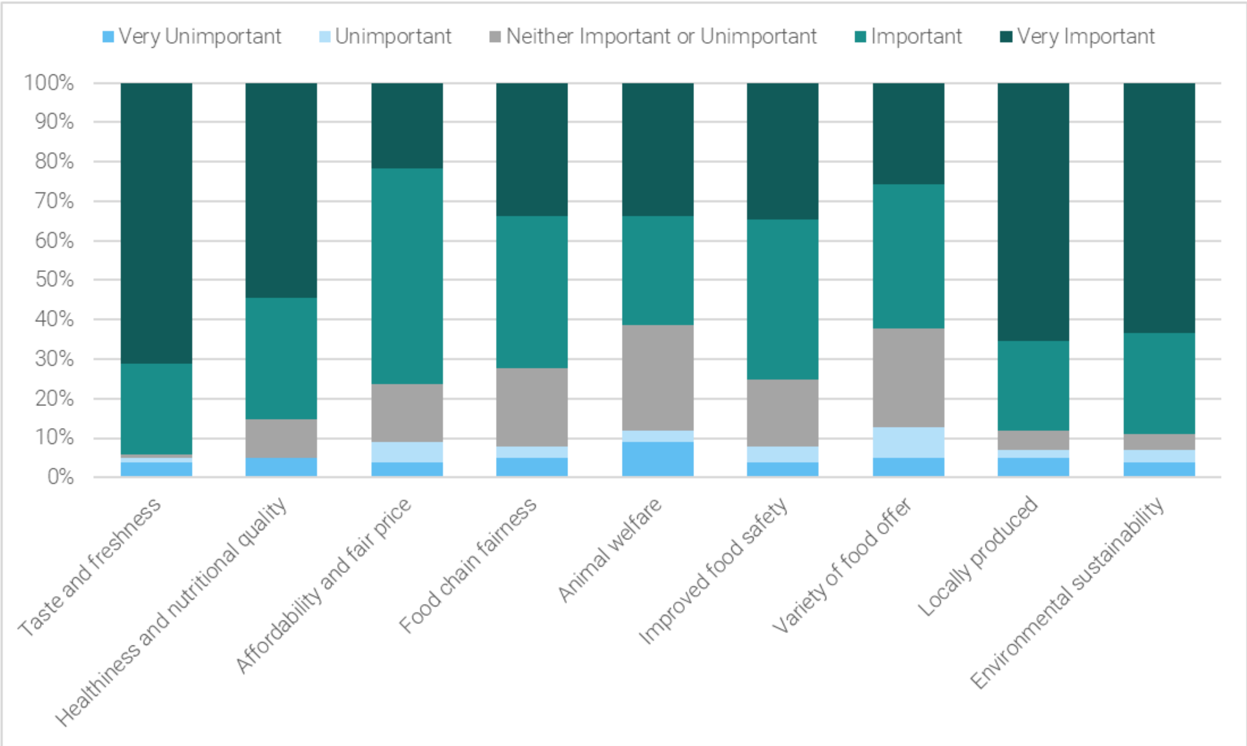



*Figure 12 – Commitment to and interest in various types of sustainability by the CRFSI, per sustainability discipline. Datapoints were collected in Q3.10 in DCP100+.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

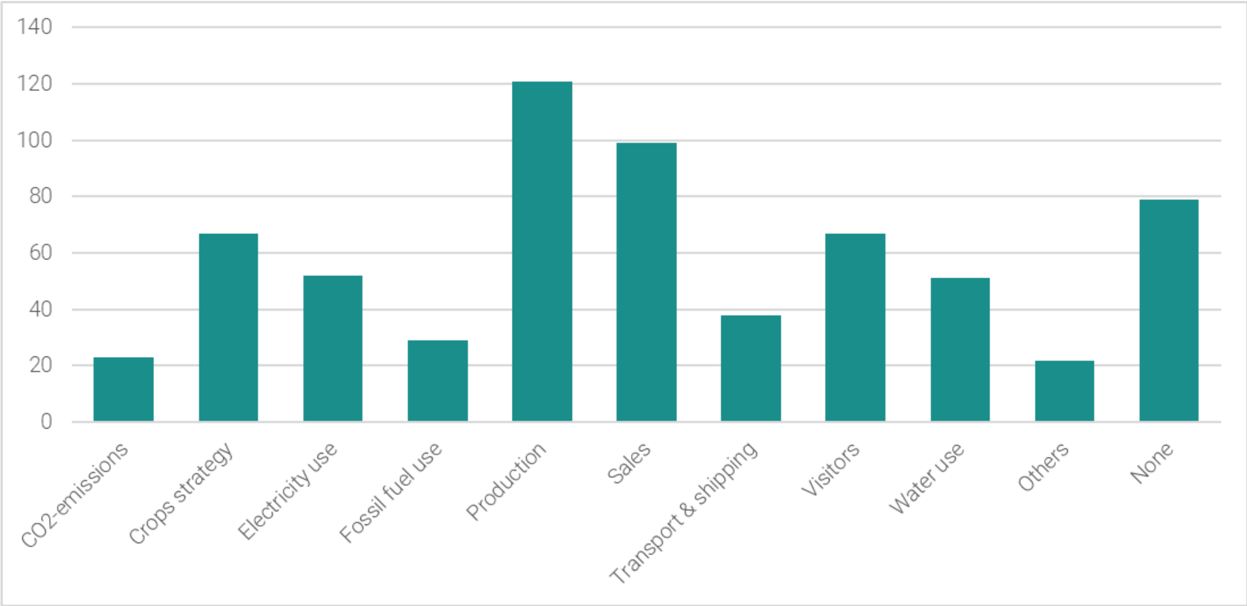



Figure 13 – Overview of the total number of data items tracked by a CRFSI, per type of data collected. Datapoints were collected in Q18.1 in DCP600+.



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663**.**

## 4.2 Environmental pillar: LCA

The **Environmental** pillar concerned the human impact on the environment, as well as enhancing ecosystem services. In the initial, simplified survey, an overview of basic technical details that could inform future assessments was generated. A scan was made of the availability of data on resource use, waste and transport at the CRFSI. The second, detailed survey built on this, by including detailed, targeted requests for these data points. In order to minimise the impacts of resource use, non-renewable resources and waste generation, the KPIs included questions related to primary production, resource use efficiency, waste management and transport. The challenge in this pillar was to retrieve quantitative data to assess the direct and indirect environmental impacts.

### 4.2.1 Production systems

The production stage represents a relevant hotspot of environmental impact. It can be predicted by verifying e.g., the typology of technology used for crop production, the animal feed provenance, the typology of fishing gears, the inclusion of agricultural biodiversity measures, and certain food characteristics. Data on the main typologies for crop production systems, animal rearing and fisheries were collected and are presented in Figures 14-16.

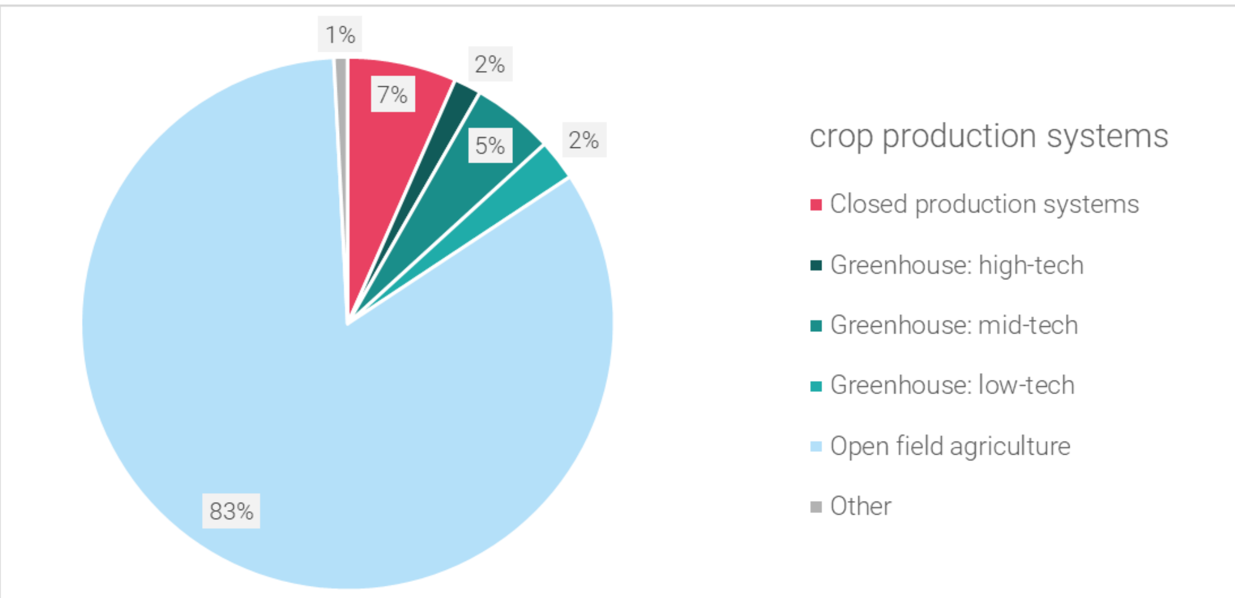



*Figure 14 – Spread of production system typologies used in CRFS, per country. Datapoints were collected in Q6.1.1.1b in DCP600+.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

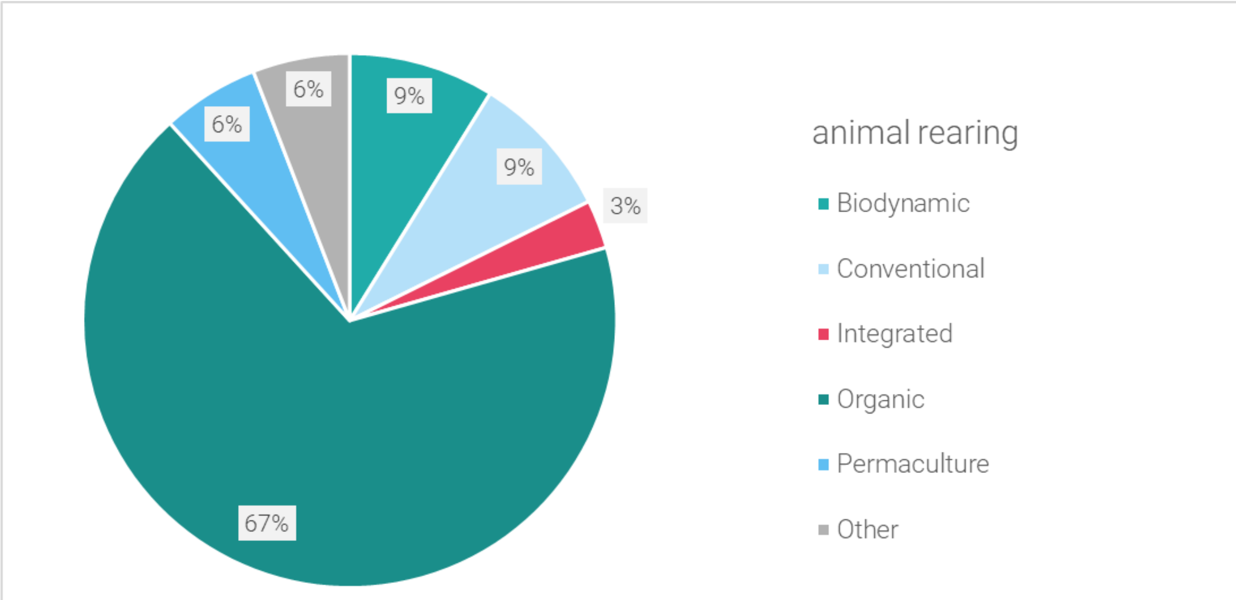



*Figure 15 – Spread of animal rearing systems used in CRFS, per country. Datapoints were collected in Q6.1.1.3b in DCP600+.*

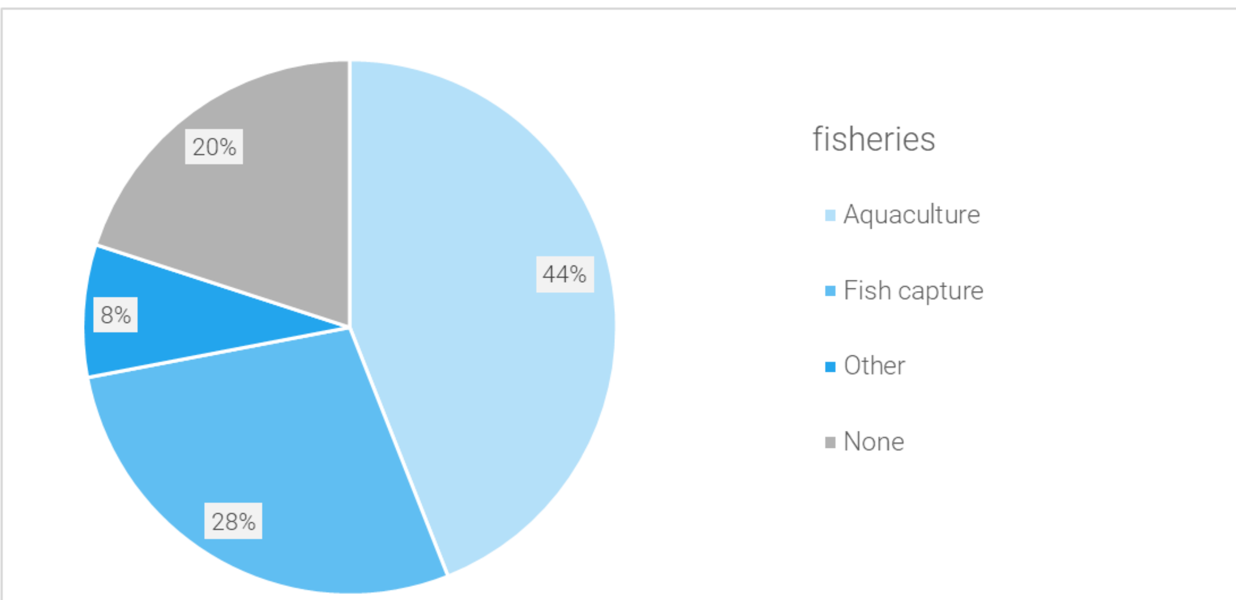



*Figure 16 – Spread of fishery systems used in CRFS, per country. Datapoints were collected in Q6.1.1.2b in DCP600+.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

### 4.2.2 Resource use management

The use of different resources, such as water, energy, fossil fuel, has a direct environmental impact. The commitment of a CRFSI to improving their performance in these fields can result in a significantly lower environmental impact (see Figure 17). It is important to investigate how these resources are used and potentially reused, for example for electricity or heating supply (Figure 18). Another direct impact is constituted by waste. Measures to reduce or reuse waste are mapped (Figures 19-20).

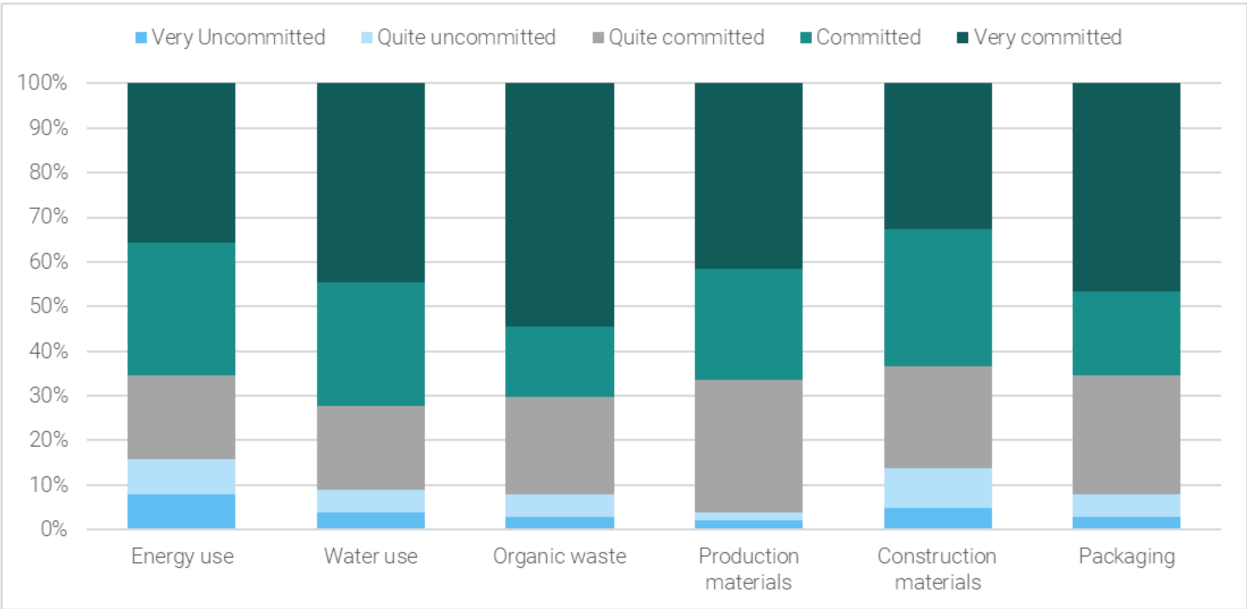



*Figure 17 – Commitment of CRFSI to improving environmental sustainability. Datapoints were collected in Q6.6 and Q6.10 in DCP100+.*

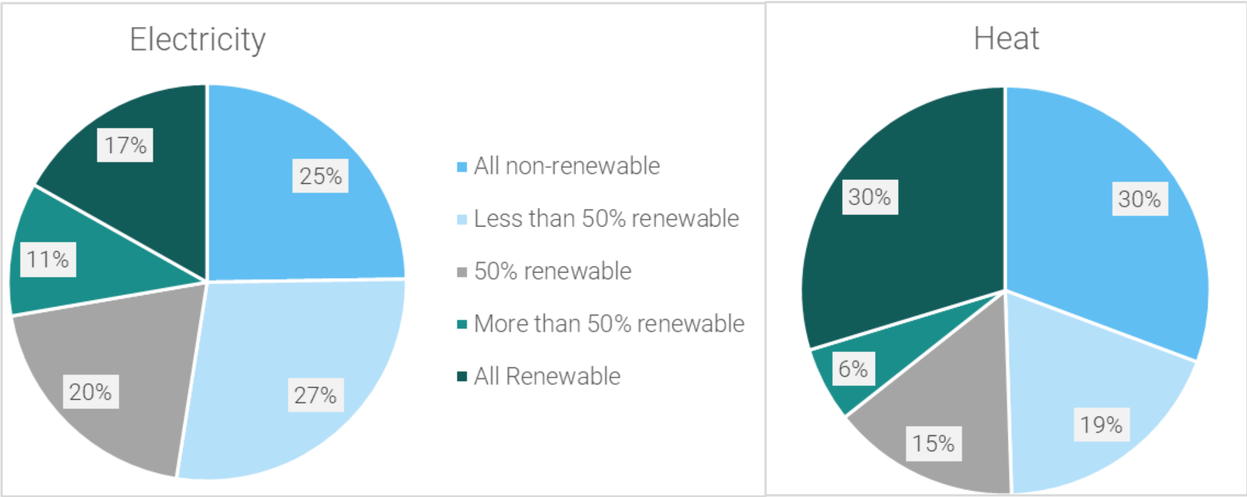



*Figure 18 – The distribution of sources for electricity and heating in CRFSI. Datapoints were collected in Q6.7 and Q6.8 in DCP100+.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

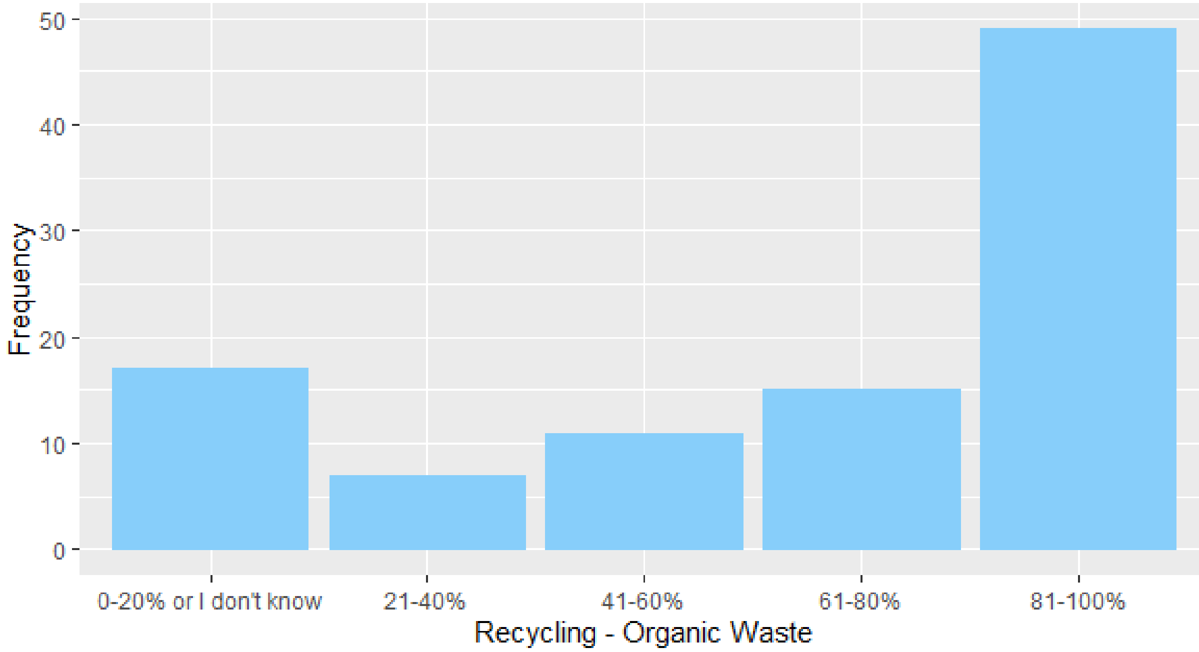



*Figure 19* – The prevalence of recycling organic waste in CRFSI. Datapoints were collected in Q6.9.1 in DCP100+.

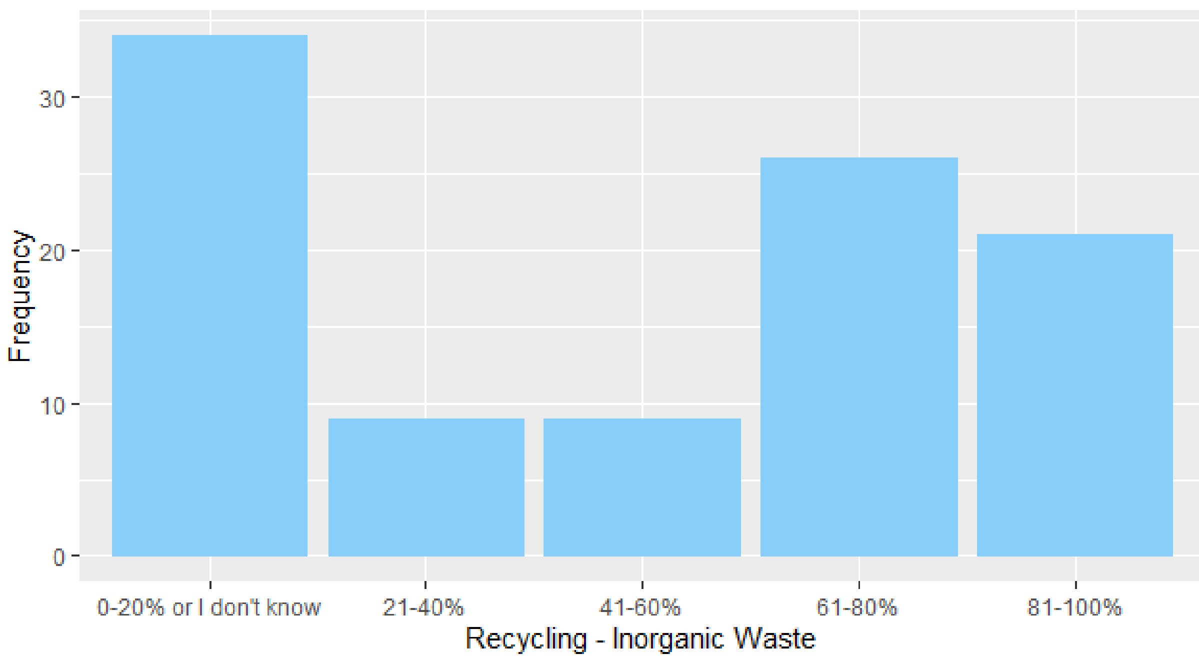



*Figure 20 – The prevalence of recycling inorganic waste in CRFSI. Datapoints were collected in Q6.9.2 in DCP100+*.



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663**.**

### 4.2.3 Transport

Transport of food from suppliers and to consumers represents another relevant impact category. The transport of supplies and the required fuel is presented in Figure 21. The transport of goods to the customers of CRFSI and the required fuel is presented in Figure 22.

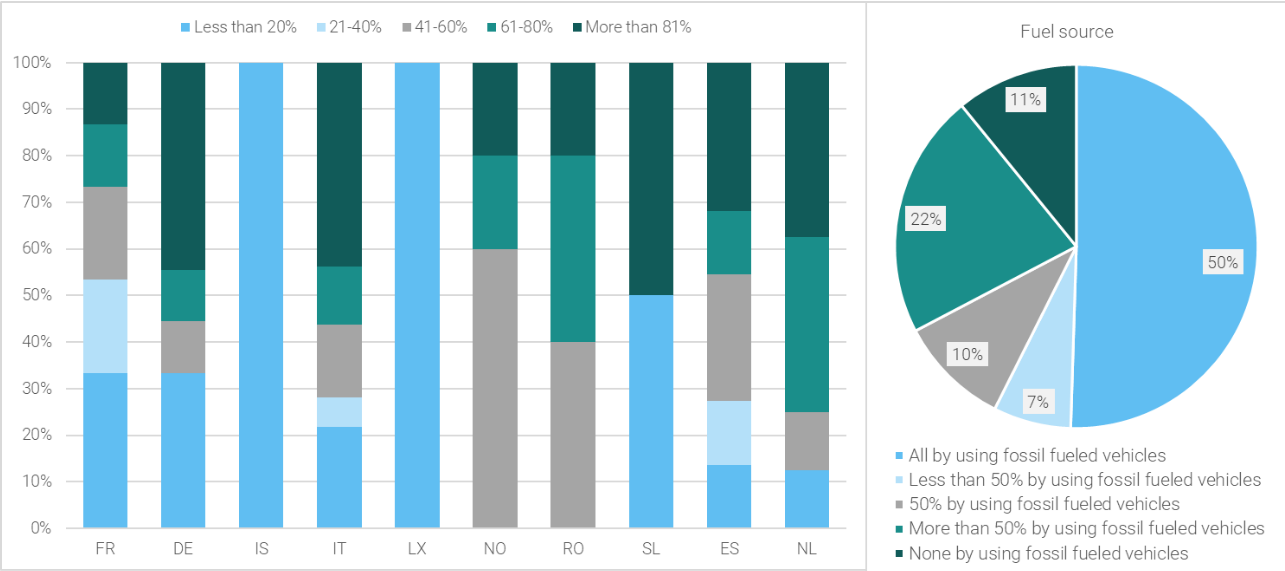



*Figure 21– Percentage of supplies of CRFSI that were locally sourced, per country (left). The reported fuel sources for the required transport are specified on the right. Datapoints were collected in Q4.5 and Q6.15 in DCP100+.*

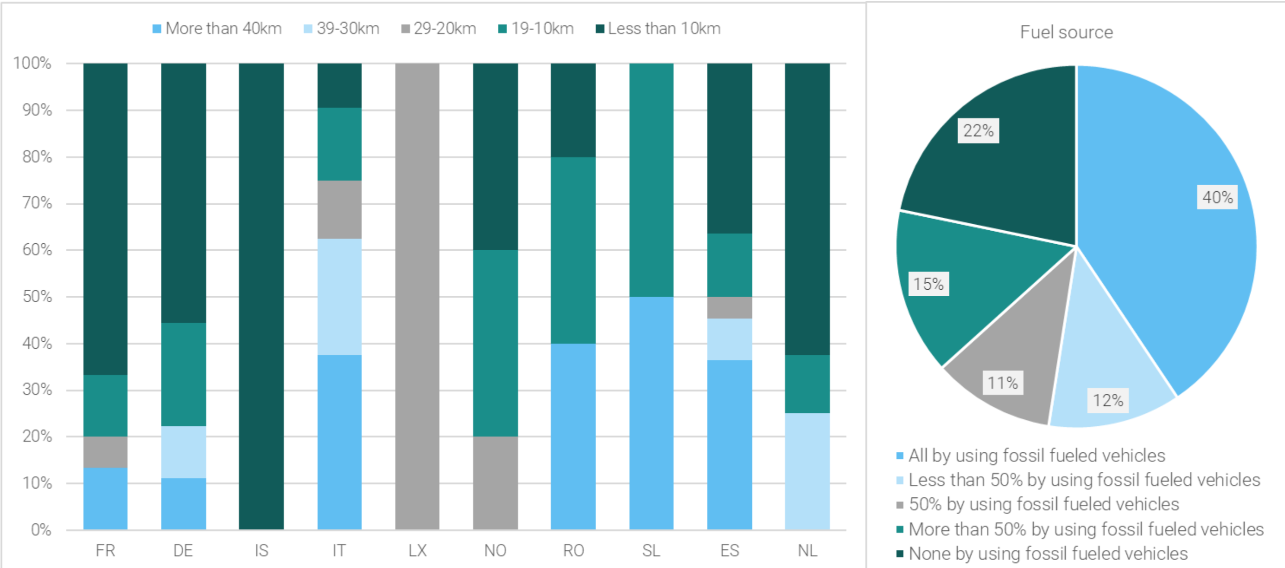



*Figure 22 – Average distance from the CRFSI to their main customers, per country (left). The reported fuel sources for the required transport are specified on the right. Datapoints were collected in Q6.13 and Q6.14 in DCP100+.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

## 4.3 Economic pillar

The **Economic Pillar** focuses on the general cost structure and market of each CRFSI. In the initial, simplified survey, an overview of the corporate and financial structure was created and sales channels were mapped. The second, detailed survey built on this by specifying the cost structure and various revenue streams (product, activity, public or private). As such, the KPIs included cost & profitability, market potential and customer profile.

### 4.3.1 Revenue streams

Key aspects are the general profitability in terms of profit margins, revenue diversification (product revenue, activity revenue or other forms of income such as public or private funding) and the business future outlook (Figures 23-26).

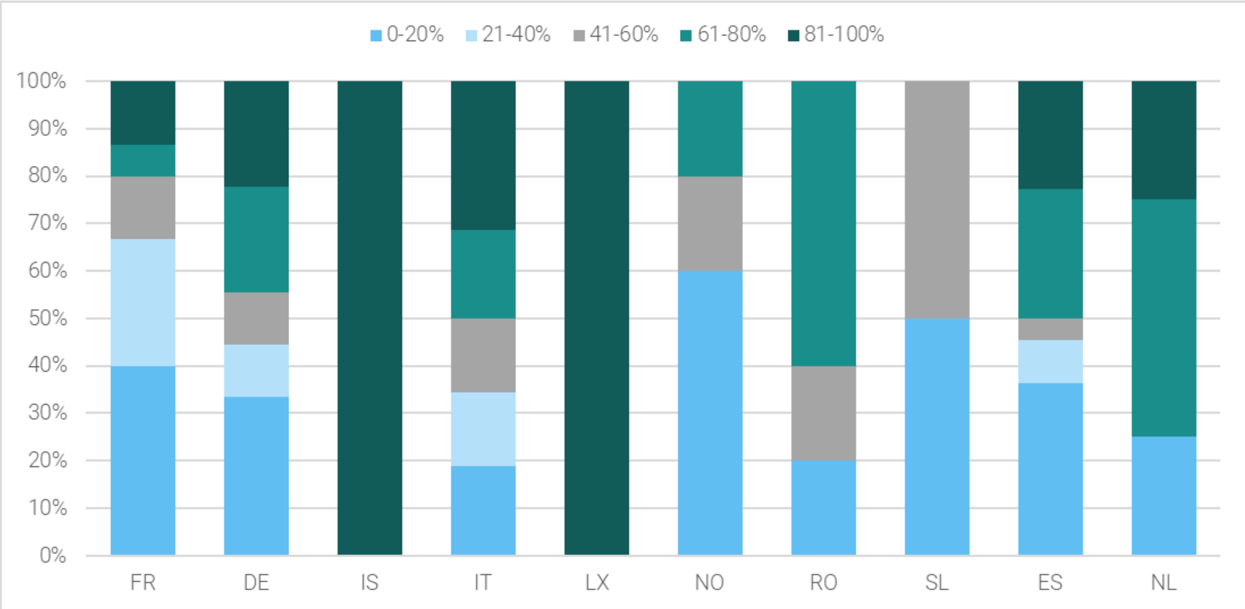



*Figure 23 – Relative revenues of CRFSI from product sales, per country. Datapoints were collected in Q4.2.1 in DCP100+.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

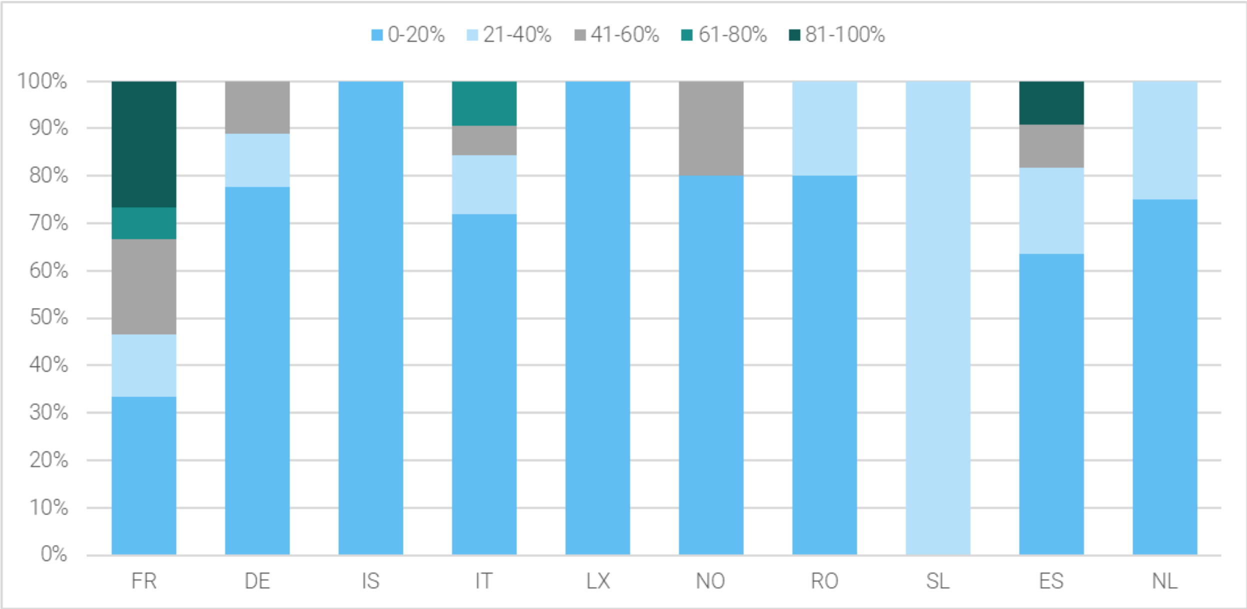



*Figure 24 – Relative revenues of CRFSI from other activities, per country. Datapoints were collected in Q4.2.2 in DCP100+.*

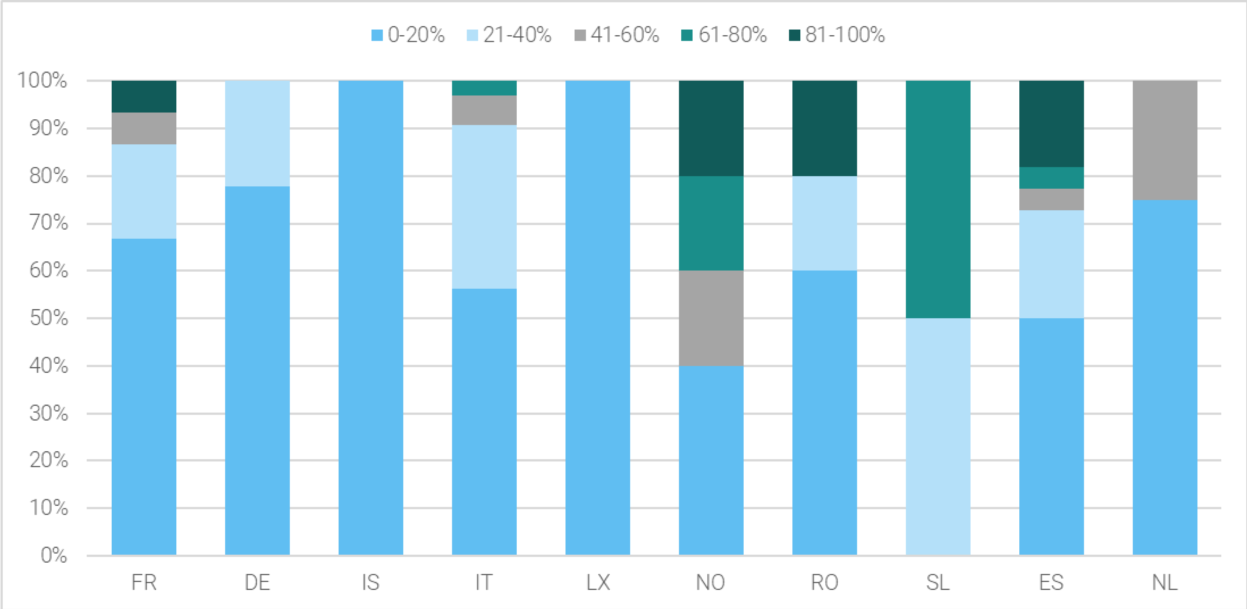



*Figure 25 – Relative revenues of CRFSI from public funding, per country. Datapoints were collected in Q4.2.3 in DCP100+.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

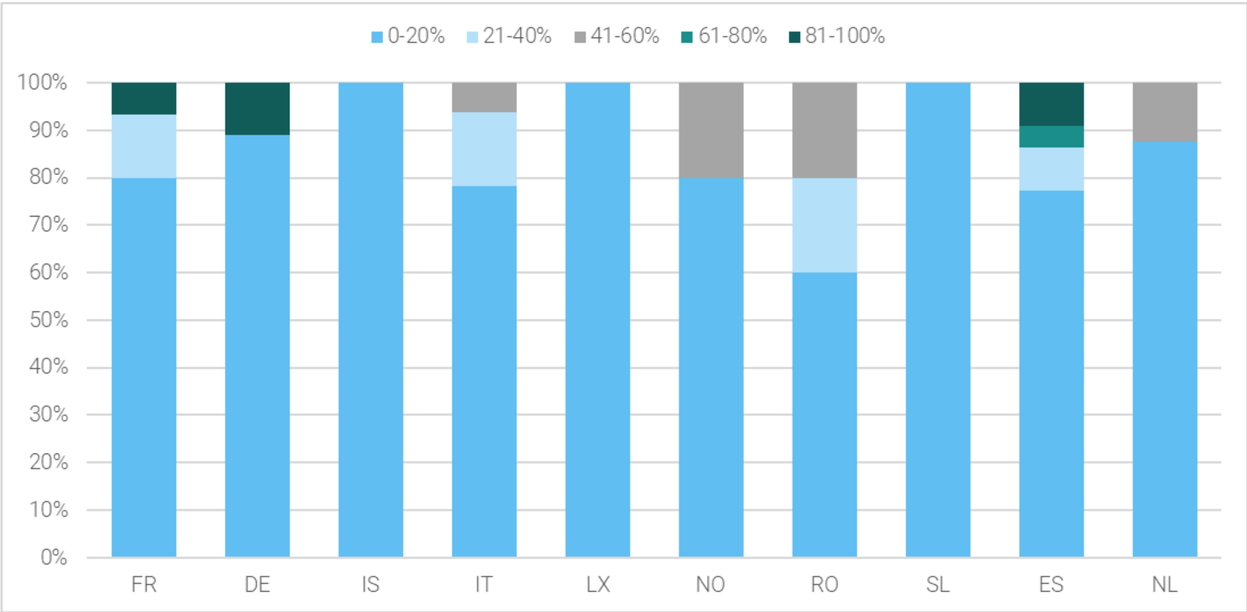



*Figure 26– Relative revenues of CRFSI from private funding, per country. Datapoints were collected in Q4.2.4 in DCP100+.*

## 4.3.2 Integrated in the local economy

The embeddedness of CRFSI within the local economy represents an important source of economic impact. This is proxied by assessing the locally sourced supply and labour (Figure 27), as well as fair practices towards suppliers (Figure 28).

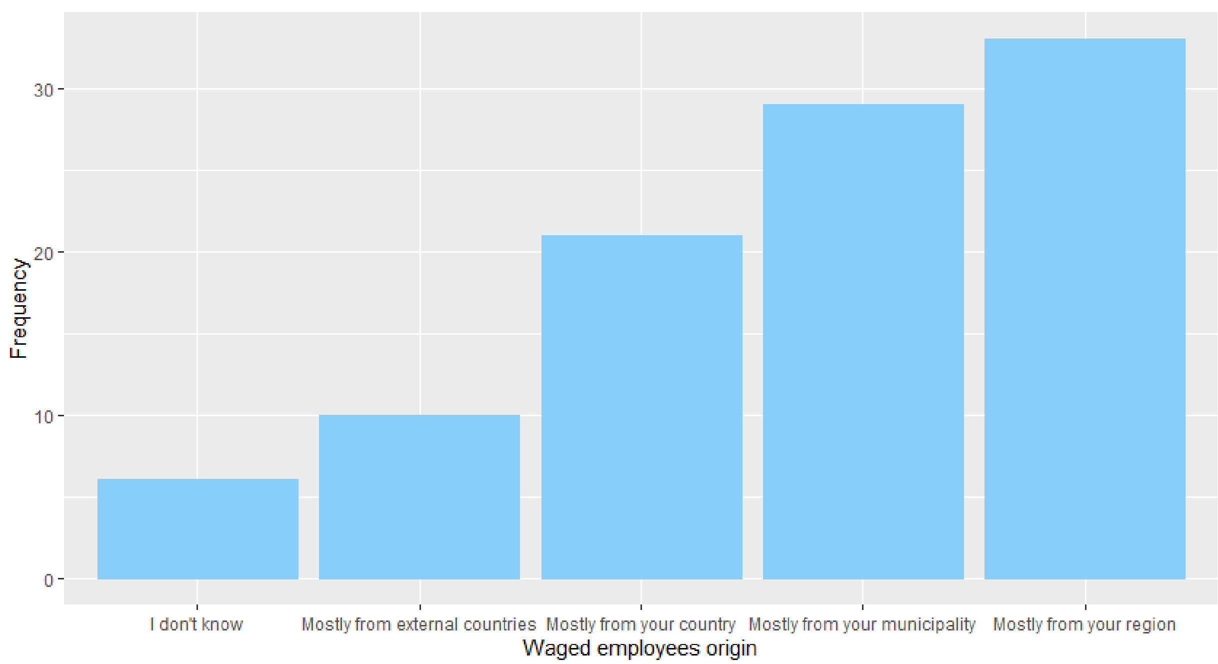



*Figure 27– Origin of waged employees in relation to the CRFSI to illustrate locally sourced labour. Datapoints were collected in Q4.4 in DCP100+.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

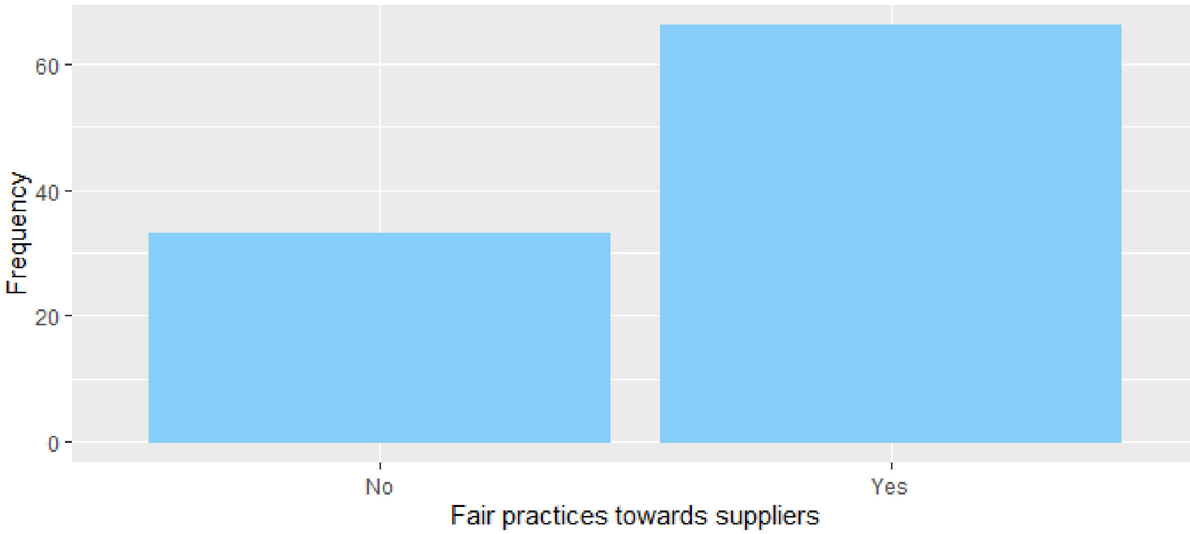



*Figure 28 – Number of CRFSI that engage in explicit fair practices towards their suppliers. Datapoints were collected in Q4.6 in DCP100+.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

### 4.3.3 Customer and sales profiles

The customer profile is analysed to give an overview of the market and operations of the CRFSI, to assess if CRFSI meet citizens' and consumers' dietary habits, perceptions, values, and attitudes, on CRFSI food offer and food commercialization (see also Figure 38). This sustainability analysis allows to assess to what extent the various CRFSI types satisfy the various customers' purchasing behaviour habits. An important part is the customer profile (Figures 29-31) and the available sales venues for these customers (Figures 32-33).

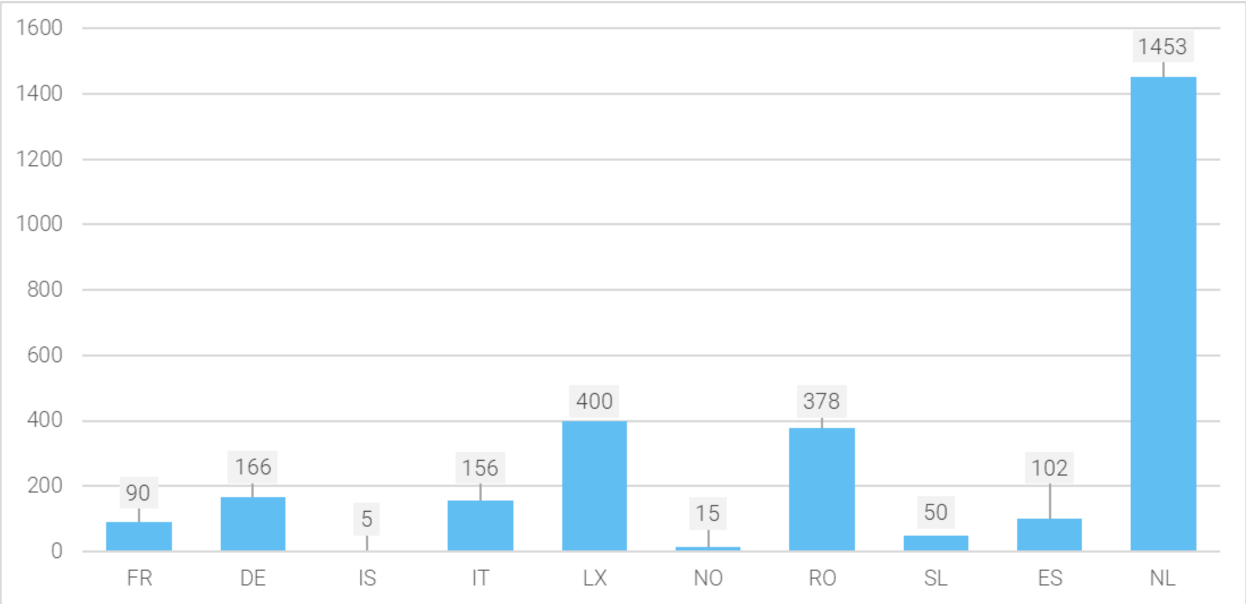



*Figure 29 – Average number of monthly customers for a CRFSI, per country. Datapoints collected in Q5.1 in DCP100+.*

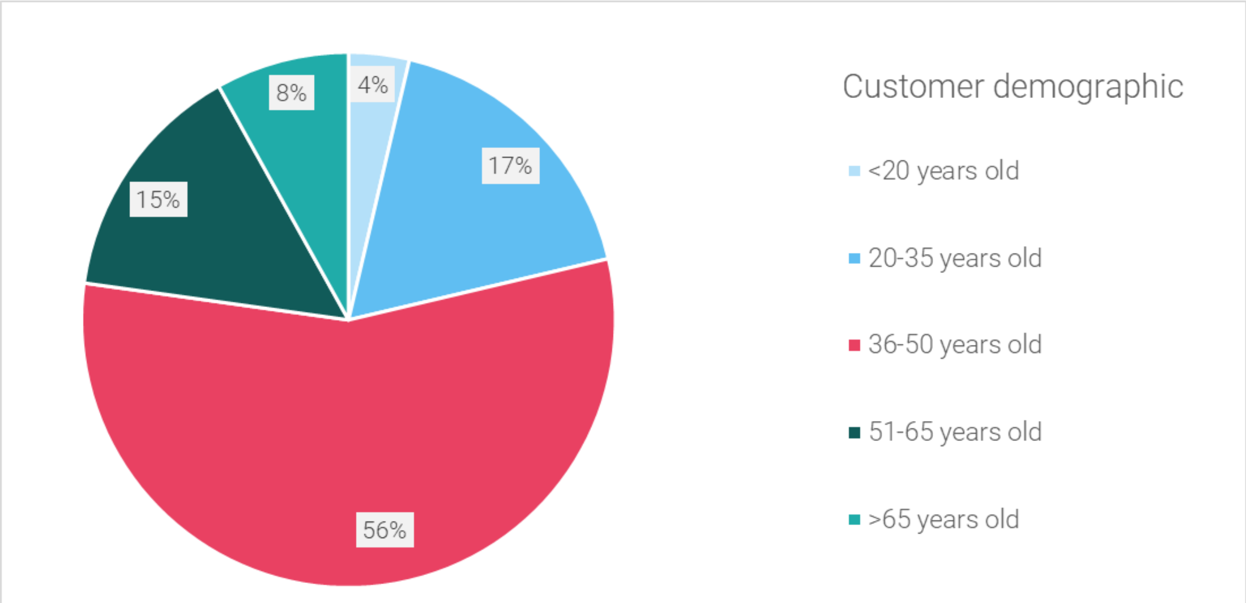



*Figure 30* – The average customer demographic with respect to age. Datapoints collected in Q5.2 in DCP100+.



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

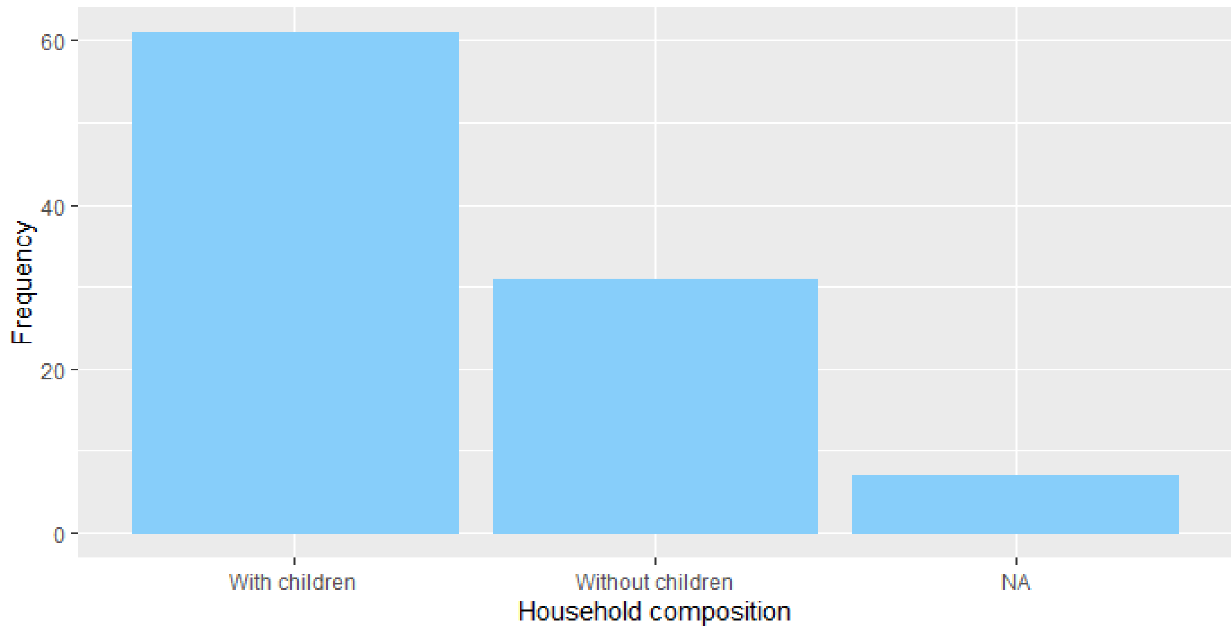



*Figure 31 – The average customer demographic with respect to family composition. Datapoints collected in Q5.3 in DCP100+.*

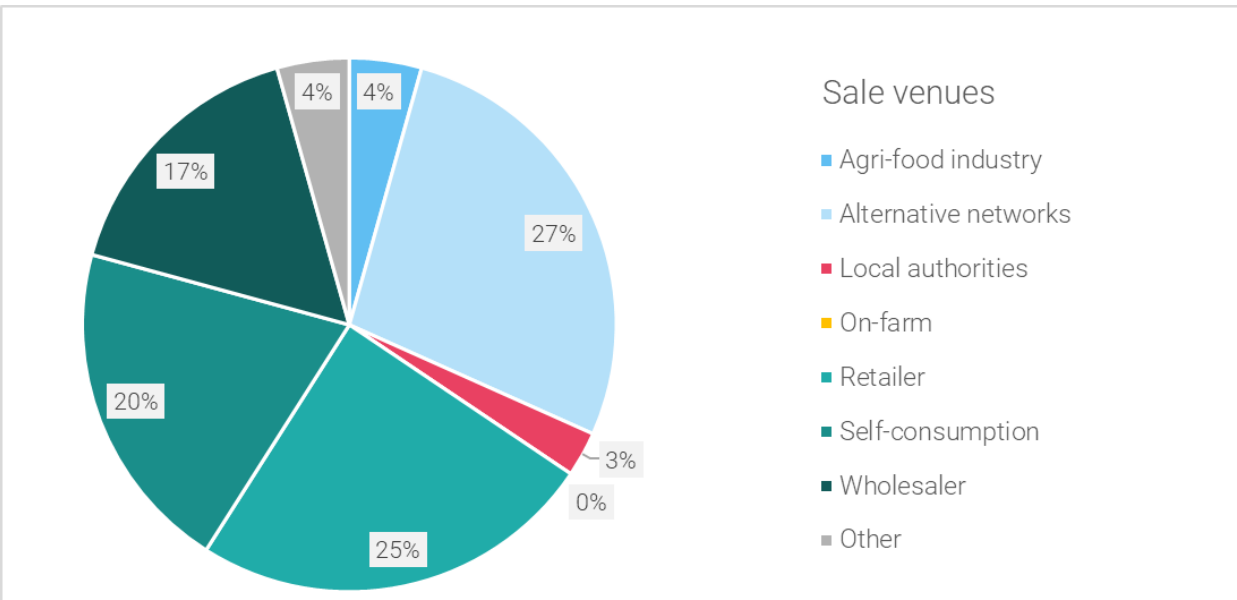



*Figure 32 – The distribution of sales venues used by CRFSI. Datapoints collected in Q6.1.2 in DCP600+.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

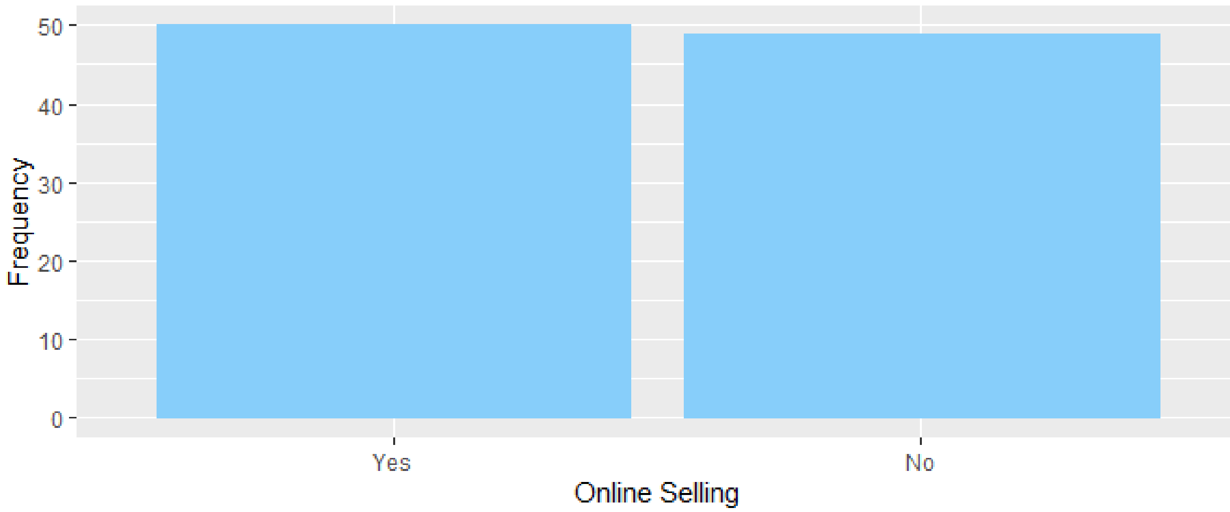



*Figure 33 – The use of digital versus traditional sales channels within CRFSI. Datapoints collected in Q4.11 in DCP100+.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

## 4.4 Social pillar

The **Social** pillar focused on the process for creating sustainable, successful places that promote and diffuse wellbeing. In the initial, simplified survey, an overview is generated on the size of the company, the number of employees and the diversity of staff. On the product side, it investigates key product characteristics, food labels, quality control standards, as well as the main sales channels. The second, detailed survey created a more detailed overview of the job creation & quality, community outreach, engagement & education, food quality and safety.

### 4.4.1 Workforce composition

A direct social impact is the creation of jobs within the community. Important factors are the number of jobs, compensation, workforce composition and training (Figure 34). Furthermore, gender balance is another predictor of a positive impact (Figure 35), and it is considered when assessing a job.

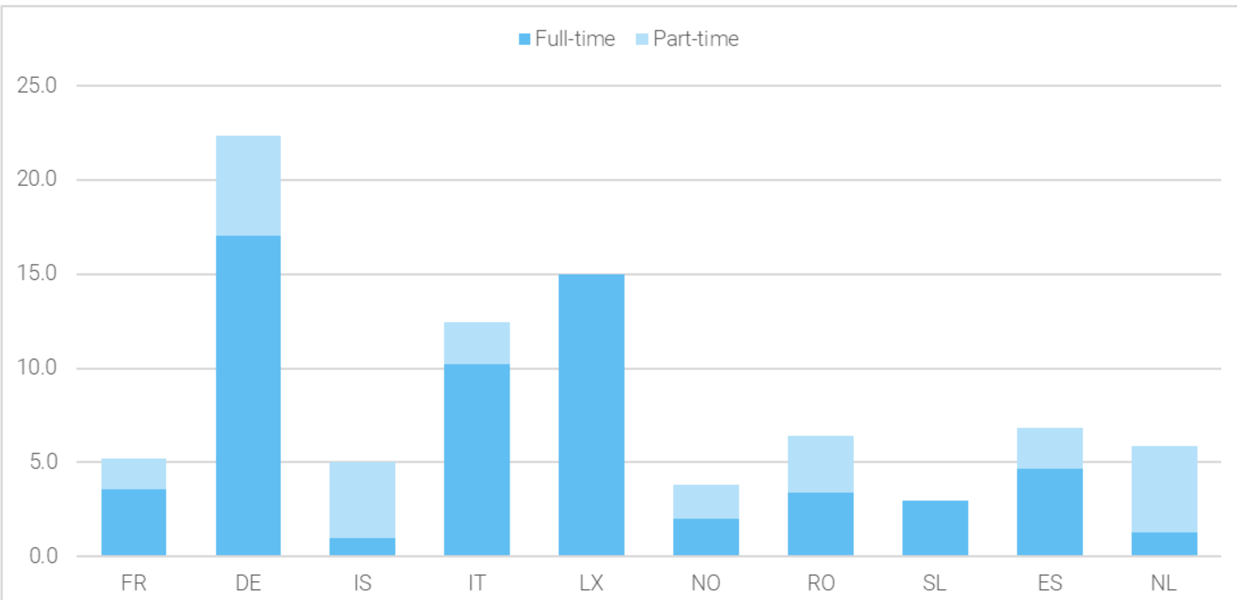



*Figure 34 – Average number of employees with full-time and part-time contract per CRFSI, per country. Datapoints were collected in Q3.1.4 and Q3.1.5 in DCP100+.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

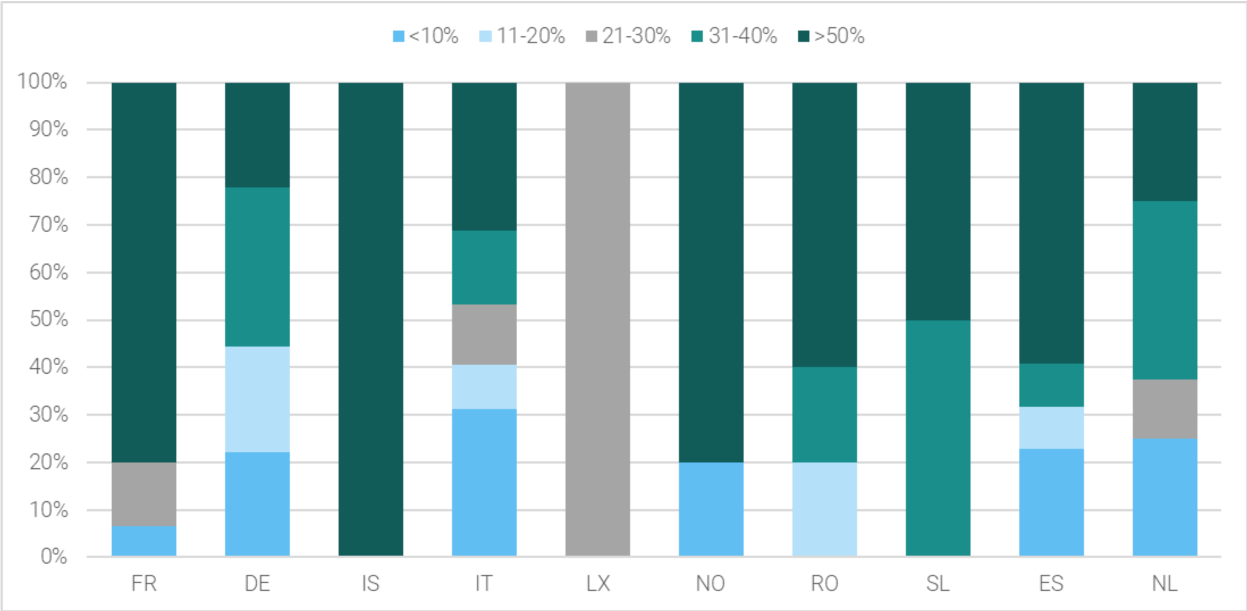



*Figure 35 – Gender balance of CRFSI, illustrated as the relative share of waged female employees, per country. Datapoints were collected in Q3.5 in DCP100+.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

### 4.4.2 Community integration

The direct social impact on the community is also closely related to engagement of a certain demography. It is typically measured in number and type of events organised (Figure 36), community training opportunities, or activities specifically organised for disadvantaged people in a community (Figure 37).

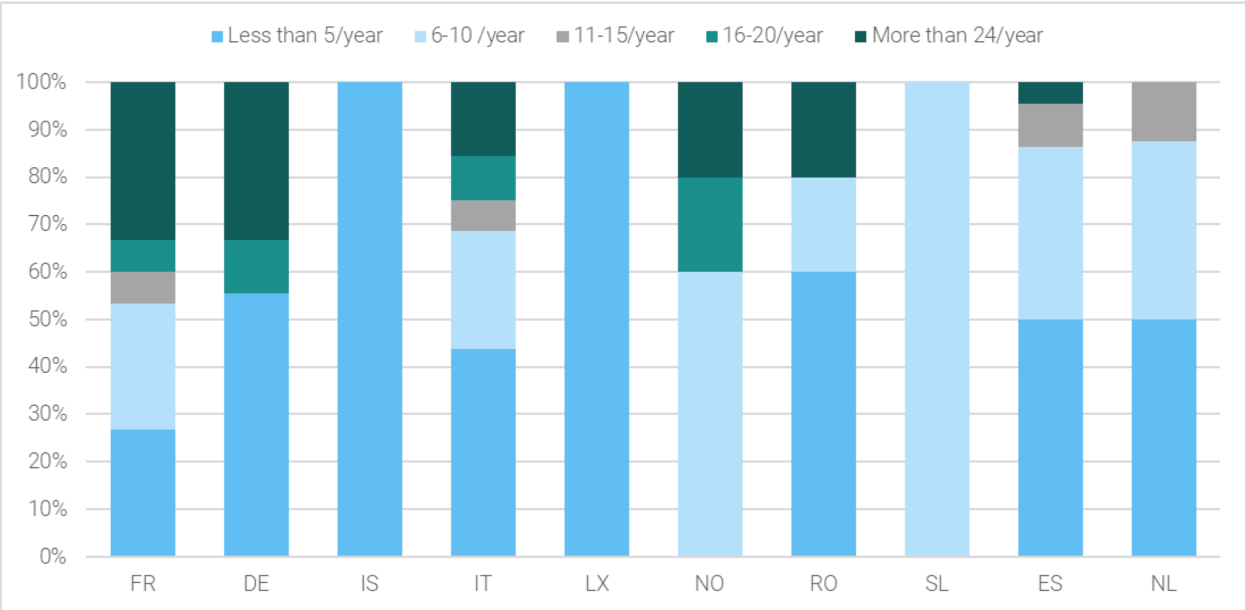



*Figure 36 – Frequency of activities organised by CRFSI for the local community. Datapoints were collected in Q3.6 in DCP100+.*

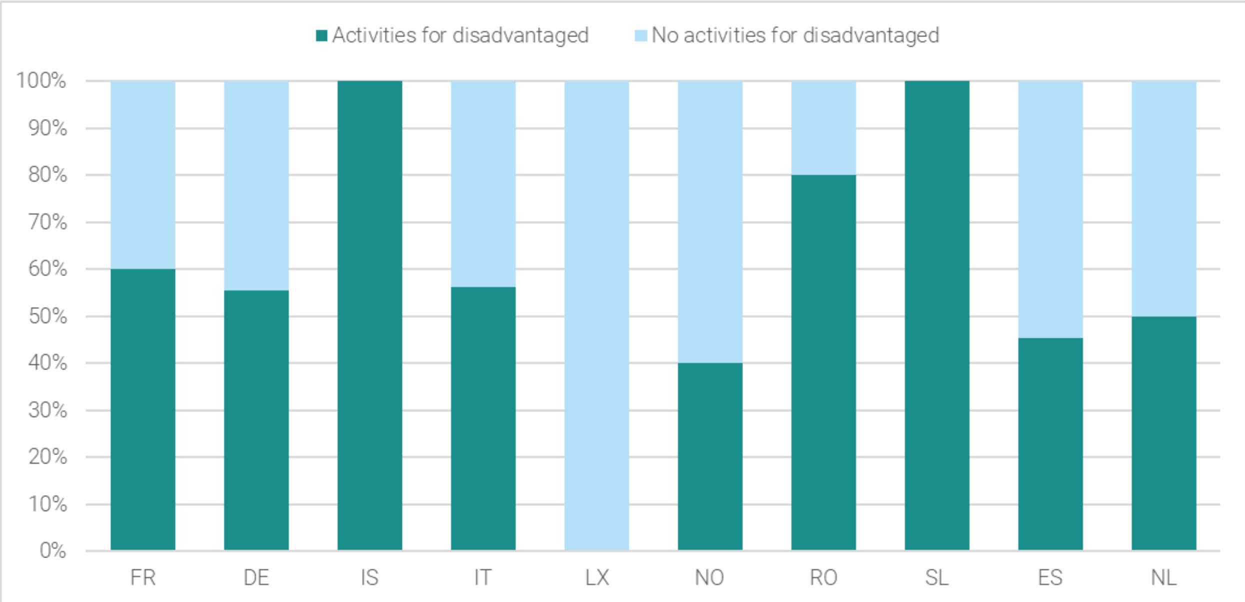



*Figure 37 – Activities for disadvantaged people in the community organised by CRFSI, per country. Datapoints were collected in Q3.7 in DCP100+.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

### 4.4.3 Food quality and safety

Quality characteristics include several perception factors (appearance, texture, and flavour) and products characteristics (price, animal welfare degree etc.) (Figure 38).

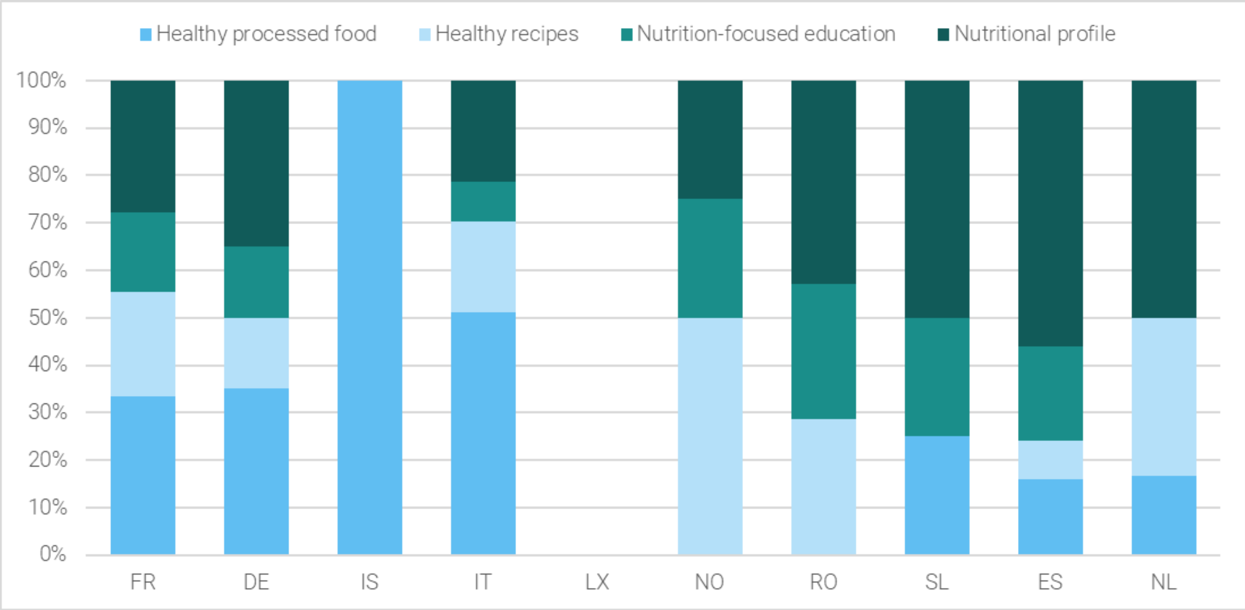



*Figure 38 – The main interest of customers of the CRFSI, per country. Datapoints were collected in Q5.4 in DCP100+. Luxembourg (LX) did not provide data.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

## 4.5 Future developments in light of market trends and COVID-19

The resilience and future development of CRFS was investigated by including their general trends and developments during COVID-19 and in the future. The CRFSI were asked to provide projections for the coming three years with respect to product sales, other revenue streams, general profits and the customers/clients/users (Figure 39-42).

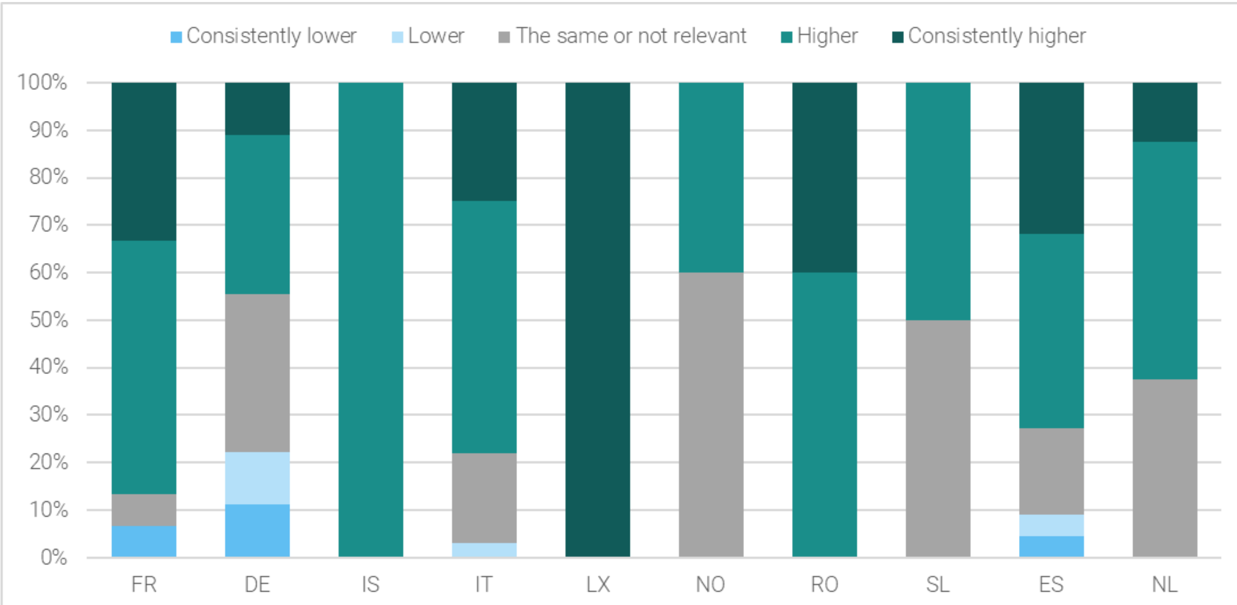



*Figure 39 – The projected development of product sales in light of COVID-19 and other development over the next 3 years, per country. Datapoints were collected in Q4.3.1 in DCP100+.*

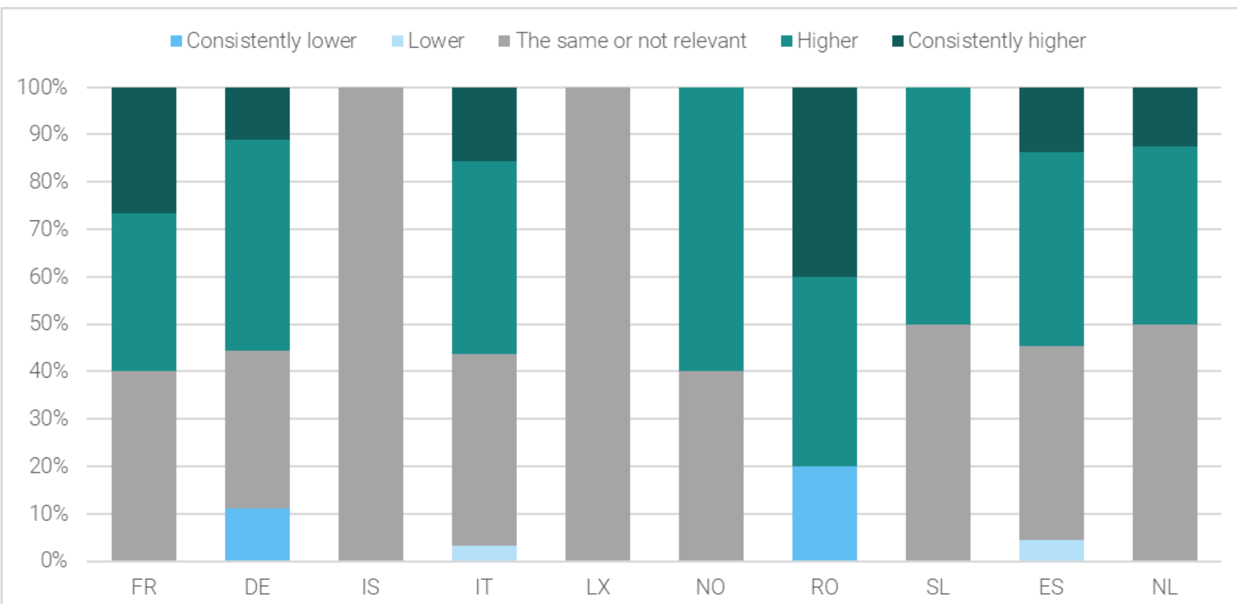



*Figure 40 – The projected development of other revenue streams in light of COVID-19 and other development over the next 3 years, per country. Datapoints were collected in Q4.3.2 in DCP100+.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

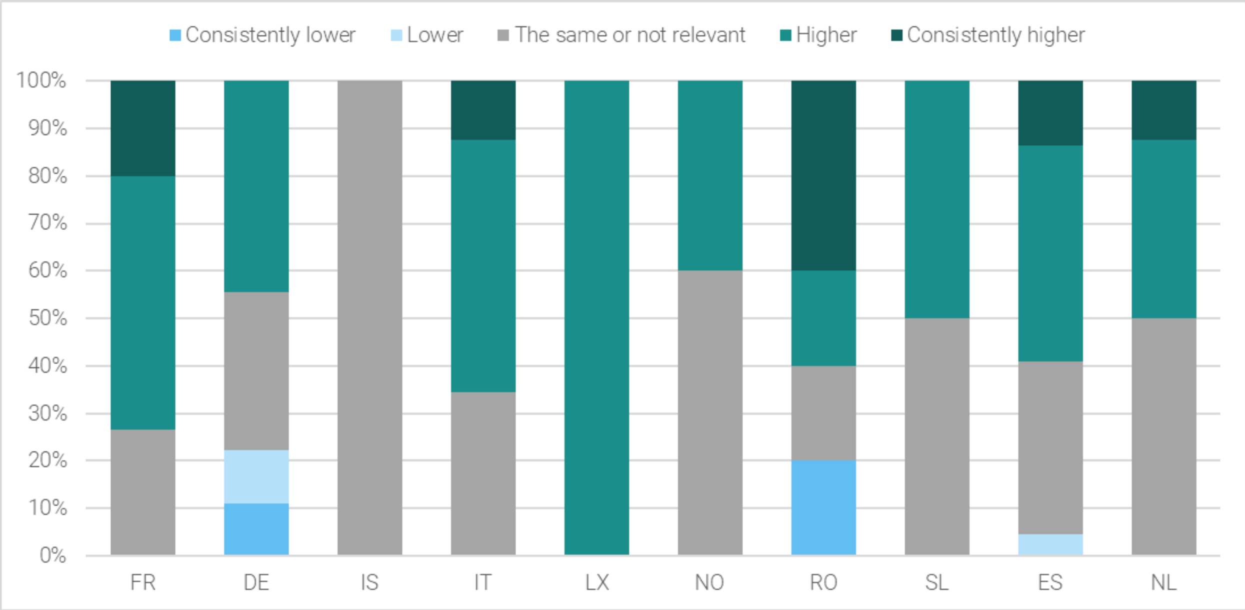



*Figure 41 – The projected development of general profits in light of COVID-19 and other development over the next 3 years, per country. Datapoints were collected in Q4.3.3 in DCP100+.*

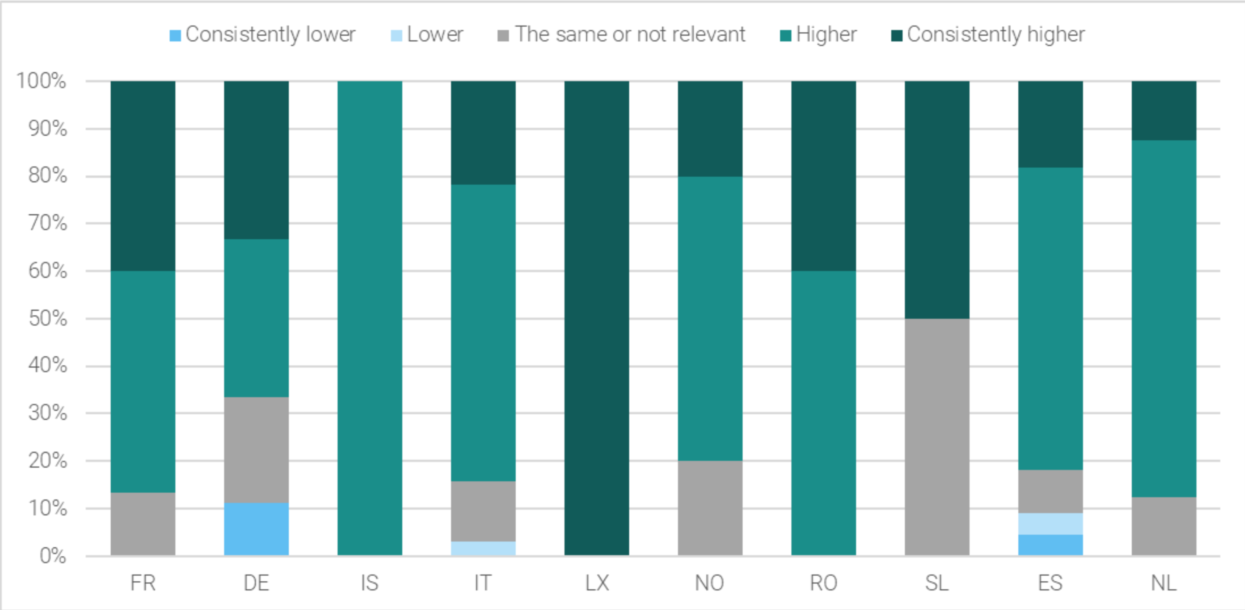



*Figure 42 – The projected development of consumers/clients/users in light of COVID-19 and other development over the next 3 years, per country. Datapoints were collected in Q4.3.4 in DCP100+.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

# 5. Conclusions

## 5.1 General

The data collection followed the methodological framework and data collection protocol outlined in D2.2 and D2.3, respectively. The data forms an overview of the structures, characteristics, interests and commitments of a multitude of CRFSI from throughout Europe. Various datapoints were illustrated in this report.

As further processing, analysis and interpretation of the data will be conducted in D2.5, few concluding remarks can be made on the data itself or the collection thereof. One remark is that in the collection of vast amounts of specialised data, such as in this report, a balance must be struck between broad applicability and precision. In the end, we were able to retrieve data from a broad variety of CRFSI. However, this data set still misses specific stakeholders, CRFS typologies, locations, etc. These data gaps are inherent to the task at hand. We have formulated lessons learned to guide future projects (Section 5.2)

## 5.2 Lessons learnt from data collection

Several potential risks and challenges for data collection were identified in D2.3. Their validity and relevance to the Data Inventory presented in this document are discussed below.

**Lesson 1: Influence of the consortium on CRFSI sample: identification, selection and contact**

The geographical spread of CRFSI indeed closely followed the spread of consortium partners and not the entirety of the European Union. Data collection from initiatives in other locations was inhibited by language barriers and affinity with the foreign market. Geographical spread could be improved in future studies by broader consortia, containing representatives of each target location. Local representatives and native speakers could circumvent a limited (English) online presence of initiatives.

**Lesson 2: Continuation of geographical spread**

The DCP100+ indeed perpetuated the geographical spread inherent in the original set of CRFSI from DCP600+, as new initiatives could not be reached due to the challenges listed above. In the future, the initial selection of CRFSI should already maximise the spread of initiatives. Subsequent surveys should take into account geographical location, typology, response rate and other characteristics to maintain an adequate spread throughout.

**Lesson 3: Applicability of questions**

The balance between general and detailed performance indicators resulted in some questions not exactly matching the operations of each CRFSI. This inhibited some CRFSI in providing answers and finishing the surveys. In turn, this complicated assessing the sustainability performance of these initiatives. Proper communication in an iterative process between the assessor and CRFSI were key to ensure adequate data collection.

**Lesson 4: Effect of COVID-19 pandemic on communication and participation**

The pandemic has presented and continues to present significant challenges to the agro-food system, which had an effect on response rate. It was reported as a key reason by participants of the first survey to not participate in the second survey. The withdrawal rate depended greatly on the type of stakeholder.

**Lesson 5: Workflow between collected data and literature reviews**



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

The workflow was specified so that literature reviews and data collection from CRFSI would be conducted in an iterative process. However, the scale of the literature reviews required a significantly longer process and the time pressure on data collection from CRFSI proved greater. This resulted in both processes becoming increasingly unlinked. For future projects it is recommended to start with literature reviews and use these as a foundation for the data collection from CRFSI.

# 6. Moving forward

Data was collected following the methodology developed in D2.2 and D2.3 and was partially presented in this report. The collected data was be used for the simplified sustainability assessment of 100+ CRFSI selected within the project FoodE (D2.5). The data that was collected within the three sustainability pillars can now be used in an integrated Life Cycle Thinking manner.



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

## A1. Appendix 1 – Literature review on Multifunctional Urban Agriculture.

**Title:** Features and Functions of Multifunctional Urban Agriculture in the Global North: A Review
**Authors:** Francesco Orsini, Giuseppina Pennisi, Nicola Michelon, Alberto Minelli, Giovanni Bazzocchi, Esther Sanyé-Mengual and Giorgio Gianquinto.
**Publication date:** 16 November 2020
**DOI:** 10.3389/fsufs.2020.562513

### Summary

In recent years, urban agriculture (UA) projects have bloomed throughout the world, finding large applications also in the developed economies of the so-called Global North. As compared to projects in developing countries, where research has mainly targeted the contribution to food security, UA in the Global North has a stronger multifunctional connotation, and results in multiple combinations of farming purposes and business models pursued. The present review paper explores the contribution and role that UA plays in cities from the Global North, defining its functionalities toward ecosystem services (ES) provisioning and analysing the factors that hinders and promote its regional diffusion and uptake. The manuscript integrates a description of UA growing systems, as well as opportunities for crop diversification in the urban environment, and a comprehensive classification of UA business models. The distinctive features in terms of business models, farming purposes, and farm size are then applied over an inventory of 470 UA projects in the Global North, allowing for a characterization and comparative analysis of distribution frequency of the different project typologies.

### Key results and conclusions

- Statistically significant association [X2 (25) = 92.568, p <0.000] between projects dimension class and business model typologies was observed.
- Share-economy business model is highly diffuse (>49% of the total) in small projects with a surface area lower than 5,000 $m^2$, while in general experience and experimental business models are less frequent for all the considered projects dimension class.
- From the standardized residual analyses, it emerged that diversification business model was more common (38.7%) for projects with a surface area ranging 25,001 to 100,000 $m^2$ as compared to the other projects dimension classes, while differentiation business model resulted more represented in the biggest project dimensions category (surface area > 100,000 $m^2$). On the other hand, the shared economy business model was statistically underrepresented.
- A statistically significant association [X2 (20) = 137.519, p < 0.000] between class of projects dimension and farming purposes was observed (Figure 3B, n = 407). In general, it was observed that social and educational purpose is highly represented (>54% of the total) in small projects with a surface area lower than 5,000 $m^2$, while for the biggest project category purpose is more common (80% of the total).
- From the standardized residual analyses, projects with commercial purpose resulted as underrepresented in small project category (surface area ≤1,000$m^2$), while being more common in projects belonging to the highest projects dimension class, a trend which resulted completely inversed for social and educational projects. Projects with image purpose also resulted overrepresented in the smallest project dimension class.
- Conversely, chi-square test did not show a statistically significant relation between class of projects dimension and cities population [X2 (25) = 41.639, p = 0.05, n = 417], between class



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

of projects dimension and category of city density [X2 (10) = 12.157, p = 0.275, n = 386] and between class of projects dimension and city climate [X2 (115) = 20.543, p = 0.152, n = 417].

## Key illustrations

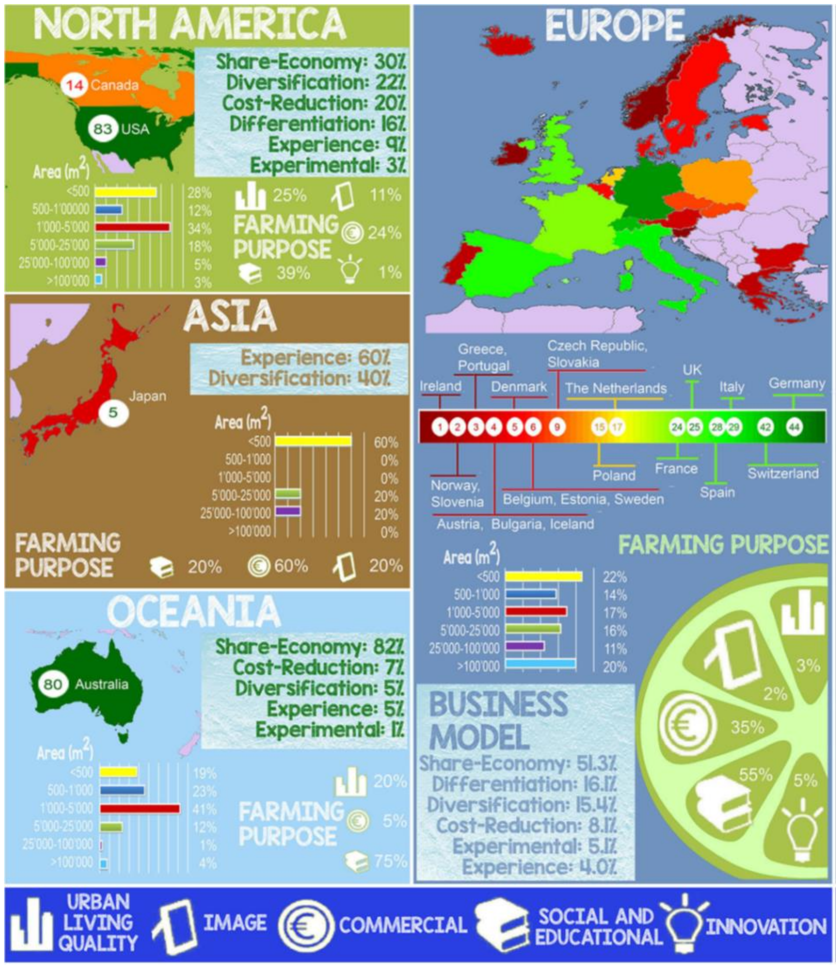



*Figure A1-1 – Infographics on the inventory of UA projects in the Global North countries. In white circles the number of cases per country, also reflected within country colour over the heatmap (e.g., red 0–10 projects per country, orange-yellow 10–20 projects per country, green more than 20 projects per country). In each World Region, figures on farm area, business model and farming purpose are integrated. Area charts represent the distribution frequency in the different size classes. Business models are classified in six categories: cost reduction, diversification, differentiation, share economy, experience, and experimental and placed in order of frequency. Farming purposes are classified accordingly in five categories: urban living quality, image, commercial, social and educational, innovation. Sample composed of 417 UA projects.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

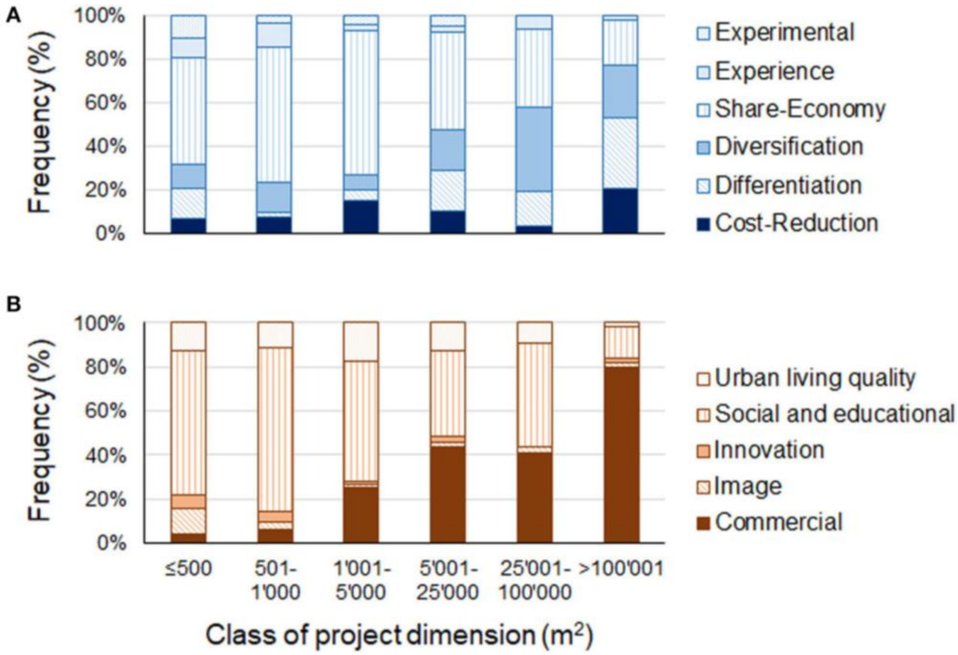



*Figure A1-2 – Relative distribution frequency (%) of business models (n = 399) and farming purposes (n = 407) with respect to the class of project dimension among the case studies included in the database.*

For the full work on Multifunctional Urban Agriculture, please visit:
[https://doi.org/10.3389/fsufs.2020.562513](https://doi.org/10.3389/fsufs.2020.562513)



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

## A2. Appendix 2 – Literature review on indoor LEDs light for specialized metabolites enhancement in valuable crops

**Title:** Beyond vegetables: effects of indoor LED light on specialized metabolite biosynthesis in medicinal and aromatic plants, edible flowers, and microgreens
**Authors:** Elisa Appolloni, Giuseppina Pennisi, Ilaria Zauli, Laura Carotti, Ivan Paucek, Stefania Quaini, Francesco Orsini and Giorgio Gianquinto
**Publication date:** 31 August 2021
**DOI:** 10.1002/jsfa.11513

### Summary

Specialized metabolites from plants are important for human health due to their antioxidant properties and light is one of the main factors modulating the biosynthesis of specialized metabolites. Recent developments in light emitting diode (LED) technology have enabled improvements in artificial light applications for horticulture. In particular, the possibility to select specific spectral light compositions, intensities and photoperiods has been associated with altered metabolite content in a variety of crops. This review aims to analyse the effects of indoor LED lighting recipes and management on the specialized metabolite content in different groups of crop plants (namely medicinal and aromatic plants, microgreens and edible flowers), focusing on the literature from the last 5 years. The literature collection produced a total of 40 papers, which were analysed according to the effects of artificial LED lighting on the content of anthocyanins, carotenoids, phenols, tocopherols, glycosides, and terpenes, and ranked on a scale of 1 to 3.

### Key results and conclusions

- Most studies applied a combination of red and blue light (22%) or monochromatic blue (23%), with a 16 h day$^{-1}$ photoperiod (78%) and an intensity greater than 200 ~mol m$^{-2}$ s$^{-1}$ (77%)
- These light features were often the most efficient in enhancing specialized metabolite content, although different performance variations were observed, according to the species considered and the compound analysed.
- The review aims to provide valuable indications for producers or researchers for the definition of the most promising spectral components toward the achievement of nutrient-rich indoor-grown products depending on the specialized metabolite to be enhanced.



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

## Key illustration

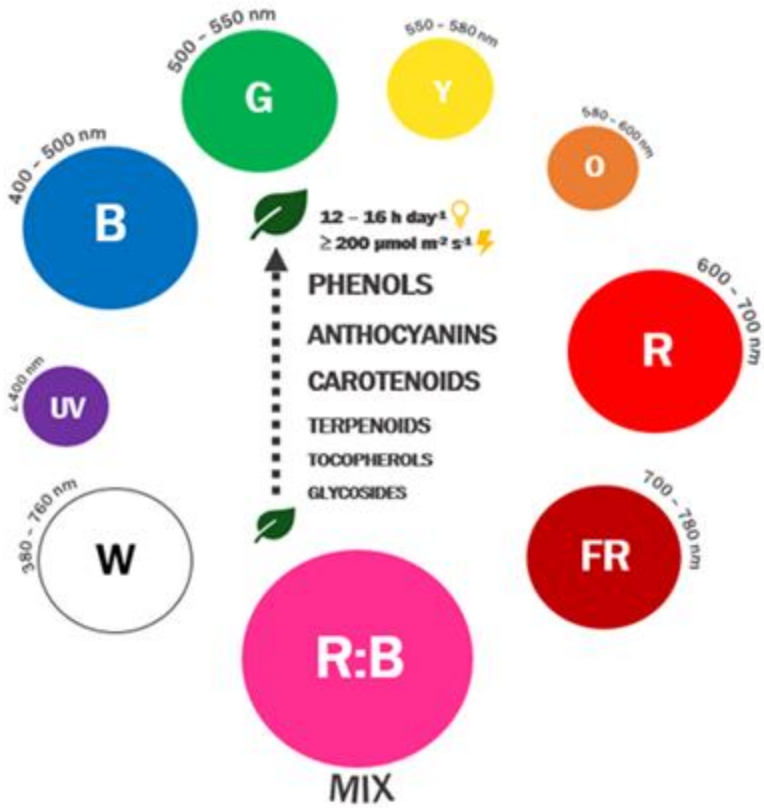



*Figure A2-1 – Main light spectra, intensity, photoperiod and secondary metabolites investigated*

For the full work on indoor LEDs lights for specialized metabolite enhancement, please visit: https://doi.org/10.1002/JSFA.11513



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

## A3. Appendix 3 – Literature review on supplemental LED light for greenhouse tomato cultivation

**Title:** Supplemental LED Lighting Effectively Enhances the Yield and Quality of Greenhouse Truss Tomato Production: Results of a Meta-Analysis
**Authors:** Elisa Appolloni, Francesco Orsini, Giuseppina Pennisi, Xavier Gabarrell Durany, Ivan Paucek, Giorgio Gianquinto
**Publication date:** 29 April 2022
**DOI:** 10.3389/fpls.2021.596927

### Summary

Greenhouse-grown truss-tomato (Solanum lycopersicum) is characterized by long stems usually trained in high-wire systems, which apply high plant density to increase cultivation performances. However, these intensive growing systems, together with light interception of greenhouse cladding materials and climatic characteristics (e.g., cloudy days, high latitude), may determine intra-canopy mutual shadings and sub-optimal lighting conditions. In this context, artificial supplemental lighting may represent an opportunity to improve quantitative and qualitative aspects of production, especially if performed with highly efficient light emitting diodes (LEDs). A wide number of studies investigating the topic are available in literature. However, research results are often diversified as a consequence of variable lighting, environmental and cultivation conditions among performed experiments. The hereby research presents a meta-analysis with the aim to answer the following research question: does supplemental LED enhance yield and qualitative aspects of greenhouse-grown truss tomato? The study was based on a literature review of 31 published papers and 100 total observations analysed by the difference among independent groups. as compared to control conditions, while not significant alterations were observed for stomatal conductance.

### Key results and conclusions

- Results showed a significant positive effect of supplemental LEDs lighting enhancing yield (+40%), fruit soluble solids (+6%) and ascorbic acid (+11%) contents, leaf chlorophyll content (+31%), photosynthetic capacity (+50%) and leaf area (+9%).
- Stomatal conductance did not show any significant alteration in case of application of supplemental LED light.
- Supplemental LED lighting can effectively enhance yield and quality of greenhouse truss tomato.



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

## Key illustrations

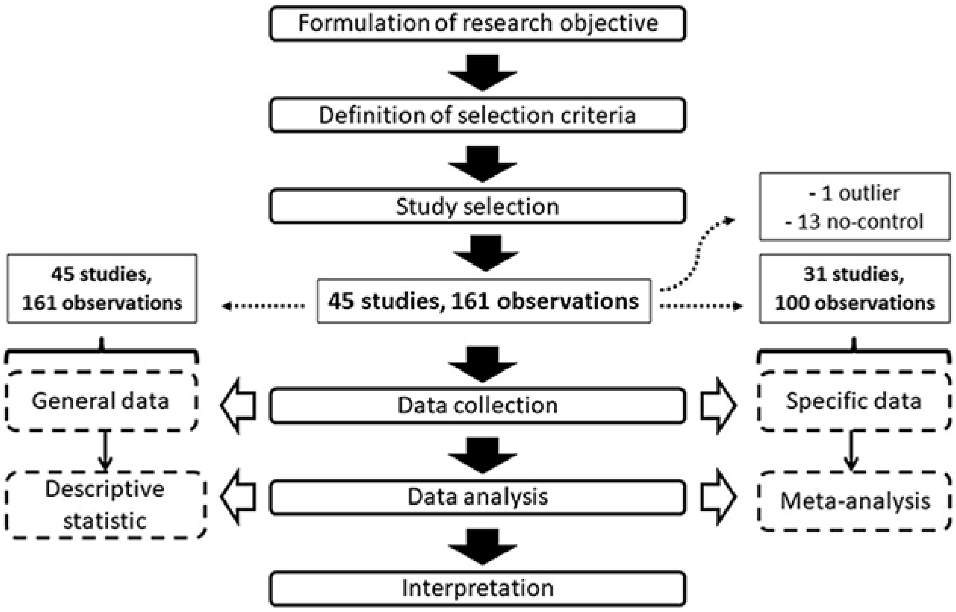



*Figure A3-1 – Flow diagram showing the steps of the study selection and analysis.*

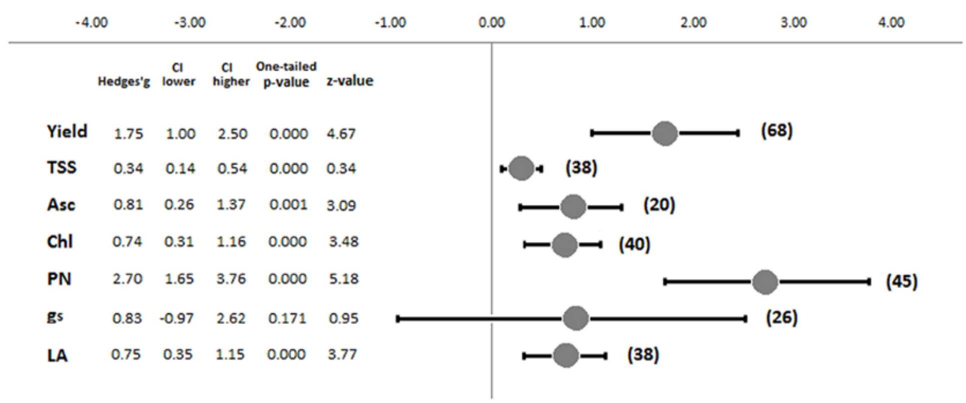



*Figure A3-2 – Forest plot showing the statistical meta-analytic evaluation the investigated parameters (Yield, Yield; TSS, soluble solid content; Asc, ascorbic acid content; Chl, chlorophyll content; PN, photosynthetic capacity; gs, stomatal conductance; LA, leaf area). Numbers within brackets refer to k response ratios. The meta-analysis parameters are the effect size value (Hedges'g), low and high confidence intervals (CI), and tests of the null hypothesis (one-tailed p-value and z-value).*

For the full work on the Review on supplemental LED light for tomato production, please visit: https://doi.org/10.3389/fpls.2021.596927



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

## A4. Appendix 4 – Literature review on sustainability of plant factories with artificial lightning

**Title:** Sustainable use of resources in plant factories with artificial lightning (PFALs)
**Authors:** Francesco Orsini, Giuseppina Pennisi, Farhad Zulfiqar and Giorgio Gianquinto.
**Publication date:** October 2020
**DOI:** 10.17660/eJHS.2020/85.5.1

### Summary

Plant Factories with Artificial Lightning (PFALs) are spreading due to the claimed efficiency in natural resources use, although at the cost of higher energy needs as compared with more traditional food systems. In recent years, research literature on PFAL technological features and management protocols has bloomed, mainly targeting innovation in lightning technologies, growing systems and environmental control units. To date, however, a comprehensive analysis of resource use and environmental impacts associated with PFAL systems is lacking. The present review paper aims at providing valuable insight on PFAL sustainability and compare their applications against current technologies and food systems with a special focus on resource use efficiency.

### Key results and conclusions

Strategies for PFALs sustainability improvement based on Energy Use Efficiency (EUE), Land Surface Use Efficiency (SUE), and Water Use Efficiency (WUE).

- Lamps: The use of movable lamps to reduce initial investment costs; Different lamps typologies influence EUE. Higher diodes PPE increase EUE; Use of zoom lens increase EUE.
- Spectral composition: RB≥3 increase WUE, SUE, EUE in basil and lettuce; RB≥2 increase WUE, SUE, EUE in rocket and chicory; RB=2.7 and RB=4 increase EUE in lettuce.
- Light intensity: Increased light intensities reduce EUE.
- Growing system: Vertical columns increase SUE as compared with horizontal systems, but decrease plant size; Adaptive plant spacing increase SUE; Aeroponics increase WUE.
- Climate management: Dehumidification of water from internal air allows to water transpired by plants and increase WUE; Use of co-generation system increase EUE as compared with heat pumps; Changes in insulation (U-value) and albedo of façades affect EUE; Use of fibre-optic solar energy transmission system increase EUE; Use of solar collectors and optical fibres to integrate solar radiation in PFALs for increased EUE.



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

## Key illustrations

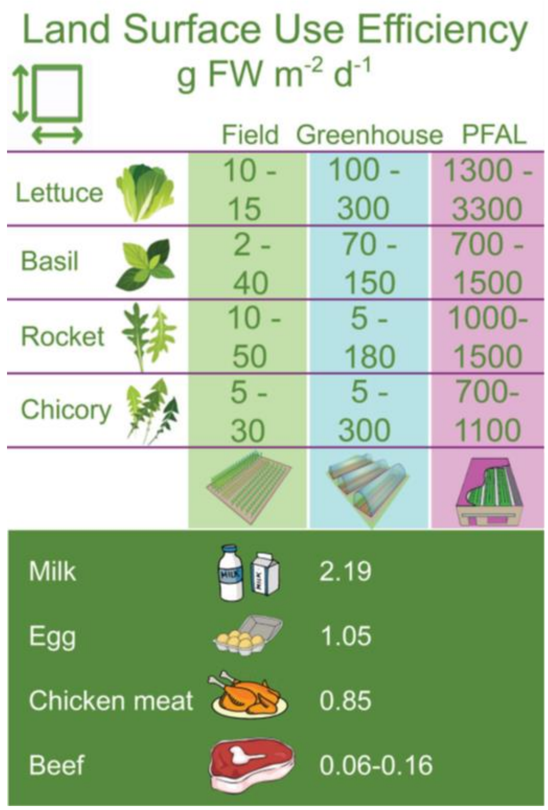
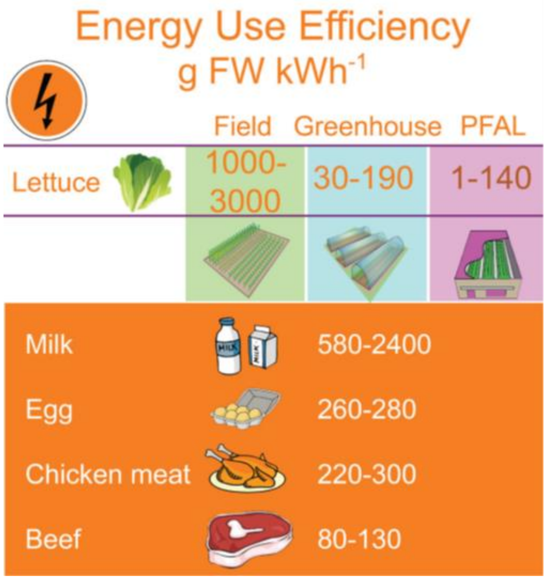




*Figure A4-1 – Water Use Efficiency of selected food products in response to the cropping/production system. Value ranges retrieved from literature.*

*Figure A4-2 – Land Use Efficiency of selected food products in response to the cropping/production system. Value ranges retrieved from literature.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.



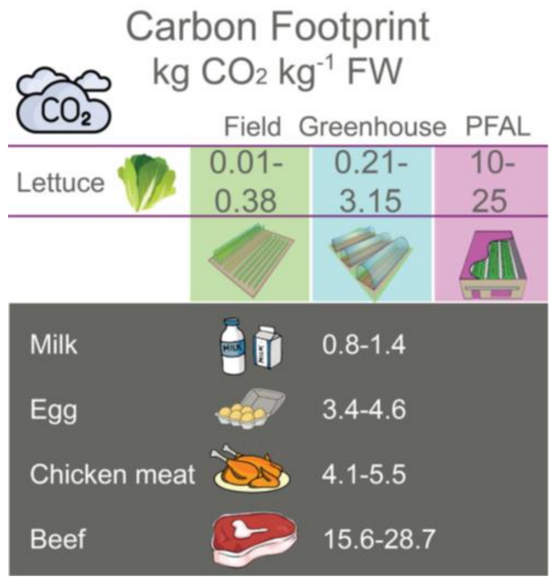




*Figure A4-3 – Energy Use Efficiency of selected food products in response to the cropping/production system. Value ranges retrieved from literature.*

*Figure A4-4 – Carbon Environmental impact assessment of selected food products in response to the cropping/production system. Value ranges retrieved from literature.*

For the full work on the Review on sustainability of plant factories with artificial lightning, please visit: https://doi.org/10.3389/fsufs.2020.562513

## A5. Appendix 5 – Closed-Loop Crop Cascade to Optimize Nutrient Flows and Grow Low-Impact Vegetables in Cities



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

**Title:** Closed-Loop Crop Cascade to Optimize Nutrient Flows and Grow Low-Impact Vegetables in Cities
**Authors:** Rufí-Salís M, Parada F, Arcas-Pilz V, Petit-Boix A, Villalba G and Gabarrell X.
**Publication date:** November 2020
**DOI:** 10.3389/fpls.2020.596550

## Summary:

Urban agriculture systems can significantly contribute towards mitigating the impacts of inefficient and complex food supply chains and increase urban food sovereignty. Moreover, improving these urban agriculture systems in terms of nutrient management can lead to a better environmental performance. Based on a rooftop greenhouse in the Barcelona region, we propose a cascade system where the leachates of a tomato cycle from January to July (donor crop) are used as the main irrigation source for five successive lettuce cycles (receiving crop). By determining the agronomic performance and the nutrient metabolism of the system, we aimed to define the potential of these systems to avoid nutrient depletion and mitigate eutrophication, while scaling the system in terms of nutrient supply between the donor and the receiving crops. The results showed that low yields (below 130 g per lettuce plant) are obtained if a cascade system is used during the early stage of the donor crop, as the amount of nutrients in donor's leachates, especially N (62.4 mg irrigated per plant in the first cycle), was not enough to feed the lettuce receiving crop. This effect was also observed in the nutrient content of the lettuce, which increased with every test until equaling the control (4.4% of N content) as the leachates got richer, although too high electrical conductivity values (near 3 dS/m) were reached at the end of the donor crop cycle. Findings on the uptake of the residual nutrient flows showed how the cascade system was able to take advantage of the nutrients to produce local lettuce while mitigating the effect of N and P in the freshwater and marine environments. Considering our case study, we finally quantified the scale between the donor and receiving crops and proposed three major ideas to optimize the nutrient flows while maintaining the yield and quality of the vegetables produced in the receiving crop.

## Key Results and Conclusions

The present paper has presented an evaluation of a cascade system with a long-cycle tomato donor crop and five successive cycles of lettuce. The assessment of the agronomic performance and the nutrient flows have shed light on the potential of these systems to mitigate nutrient depletion in cities while producing food in the framework of urban agriculture. The variation of nutrient content of the leachates produced by the donor crop is a key parameter to plan the amount of plants that can be planted of the receiving crop. The early stage of the donor crop could only produce 0.1 lettuces per tomato plant, with N as the limiting nutrient. On the other hand, the late stage of the donor crop was able to leach enough nutrients to feed 9 lettuces per tomato plant. However, attention must be paid on the electrical conductivity of the water flow to stay within non-harmful values. Nevertheless, the cascade system was shown to be efficient to mitigate the nutrient discharge of open systems, especially in terms of N and P to avoid eutrophication impacts in the early stage of the tomato crop. To this end, a good scaling between the two crops of the system is vital to tap the full potential of the cascade set-up, while having different options in terms of system management. Given the findings of this study, we encourage future researchers to test



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

different kind of horticultural crops. Considering the nutritional problems in the beginning of the cycle of the donor crop and the harmful salinity that can be reached at the end, further research should test possible combinations of donor and receiving crops that minimize these two problems. Reporting the limitations of these kind of systems is key to a transparent process of decisionmaking in the implementation of optimization strategies in urban agricultural systems. In terms of experimental design, further research assessing the nutritional flows of cascade systems should increase the number of plants that will be analyzed in terms of nutrients to precisely determine the variability of concentrations within the same treatment and test

For the full article please visit: [Frontiers | Closed-Loop Crop Cascade to Optimize Nutrient Flows and Grow Low-Impact Vegetables in Cities | Plant Science (frontiersin.org)]

## A6. Appendix 6 –Formalizing Objectives and Criteria for Urban Agriculture Sustainability with a Participatory Approach

**Title:** Formalizing Objectives and Criteria for Urban Agriculture Sustainability with a Participatory Approach



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

**Authors:** Paola Clerino, Agnès Fargue-Lelièvre
**Publication date:** September 2020
**DOI:** 10.3390/su12187503

## Summary:

The last few years have seen an exponential development of urban agriculture projects within global North countries, especially professional intra-urban farms which are professional forms of agriculture located within densely settled areas of city. Such projects aim to cope with the challenge of sustainable urban development and today the sustainability of the projects is questioned. To date, no set of criteria has been designed to specifically assess the environmental, social and economic sustainability of these farms at the farm scale. Our study aims to identify sustainability objectives and criteria applicable to professional intra-urban farms. It relies on a participatory approach involving various stakeholders of the French urban agriculture sector comprising an initial focus group, online surveys and interviews. We obtained a set of six objectives related to environmental impacts, link to the city, economic and ethical meaning, food and environmental education, consumer/producer connection and socio-territorial services. In addition, 21 criteria split between agro-environmental, socio-territorial and economic dimensions were identified to reach these objectives. Overall, agro-environmental and socio-territorial criteria were assessed as more important than economic criteria, whereas food production was not mentioned. Differences were identified between urban farmers and decision makers, highlighting that decision makers were more focused on projects' external sustainability. They also pay attention to the urban farmer agricultural background, suggesting that they rely on urban farmers to ensure the internal sustainability of the farm. Based on our results, indicators could be designed to measure the sustainability criteria identified, and to allow the sustainability assessment of intra-urban farms.

## Key Results and Conclusions

Our study identified a set of sustainable objectives and criteria applicable to French PIUA. The objectives are mainly related to external sustainability, highlighting that stakeholders expects PIUA to have many impacts on the sustainable development of cities. The participatory process of our study allows us to identify the importance given to the different objectives and criteria by the stakeholders. Agro-environmental and socio-territorial criteria are assessed as more important than economic criteria. PIUA sustainability fits into the trends observed in Europe, or Hong Kong, with an emphasis on external sustainability aspects, aiming environmental, social and economic benefits for the global society, and pushing aside food production. The opposite can be found in global South countries where food production is a major goal for urban agriculture, completed by benefits directly aimed at the farmers. The sustainability criteria developed in this study might be applied on urban farms in other global North countries, however their direct application on urban farms in the global South or on peri-urban farms and community gardens in the global North might not be relevant. Therefore, it seems that sustainable PIUA in France is a form of agriculture that provides a variety of services to the city and city dwellers apart from food production, and that decision makers are ready to subsidize these projects. Decision makers and advisors focus on urban farmers' background, suggesting that they also rely on urban farmers to ensure internal sustainability of the farm. By relying on our results, indicators could be designed



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.

to measure the sustainability criteria identified, and to allow the sustainability assessment of PIUA projects, as expected by PIUA stakeholders.

For the full article please visit: https://doi.org/10.3390/su12187503

## Key illustrations

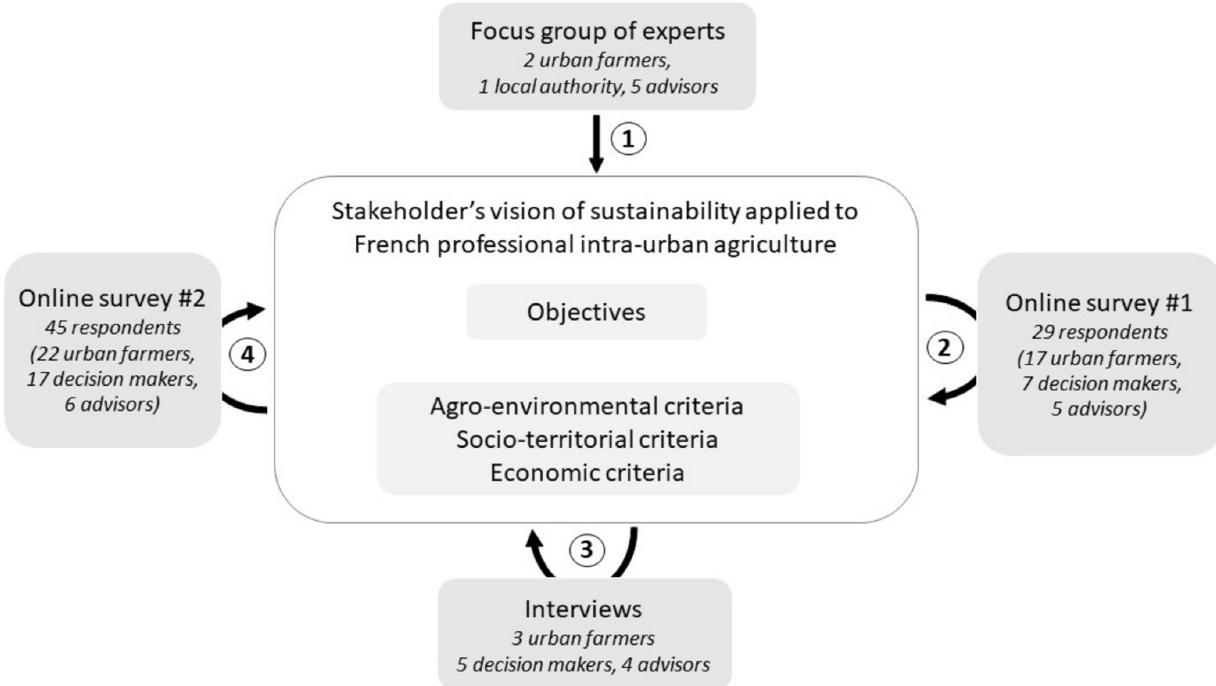



*Figure A6- 1. Participatory process to elaborate sustainability objectives and criteria for professional intra-urban agriculture.*



This project has received funding from the European Union's *Horizon 2020 research and innovation programme* under grant agreement No 862663.