Food Systems Science Network

Higher Education Food Systems Curricula

Deliverable D 5.2

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Executive summary

The aim of this report is to map and analyze existing curricula in higher education programs in the field of food systems science in order to set the basis for future curricula development. A literature review about the Food Systems education, Skills for the future and Transforming principles into practices, together with the FoSSNet Conceptual Framework provides the basis for the mapping, which was conducted by a mixed methods approach, including a qualitative analysis of educational texts, an informatics based analysis to map Bloom's taxonomy in the educational documents, and a survey to educators.

The mapping demonstrates a growing diversity of Food Systems Programs and courses, with pedagogical approaches that are skills oriented, emphasizing Real-World Learning and interdisciplinary, problem-based, and experiential learning strategies. The educational programs are geographically distributed and internationally networked. While bachelor programs and lifelong learning initiatives exist, most food systems programs are found at Master's level.

The informatics study of Bloom's taxonomy confirmed that the Food systems programs generally align with broader trends in European Master's-level, with an emphasis on higher-order cognitive processes, particularly those associated with the Create and Evaluate domains. One concern is the possibility of gaps in foundational learning support which calls for a clear focus on practices for inclusion of, and support to, students from underrepresented backgrounds.

The Educators' survey further underlined the importance of inclusion, both of underrepresented groups and disciplines, and perspectives. A broadened geographic representation is also important for achieving a more inclusive education. The Educators' survey also pointed at prevailing disciplinary barriers, and a general sense of fragmentation.

For further development, to align curricula more closely with the competencies required for system transformation, innovation and inclusive governance is key. Strategic curriculum reform should prioritize interdisciplinarity, applied systems thinking, stakeholder engagement, and the development of human-centered competencies, ensuring graduates are equipped to lead the transition toward sustainable and equitable food futures. Therefore, efforts to expand food systems education in basic and undergraduate studies and to underrepresented regions in Europe should be made. To provide courses and modules for professionals and to provide them with the tools to apply food systems thinking in their everyday work in the food sector is another key task for development.

As next steps, FoSSNet in Collaboration with CLEVERFOOD, FoodCLIC, Food Paths and other related projects will continue the development of a higher education network for food systems education and literacy. Based on the findings in this report, a collaborative curriculum design and piloting of next generation food systems curriculum will take place.

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Abbreviations

Abbreviation	Explanation
HEI	Higher Education Institutions
CF	Conceptual Framework
FSS	Food Systems Science

1. Introduction – Why map food systems education in higher education institutions?

This deliverable is the first step in FoSSNet's task 5.2, the development of next generation Food Systems Science curricula. The aim is to map and analyze the existing curricula in higher education programs in the field of food systems science in order to set the basis for future curricula development.

1.1 Background

Today, the challenges facing the food system demand immediate action. To foster a new generation of talented individuals, researchers, and professionals who possess the knowledge, skills, and techniques needed to become agents of change for a sustainable and resilient food system is essential for successfully transitioning our food system. Indeed, the complexity of the food system necessitates new approaches that contemplate systemic methods to identify relationships between parts of the food system, thereby supporting the resolution of challenges.

Developing food systems education is therefore an important task for higher education institutions. This report is an attempt to set a baseline for further development of food systems education in Europe by analyzing the current status of food systems education and curricula and presenting suggestions for next steps for curricula development.

Scientific literature is casting a growing awareness that the current educational system is not optimized to deal with complex challenges, nor does it equip students with the accurate tools to address these complex challenges, as evidenced in R&I and policy development (Carino et al., 2020; Den Boer et al., 2021, Sørensen et al., 2021). Two policies in the European educational landscape are particularly important here: firstly, the Bologna process, which streamlines higher education in Europe, facilitates collaboration between universities, and, not least, promotes the mobility of students and the recognition of education in other European countries. Secondly, a dedicated focus on lifelong learning focusing on professionals, to broaden the field of education as well as the target learners groups for courses and programs. In combination, these changes have resulted in a movement toward focusing more on developing skills rather than a set of pre-defined knowledge as the goal for higher education.

1.2 Skills for the future

Over the past number of decades, the role of new skills for achieving a more sustainable food system has been discussed in several research disciplines. Back in 1993, Newcomb (1993) proposed leadership programs, extension education, agricultural communication and international development curricula to university agricultural education. More recent research includes that performed by Charatsari and Lioutas (2019) who stressed the importance of

cultivating ‘soft skills’, including communication, collaboration, consultancy, and interpersonal skills, while others have identified network-building capacities (Lamichhane et al., 2016), facilitation expertise (Moschitz et al., 2015), entrepreneurial monitoring and co-innovation (Dogliotti et al., 2014), and guidance capabilities (Wezel et al., 2014), just to name but a few examples from the scientific literature dealing with skills development in the agrifood sector.

In the context of education, suggestions to encourage interdisciplinarity (Bryant et al., 2014), developing systems thinking (Hilimire et al., 2014), experiential learning (Ahmed et al., 2017), promoting collective action and encourage critical reflection and self-reflection (Valley et al., 2018) have been made. To overcome silo thinking and a limited scope of education, a more systemic and holistic approach in farming (Francis et al., 2017), rural development (Wals et al., 2004), and agronomic research and education (Vietor, 2018) is recommended.

Systems thinking is key in food systems approaches (Martin et al., 2024), which focus on relations between different food systems components and actors in working toward desired food systems outcomes (Ericksen, 2008; IPES, 2015). This understanding of food systems as relational and systemic has been widely adopted by organizations recognized to be implementing and defining food systems approaches, including the CGIAR (Liebig et al., 2022), IPES Food, and the Committee on World Food Security’s (CFS) High Level Panel of Experts (HLPE).

Interdisciplinarity is an integral aspect of food systems science (Drewnowski et al., 2020; Grace et al., 2020; Pope et al., 2021b; IPES, 2015), where disciplines of health, economics, society and the environment come together (Drewnowski et al., 2020), as there is no single solution to food systems challenges (Béné et al., 2019; Bustamante et al., 2024; de Vries et al., 2022; Ingram, 2019). This interdisciplinarity is challenging because different disciplines frame food systems challenges and solutions differently (Béné et al., 2019; LEI International Policy et al., 2020; Westengen et al., 2025). In their study, Huisman et al. (2020) conclude that a combination of interdisciplinary approaches, collaboration between educators, students and external stakeholders, and internationalization are important in order to break the current silos of national perspectives, limited collaboration both within and beyond academia, and to treat students and teachers as collaborators in the development of transforming practices to address societal challenges.

Another important issue is to not only think of Food systems learning in longer university programs at EU level, but rather as micro-credential for professional education and CPD (continuous professional development), preferably in collaboration between HEIs, the food sector and other stakeholders (Viaggi et al., 2021, Directorate-General for Education, Youth, Sport and Culture European Commission, 2017; Nix & Fink, 2022; IPES, 2015).

For stakeholders to engage in the complex dynamics of food systems, they need to have a functional minimal understanding of the different food systems components and disciplines involved (Pope et al., 2021). This food systems literacy is defined as the degree of competence that an individual has to analyze, communicate about and address challenges in food systems (Pope et al., 2021).

In addition, different actors have different roles, which are also shifting continuously (European Commission. Directorate General for Research and Innovation 2019). Lifelong learning initiatives (including both professional education and various continuous education programs) should address learning of the skills needed to become food systems literate, and thus integrate different knowledges in food systems science from their professional perspective. Although there is no scientific agreement on the skills needed for food systems transformation, the importance of integrating different disciples is shared by many (Sørensen et al., 2021).

As a result of this growing awareness, numerous initiatives to define skills for the future to deal with complex issues related to systems and sustainable development have been launched.

The framework *Key competencies in Sustainability Framework* by Redman & Wiek (2021) highlight eight competencies for driving sustainability transformations:

- Systems thinking
- Futures thinking
- Values thinking
- Strategic thinking
- Interpersonal skills
- Intrapersonal skills
- Implementation skills
- Integration skills.

This framework was used in the CleverFood *Guidance document on transforming higher education teaching* (Urias & Rao 2024), where the alignment between learning outcomes in HEIs' Food Systems programs and the framework was examined.

The JRC Policy for science report GreenComp – The European sustainability competence framework (Bianchi et al., 2022) lists twelve competences organized into the four areas:

- Embodying sustainability values, including the competences valuing sustainability, supporting fairness, promoting nature.

- Embracing complexity in sustainability, including the competences systems thinking, critical thinking, problem framing.

- Envisioning sustainable futures, including the competences futures literacy adaptability, exploratory thinking.

- Acting for sustainability, including the competences political agency, collective action, individual initiative.

The Climate-KIC Professional Competence Framework (Peiró et al., 2021) was designed as a tool for empowering professionals across various disciplines to drive sustainable development through System Innovation. It outlines twenty competences grouped into five stages:

- Exploring, which includes the competences Systems Thinking, Knowing Capabilities and Resources, Network Development.

- Framing, which includes the competences Defining Challenges, Identifying Opportunities, Facilitating Collective Creativity, Shared Visioning.

- Designing, which includes the competences Developing Ideas, Evaluating Potential Solutions, Setting Goals, Formulating Strategies.

- Implementing, which includes the competences Testing and Piloting, Motivating and Mobilizing Others, Collaborating with Others, Coordinating Action.

- Strengthening, which includes the competences Reflecting and Adapting, Monitoring and Learning, Showing Perseverance, Scaling-up.

The EIT Food Competency Framework (EIT Food 2022) lists eight food system competencies:

1. Technology management
2. Data management
3. Food systems
4. Entrepreneurship
5. Problem solving
6. Critical thinking
7. Leadership
8. Communication.

All competencies are rooted in Sustainability and divided in two types of capabilities – Technical capabilities and Underpinning capabilities. For each competency, there are four levels of mastery – Explore, Practice, Master, Inspire. In addition, the EIT Food report lists

learning outcomes per competency level. This approach facilitates assessment of progression that are not covered in most of the listing of future skills.

The European Science for Innovation and Research (ESIR) group proposes a transformative approach to reshape higher education (Dixson-Declève et al., 2023), encouraging:

- Inter and Transdisciplinary Learning
- Lateral Skills Development
- Resilience Through Systems Thinking
- Creativity as a Core Competency
- Futures Literacy
- Participatory Research and Ethical Reflection
- Art & Technology as a Catalyst for Innovation.

Recently, the World Economic forum recently has published a list of the top growing Future skills for 2030 (World Economic Forum, 2025):

- AI and Big Data
- Networks and Cybersecurity
- Technological Literacy
- Creative Thinking
- Resilience, Flexibility, and Agility
- Curiosity and Lifelong Learning
- Leadership and Social Influence
- Talent Management
- Analytical Thinking
- Environmental Stewardship.

In 2018, the NextFood Project (www.nextfood-project.eu) started work to identify pathways of skills that students should be equipped with to address the upcoming global challenges within agrifood and forestry disciplines: Innovative Mindset, Lifelong Learning, Network Building, Strategic Management, Sustainability, Systems Perspective, Technological Knowledge and Versatility (See Burleigh and Jönsson, 2024). As a way to work toward the envisioned sets of skills, an audit tool was designed to help educational actors assess how their programs, modules, courses, and other educational activities perform in relation to each of the skilling pathways. Simultaneously, the tool encourages individual and/or group reflection on various ways to develop educational activities along the pathways (Dimitrievski

et al., 2020). This tool will be used in a modified way in the upcoming curricula development work in FoSSNet.

Thus, there is extensive scientific literature and policy recommendations that conclude that education for sustainable food system should have:

- Inter- and transdisciplinary approaches
- Think and act beyond silos in both academia and industry
- Develop new sets of skills, both soft and hard
- Systems thinking as an integrated part of curriculum.

1.3 Transforming principles into practices

In Europe, many educational institutions have already taken action toward the development of skills for the future with relevance for food systems transformation. Attempts to introduce new ways of learning and teaching about food and sustainability, such as the introduction of food studies (Hamada et al., 2015), agroecology (Lieblein et al., 2012), and critical food systems education and education for food sovereignty (Mann, 2019) have been made. These concepts are often inspired by alternative pedagogical models. To move beyond conventional pedagogy toward more interactive and student-centered learning loops, (Francis et al., 2016; Galt et al., 2013) and using multiple sources of learning rather than traditional textbooks, introducing participatory learning by involving farmers and other actors from the agrifood supply chains in teaching (Ahmed et al., 2017; Šumane et al., 2018) are examples of such pedagogic efforts.

In the context of this study, the development of interdisciplinary European Master's programs for food is especially important. Many of the recently developed programs are based on collaboration between different HEI and include student mobility and action oriented learning. Some good examples of this approach are EIT Master in Food Systems, European Master of Food Studies and FIPDES (Food Innovation and product design).

Although significant research has examined the lack of food systems perspectives and inadequate skills training in conventional food education, a knowledge gap remains concerning those challenges faced by educators and educational institutions that are already committed to teaching food systems approaches and methods. In their analysis of the food systems education performance in relation to the Sustainability Framework The CleverFood report (Urias & Rao 2024) concluded that there was a positive trend in training core competencies like systems thinking and strategic thinking, but the integration competences and stakeholder engagement were often implicit. This limited their transformative potential, which was also affected by the insufficient addressing of future thinking competencies and intrapersonal skills. Moreover, though there was a tendency to acknowledge the complexities of food systems and the need for new sets of skills, in practice food system challenges were addressed as separate, disconnected issues. Further challenges included implementing inter- and transdisciplinary education and an insufficient integration of perspectives from humanities and social sciences (Urias & Rao 2024: 4; see also Brouwer, 2020; Verstraeten, 2025)

Consequently, a review of curricula, learning models and outcomes and ways of assessing the learning outcomes are important for the development of Food systems education. This report brings these perspectives to the forefront through examining a number of food systems program at different levels, while also bringing in the educators' perspective through a survey. Furthermore, to understand the educational needs of the network, we are currently in the process of developing learner personas within FoSSNet.

1.4 Mapping into the FoSSNet conceptual framework

The FoSSNet Conceptual Framework (CF) was developed to facilitate the understanding of food systems complexity, both for science and education activities. While the model offers an overview of the conditions and actors and activities defining the food systems, at the same time it visualizes the complex interactions between drivers, activities, outcomes and feedback loops within the system (fig 1.)

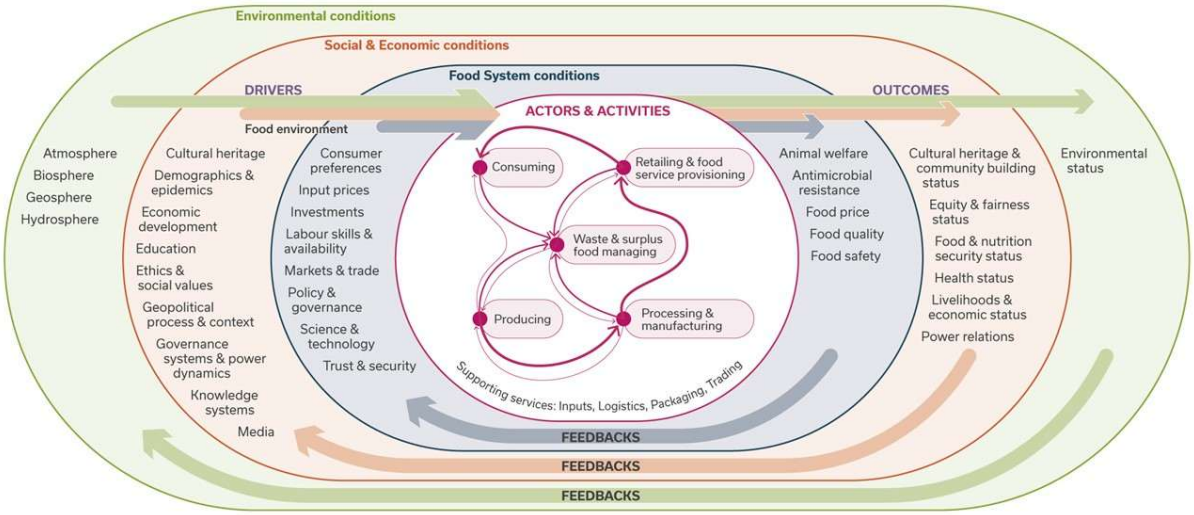

Fig 1. FoSSNet Conceptual Framework, version June 25, 2025.

By developing the FoSSNet Conceptual Framework, definitions for Food Systems Science have been established following the rationale below:

- **What?** Food System Science (FSS) is the interdisciplinary study of food system drivers, core activities, outcomes and feedbacks, and their dynamic, two-way relationships across time and space.

- **How?** FSS requires a systems approach to integrate diverse knowledge in an independent, transparent, democratic, participatory, fair and equitable way, recognizing social, cultural, political, economic and biophysical contexts.
- **Why?** FSS is needed to better understand and foster transformative action in policy and practice on innovation, conservation, restoration and exnovation[1] in interconnected social, economic and biophysical systems. Such action helps the transition toward more sustainable, resilient, and nature- and people-positive food systems.

This rationale is easily transformed into a motivation for Food systems education – it is needed to help the transition toward more sustainable, resilient, and nature- and people-positive food systems. The Conceptual Framework demonstrates the complexity of Food Systems, a complexity that challenges anyone trying to perform teaching and learning about food systems. In the final section of the deliverable, the Conceptual framework and its potential role in suggested future actions to develop food systems education in Europe will be discussed.

2. The process – A mixed methods approach

Using both qualitative and quantitative methods, thee mapping was conducted in several steps. This mixed methods approach, where a combination of quantitative and qualitative research methods is used to gain a more comprehensive and nuanced understanding of a complex research topic, has gained popularity especially in social sciences during the last years (Saraswati & Devi 2023). Due to its multi-faceted nature, the method is suitable for an analysis of food systems education.

The CleverFood's report "Guidance document on transforming higher education teaching" (Urias & Rao 2024), presented a comprehensive overview of Food systems education in Europe. This report builds on the CleverFood list of educations, complemented by an independent search (see 2.1), which added more educational programs (see Table 1). Most importantly, the qualitative text analysis of the programs added an analysis of the individual curricula, as well as the teaching methods and types of assessment.

The second research method was an informatics study that used web scraping to collect data from selected food systems educational program websites. This provided a computational approach for mapping Bloom's taxonomy to assess the cognitive level and scope of academic descriptions in higher education courses. For this study, we chose to focus primarily on Master's programs (ISCED level 7), as they were the most prevalent and offered a standardized framework for comparison. Initiated in 1999, the Bologna Process has helped harmonize higher education across Europe by establishing common structures and learning

[1] Exnovation refers to the process of abandoning or removing a practice, technology, or product within an organization or system.

outcome frameworks for Master's programs, and recent comparative studies (e.g., Burleigh and Jönsson 2024) provide a basis for this approach. While a few Bachelor's and continuing education programs were also included, the findings primarily reflect Master's-level education. Mapping keywords to textual descriptions also enabled comparison with the broader FoSSNet research and education mapping activities presented in Deliverable 4.1, thereby linking educational content to FoSSNet's research agenda mapping efforts.

Finally, the educators' perspective on teaching about food systems was added through a survey, distributed via FoSSNet's website, and through participation in conferences and events (see 2.3). For this report, the main contribution was to add information and perspectives on engagement with external stakeholders and inclusion and exclusion dimensions of teaching food systems. A more elaborated analysis of the survey, which remains open, will be delivered in the upcoming milestone, *Analysis and evaluation of food system curricula*, to be published in January 2026.

The combination of methods provides a mapping that sheds light on food systems curricula from different angles. While the qualitative text analysis offers in-depth analysis of the educational documents, the informatics approach added an assessment of Bloom's taxonomy and enabled comparison with a broader set of food systems documents. By adding personal reflections from experienced educators, the survey enabled a nuancing of the statements in the written documents.

2.1 Mapping and analyzing educational materials – a text based analytical approach

To gain a comprehensive understanding of the current landscape of Food System Science (FSS) education in Europe, a targeted desk-based mapping exercise was conducted. This involved a two-step approach. The first step consisted of a systematic identification and review of higher education and professional training programs explicitly focused on food systems, sustainable food systems, or systems thinking approaches within food related disciplines. This was followed by the assessment of existing curricula from selected programs and courses specialized in the topics of interest.

Building on the initial mapping phase (A), a number of curricula were examined for Master's programs and courses. The following factors were selected according to the inclusion criteria:

- Explicitly mention food systems or systems thinking.
- Be interdisciplinary (i.e., combines hard and soft skills, industry involvement).
- Offer a degree, credits or professional certification.

Based on the criteria, six Master's programs were selected for a further in-depth analysis. The rationale for only selecting Master's program in this step was due to an insufficient basis for meaningful cross-program comparison with Bachelor's programs and courses for professionals. The selected curricula were reviewed to assess core thematic focus, alignment with key competencies, and pedagogical structure. This examination included:

- Learning outcomes/objectives
- Interdisciplinary and food systems dimensions explored (i.e., society, environment, health, policy, etc.)
- Assessment criteria
- The extent to which programs foster the development of soft skills (i.e., critical thinking, creativity, leadership, resilience, etc.)
- Mobility components (students and/or staff learning at multiple sites)
- Industry involvement (NGOs and/or others).

Based on the mapping (A) and curriculum analysis (B), critical gaps and strategic opportunities were identified for the future curricula development of Food Systems Science programs and courses. Consultation with FoSSNet partners supplemented this desk research by identifying programs not easily captured through public web searches, especially those specific to national contexts or emerging initiatives.

2.2 Methods for Informatics-based analysis to mapping Bloom's taxonomy

Python scripts (v8.11) were used to collect, organize and filter Master's-level food systems website texts from the WP5 Education Mapping database (see Appendix A1). Texts were pre-processed using Python's *Natural Language Toolkit* (NLTK), incorporating stop-word removal and lemmatization. Bloom's taxonomy vocabulary (Appendix A2) was converted into a Python dictionary and similarly lemmatized. Each Bloom keyword was counted within each document and aggregated by cognitive domain. The number of keywords per domain was consistent (14.7 ± 0.8), minimizing the likelihood that observed usage patterns are driven by lexical abundance rather than meaningful variation in educational content. After filtering and preprocessing, 22 course descriptions from the WP5 dataset remained for analysis. Given the small size of this dataset, results were visualized using a simple network layout (*networkx.spring_layout*) with node size and proximity to the central hub representing the frequency of Bloom's verbs grouped by cognitive domain. These results were then compared to a broader reference dataset comprising website texts from 1,303 European Master's programs collected by Burleigh and Jönsson (2024) (Appendix A3).

In contrast, a larger dataset of 643 texts from the FoSSNet WP4 Research Agenda study—including Horizon Europe calls (from Cordis), Scopus-indexed review articles containing the term "food systems," and Food2030 project websites (See D4.1 Appendices)—was subjected to deeper analysis. To examine how Bloom's vocabulary usage varied across document types (Cordis, Scopus, Food2030), we applied Partial Least Squares (PLS) regression (*sklearn.PLSRegression*). To identify which Bloom terms most strongly differentiated among document categories, Variable Importance in Projection (VIP) scores were calculated. We also used ordinary least squares regression (*statsmodels.ols*) to estimate the direction and consistency of these associations. To assess the robustness and generalizability of the model,

we conducted 10-fold cross-validation using a balanced, randomized subset of 87 documents per document type. In each iteration, the model was trained on nine folds and tested on the remaining one.

2.3 FoSSNet survey on food systems education

The rationale behind the survey was rooted in the need to systematically gather comprehensive data and insights from educators and stakeholders within the food systems field. By collecting these perspectives, the survey intended to inform the development of effective and inclusive educational strategies and research agendas that reflect both current realities and future needs in food systems science. The primary objectives of the survey were to explore existing food systems education, identify areas for further development in the field and highlight both established and emerging educational needs. Specifically, the survey sought to obtain detailed information from those engaged in teaching food systems at universities, at all levels and through professional education programs. Through this, the survey aimed to achieve several goals: first, to map the landscape of food systems education by collecting basic demographic and institutional data about participants; second, to identify focal areas within food systems that are currently being taught, as well as the priority areas for educational development over the next years; third, to uncover emerging topics that may not be sufficiently covered; and fourth, to understand the activities that promote diversity and inclusion in food systems education. Additionally, the survey examines interdisciplinary collaboration, assesses the strengths and gaps of current educational offerings and evaluates which disciplines need greater involvement. It further seeks to clarify the crucial skills and expertise required for future professionals, assess the impact of emerging technologies and provide an opportunity for participants to contribute suggestions for advancing the field.

By defining its scope, tailoring content for a Pan-European context, deploying via extensive networks, data processing, a multifaceted questionnaire, and validation by experts, the survey methodology is designed to gather comprehensive, representative insights from food systems educators across Europe. The methodology of the survey followed a structured and multi-stage process. In the preparation phase, the purpose was defined, guidance materials were developed, the target group (primarily university lecturers and professional educators) were identified, and the scope was tailored for pan-European relevance. The survey instrumental Master's questionnaire was designed and based on the descriptions of the need for a mapping of food systems education in Europe as described in the FoSSNet consortium agreement, and further adapted to fit the specific context of the FoSSNet network, by incorporating several rounds of revision and verification among the FoSSNet partners to ensure clarity and applicability across diverse participant backgrounds. Programming of the survey utilized Qualtrics to target networks across multiple European projects working on the topic (e.g., CleverFood and FoodPaths).

Following data collection, the process proceeded with data cleaning and processing, which involved merging datasets and conducting thorough data cleaning to ensure accuracy and consistency of the results. The cleaned data was then checked for in-depth analysis. The subsequent analysis and reporting phase focused on comparative synthesis, allowing for the examination of results across educational contexts.

3. Results

The results presented in this section derive from a comprehensive mapping process guided by a mixed-methods approach. This process consisted of three interrelated components:

1. Mapping and analyzing educational materials through a text-based analytical approach,
2. An informatics-based analysis used to classify learning outcomes according to Bloom's Taxonomy, and
3. Insights from the FoSSNet survey on food systems education, which gathered stakeholder perspectives on existing programs and training needs.

Together, these components provide a multi-dimensional view of the current landscape of Food Systems Science education in Europe and the UK, identifying strengths, gaps, and opportunities for curriculum development.

3.1 Results on qualitative mapping and curricula analysis of Food Systems Science programs and courses

This mapping provides a comprehensive overview of existing Master's programs, professional training, and continuing education initiatives in food systems across Europe and the UK. At the European Bachelor's level, food-related provision is mainly organized under traditional disciplinary titles (e.g., Food Technology, Food Engineering, Nutrition, Microbiology), and an explicit *food systems* framing is rarely articulated at BSc. program level and typically emerges as a thematic or interdisciplinary specialization at Master's level. Only a number of undergraduate programs (BSc.) were mapped, providing an insufficient basis for meaningful cross-program comparison or robust reflections. Although the basic information is provided in Table 1, the Bachelor programs were excluded from the comparative analysis. Table 1 provides an overview of the mapped programs and courses, presenting a summary of their key pedagogical approaches and structural features.

Table 1. Mapping of Food Systems Programs and courses.

Program	Level and length	Host Institution	Country	Pedagogical approach

Science and Technologies for Sustainable Food	Bachelor's, 3 years	Universisità degli Studi di milano	Italy	In-depth coursework; an interdisciplinary teamwork approach including object-based learning; collaborating on projects; cognitive tools for critical, creative, and collaborative problem-solving. Further skill enhancement via case studies, bibliographic research, and data analysis.
Bachelor of Science (Honors) in Rural Sciences and Food Systems	Bachelor's, 3 years	L-Università ta' Malta	Malta	Mandatory coursework; a complementary communication and academic skills program; multicultural mobility exposure via Eramus+.
Sustainable Food Systems	Master's, 2 years	SLU (Swedish University of Agricultural Sciences)	Sweden	Teamwork, collaborative learning and student-centered teaching. Guest lectures, and stakeholder engagement.
EIT Food Master's in Food Systems	Master's, 2 years	EIT Food; University of Warsaw; Lund University; University of Turin; Aarhus University; Universitat Hohenheim; University of Reading	Belgium, Poland, Sweden, Italy, Denmark, Germany, United Kingdom	Strong Entrepreneurial track coupled with Food Science subjects. Rotation of students in three different cross-border institutions each semester returning to the home institution on the last semester for the master's thesis and intersectoral experience.
European Master of Sustainable Food Systems Engineering, Technology and Business	Master's, 2 years	KU Leuven; Universidade Católica Portuguesa; Hochschule Anhalt; University College Dublin	Belgium, Portugal, Germany, Ireland	Six focus areas: Circular food systems; Consumer practices and public engagement; Sustainable production; Food safety/transparency and traceability; Management of food system innovations; and Protein diversification.
Food Systems Innovation | Master (1 year)	Master's, 1 year	Aeres University of Applied Sciences	The Netherlands	Theoretical knowledge, professional skills training, a design based research application, and an experimentation based curriculum; feedback to monitor progress and continuous development.

Master of Science in Nutrition and Food Systems — Faculty of Bioscience Engineering — Ghent University	Master's, 2 years	Ghent University	Belgium	General and special courses (elective) as per individual background/interest; multicultural and multidisciplinary collaboration.
Sustainable Food Systems | NMBU	Master's, 2 years	Norwegian University of Life Sciences	Norway	Project-oriented and case-based teaching; interdisciplinary and transdisciplinary teamwork; insight into complex systems across disciplines and timeframes; system understanding via hands-on reflection and teamwork; a digital learning tool under development; a mentoring scheme with a senior student.
Master's Resilient Farming and Food Systems - WUR	Master's, 2 years	Wageningen University and Research	The Netherlands	Excursions, lectures, (field) practicals and group projects.
FOOD SYSTEM: MANAGEMENT, SUSTAINABILITY AND TECHNOLOGIES | University of Parma	Master's, 3 years	Universisità di parma	Italy	Lectures (Individual study program, free and restricted choice course units)
Master of Science (MSc) in Integrated Food Studies - Study Programs at University of Copenhagen	Master's, 2 years	University of Copenhagen	Denmark	Lectures (compulsory and elective courses), workshops, and practical and theoretical exercises. Also, a company and institution visit.
MSc Food Policy - Master's degree • City St George's, University of London	Master's, 1 years	City University of London	The United Kingdom	Lectures, small group activities, class discussions, workshops and independent study.
ESHTE - Food Design	Master's, 2 years	Estoril Higher Institute for Tourism and Hotel studies	Portugal	Challenges through processes, tools, and methodologies specialized in food design and innovation; case studies, critical and creative thinking via activities; a design project activity and creating pathways for individual and group projects; collaboration with public/private entities.

Food Systems and Sustainable Development. Sistemas Alimentares e Desenvolvimento Sustentável – Universidade Fernando Pessoa	Master's, 30 weeks	Universidade Fernando Pessoa	Portugal	This training seeks to contribute to stronger governance and leadership by preparing professionals for decision-making toward sustainability and solving complex problems, which differentiates them in an emerging labor market.
Sustainable food systems – Orientamento	Master's, 1 year	University of Naples Federico II	Italy	A holistic, sciences perspective on current concepts in sustainability and the circular economy, supported by academic theory and relevant, real-world case studies.
AGRI-FOOD SUSTAINABILITY | Università di Pavia	Master's, 2 years	Universisità di Pavia	Italy	Online through self-paced learning, multidisciplinary training and coursework activities.
Master in Agroecology and Food Sovereignty	Master's	L'Università degli studi di Scienze Gastronomiche di Pollenzo	Italy	Hands-on cross-disciplinary experiential learning, deeper community engagement, working on real-world challenges, engaging practical experiences to develop core competence.
MSc Sustainable Food Systems - European Double Degree Program	Master's, 2 years	Università Cattolica, ISARA Lyon	Italy, France	Group work in collaboration with partner industries; theoretical knowledge with transversal and soft skills.
Study Program - MSc Food Studies (European) - WUR	Master's, 2 years	Wageningen University and Research, University College Cork, AgroParis Tech, Lund University	The Netherlands, Ireland, France, Sweden	Rotation of the student in three universities along with the opportunity to conduct the thesis in one of the multinational partner companies in the second year. Academic modules consisting of lecture, lab practicals, study periods, seminars, language training and communication; workshops on entrepreneurship and social activities; team building exercises.

Sustainable Food Systems - MSc - UWE Bristol: Courses	Master's, 1 year	UWE Bristol (University of the West of England)	The United Kingdom	Lectures delivered by external stakeholders; a practice-oriented approach to course content; a problem-based learning approach; skills developed to tackle real-world problems.
Sustainable Food Systems and Food Security MSc | University of Leeds	Master's, 1 year	University of Leeds	The United Kingdom	Problem based learning, based on a sequential delivery model: periods of on-site, face-to-face learning and focus on one module at a time, followed by more self-directed and collaborative learning periods, field trips to food production and consumption sites, coursework.
European Master in System Dynamics	Master's, 2 years	Radboud University, University of Bergen, New University of Lisbon, University of Palermo	Netherlands, Norway, Portugal, Italy	Students study at three of the four different partner universities starting in Bergen (Norway), then either in Lisbon (Portugal) or Palermo (Italy), and then finally in Radboud, Nijmegen (The Netherlands). Focuses on strategic modelling with system dynamics and intercultural communications via rotation in multiple countries.
Agrosciences, Environment, Territories, Landscape and Forest (AETPF)	Master's, 2 years	Agro Paris Tech, Université Paris-Saclay	France	Students study sustainable management of resources and environments in territories in a multi-disciplinary way, taking into account the issues of sustainable agriculture, agroecology and environmental protection. The 1st year provides the general disciplinary foundations and 2nd year allows specialization and/or interdisciplinary areas.
International Master "Agronomy and Agrifood Science"	Master's (2 years)	Institut Agro Montpellier	France	A two-year master's degree program *(Bac +5 level)* set up by a consortium of European universities. Students follow courses at universities in two of the consortium countries and are awarded a joint degree or double degree. Offers eight specializations; job-oriented and experience-based.

Master's degree TEAM-Actors Transitions in Environmental and Agrifood Systems Management |	Master's (2 years)	Institut Agro Rennes-Angers	France	Focus on developing skills in social sciences through interdisciplinary links *and to* develop a systemic and multi-scale approach to issues and processes. Case study, place-based and participatory analysis, interactions between academic and professionals
Spécialisations – Bordeaux Sciences Agro	Specialization courses (1 year)	Bordeaux Sciences Agro	France	Agronomy with specialization in Management in Food Value Chains, Environmental & Natural Resources Management, and Rural and Territorial management. An interdisciplinary approach with close cooperation with professionals.
ENSAIA Master Nutrition et Sciences des Aliments	Master's (2 years)	ENSAIA : Ecole Nationale Supérieure d'Agronomie et des Industries Alimentaire de Nancy	France	Master's in nutrition and cosmetics, developing skills in formulation, processing, nutrition and sustainability, but also legislative aspects, scientific monitoring, and technology transfer to industry. Students have a six-month internship during the program and work closely with professionals.
Bachelor's degree in Agroecology and Food Systems	Bachelor's (3 years)	L'Ecole Supérieure des Agricultures	France	Focus on supporting companies in the agroecological, food and environmental transitions. Active pedagogy and practical learning as a pedagogical approach.
Irregular Courses				
Summer School From Farm to Fork: New Technologies and Trends. Flyer_FromFarmtoFork_2023.pdf	Summer school.	Wageningen University and Research	The Netherlands	Variety of lectures, knowledge clips, case study presentations and group work. All courses, lectures and assignments will be conducted through Brightspace, the learning platform of WUR online.
Resilient and Sustainable Food Systems for a Food Secure Future - WUR	Professional training (B.Sc, M.Sc)	Wageningen University and Research	The Netherlands	Job-oriented and experience-based; highly interactive; extensive, interactive and participatory training where theory is merged with practice. Course activities comprise lectures, discussions, group work, case studies, assignments and field trips. Coaching trajectories are supported. Format is online or blended.

Making Agriculture Work for Food and Nutrition Security - WUR	Professional training	Wageningen University and Research	The Netherlands	Interactive sessions; builds on the participant's own experiences and cases, flexibility to elaborate on specific themes, group work, and coaching trajectories supported
Food Systems for Healthier and Sustainable Diets - WUR	Professional training Extra	Wageningen University and Research	The Netherlands	Job-oriented, and the training approach is interactive, experience- and evidence-based: this provides the participants with the opportunity to learn from expert facilitators as well as from each other and coaching trajectories supported.
Feeding Cities: Improving Food Systems in Urban Areas - WUR	Professional training Extra	Wageningen University and Research	The Netherlands	Interactive sessions, group work, and coaching trajectories supported
Facilitating stakeholder collaboration for Inclusive and Sustainable Food Systems - WUR	Professional training	Wageningen University and Research	The Netherlands	Blended program: online modules and interactive Zoom sessions as well as face to face sessions, and group work.
Evaluating and Managing for Sustainable Impact - WUR	Professional training	Wageningen University and Research	The Netherlands	Blended program: online modules and interactive Zoom sessions as well as face to face sessions, group work and coaching trajectories supported.
Climate Change Adaptation in Food Security and Natural Resource Management - WUR	Professional training	Wageningen University and Research	The Netherlands	Case studies via experts from different fields of expertise, multiple online tools. Integrative sessions, builds on the participant's own experiences and cases; group work, and coaching trajectories are supported.
Climate Action for Food Systems Transformation - WUR	Professional training	Wageningen University and Research	The Netherlands	Virtual field visits; a blended program: online modules and interactive Zoom sessions as well as face to face sessions, and group work, and coaching trajectories are supported.
Interdisciplinary Food System Teaching and Learning About IFSTAL | IFSTAL	Extra curricula courses (MSc)	University of Oxford; The London School of Hygiene & Tropical Medicine; Royal Veterinary College; SOAS University of London; University of Reading; University of Warwick	The United Kingdom	A variety of lectures, knowledge clips, case study presentations, course materials, and group work. Online units complemented by in-person and interactive workshops. An annual summer school based around live workplace projects

The following are the main points identified through the mapping:

- Growing Diversity of Food Systems Programs and courses
  - ✓ Over 20 Master's programs were identified across at least 10 countries, including the Netherlands, Sweden, Italy, Portugal, Denmark, Belgium, Norway, and the UK.
  - ✓ These programs vary in the explicit focus on food systems innovation and related areas, ranging from agroecology, sustainable food policy, nutrition, food technology, to system dynamics.

- Pedagogical Approaches Emphasizing Real-World Learning

✓ Many programs use interdisciplinary, problem-based, and experiential learning strategies.
✓ Approaches include field visits (e.g., NMBU, Wageningen), stakeholder collaboration (e.g., Aeres, EIT Food), entrepreneurship tracks (e.g., EIT Food), and case-based methods (e.g., Ghent, Copenhagen, Leeds).

- Geographically Distributed and Internationally Networked

- Several programs are structured as European joint or double degrees with cross-border mobility, such as:
  - EIT Food Master's (mobility across 3 universities)
  - European Master in Sustainable Food Systems Engineering (KU Leuven-led, mobility across 4 universities)
  - European Master in System Dynamics (4 universities in different countries)
  - Food Studies (European) – mobility across Netherlands, Ireland, France and Sweden

- Specialized Professional and Short Courses

✓ Wageningen University and Research (WUR) emerges as a hub for professional training, offering over 10 targeted courses for mid-career professionals various areas such as:
  - Urban food systems
  - Climate adaptation
  - Inclusive governance
  - Sustainable diets

✓ These training sessions are job-oriented, blended, and designed for practitioners working across sectors.

Although many of these courses are currently inactive, they serve as valuable references for

curriculum development in the field of Food Systems Science.

Following the key findings from the mapping of existing programs and courses in Food Systems, we identified areas for enhancement. Table 2 shows observations and gaps identified across the mapped programs, which reveal critical challenges and opportunities. These insights not only highlight current limitations but also serve as a strategic foundation for improving curriculum design and advancing more inclusive, and coherent educational models in Food Systems Science.

Table 2. Opportunities and Observed gaps of existing programs and courses in Food Systems.

Opportunity dimensions	Observations & Gaps
Systems Thinking	Many programs refer to food systems but lack core training in complexity science, systems modeling, or interdisciplinary integration (exceptions: Radboud University and NMBU).
Soft Skills & Entrepreneurship	Still underdeveloped in many programs, with only few offering formal training or assessment in communication, leadership, or stakeholder engagement.
Research Track Flexibility	Several programs are highly applied, but do not offer research-oriented thesis options for students pursuing academic or policy careers.
Policy and Governance Content	Often, programs like City University's MSc Food Policy and Leeds are exceptions. Integration of ethics, equity, and food justice is limited.
Mobility and Access	European joint degrees offer excellent mobility, but mobility remains optional or inaccessible in several national programs. In addition mobility comes with its own challenges particularly for non-European students
Recognition and Coherence	Lack of a unified European qualification framework or competency standards for food systems education limits cross-program alignment and student mobility.

The current landscape of food systems education in Europe and the UK is thus rich, diverse, and growing rapidly. However, to meet the demands of food system transformation, there is a clear need to bridge disciplinary silos, promote learner mobility, and align training with global sustainability and equity goals. This mapping provides a strong foundation for targeted investments, policy alignment, and academic innovation in the years ahead.

To gain a more in-depth understanding of existing Master's programs in food systems, we selected a range of curricula based on the criteria outlined in the methods section. Each of the

six selected Master's program was analyzed using the following curricula dimensions:

1. Intended learning outcomes
2. Systems thinking and interdisciplinarity in food systems
3. Assessment methods and criteria
4. Soft skills integration
5. Mobility structures and international exposure.

Appendix B 2 presents detailed information on the 5-point scale for the selected programs. A provided Excel file (Appendix B 1) contains supplementary data and presents an extended overview of the selected curricula.

Based on the comparative analysis of the six selected Master's programs (A–F; see below) in Food Systems, Table 3 presents a side-by-side comparison of these programs, extracted from publicly available curricular information. For the dimensions of soft skills integration and structured mobility, each program was assessed using a qualitative scale (High, Medium, Moderate, or Low) to capture the extent and depth of these dimensions in curricular integration. These levels are defined as follows:

- High: The dimension is fully and systematically integrated across the curriculum. It is intentional, visible in learning outcomes, and consistently supported through described activities.
- Medium: The dimension is present and meaningful, but not fully embedded. It may appear in select modules or extracurricular components.
- Moderate: The dimension is included to some extent, such as in group work, elective modules, but lacks consistent structure or visibility in assessments or in learning objectives.
- Low: The dimension is minimally present or absent from the curriculum.

Table 3. Comparative analysis of the overview of curricula of selected Food Systems Master's programs

Program	Intended Learning Outcomes	Systems Thinking and Interdisciplinarity	Assessment methods and criteria	Soft Skills Integration	Structured Mobility
A. Aeres University (Netherlands). MSc. in Food Systems Innovation	Equip graduates with systems innovation skills, intervention design, and sustainability literacy	Strong focus on system innovation, intervention design	Reflective practice, stakeholder engagement	High – embedded in pedagogy & final portfolio	Medium – study tours, local co-teaching
B. Univ. of Copenhagen (Denmark). MSc. In Integrated Food Studies	Prepare students to analyze food policy, sustainable consumption, and environmental nutrition	Policy, sustainability, food governance focus	Research essays, policy briefs and critical analysis	Moderate – through group work, case-based	Medium – optional study abroad, international case work
C. Univ. of Pavia (Italy). MSc. In Agri-Food Sustainability	Train experts in food safety, food law, and circular economy in food supply chains	Technical focus: food law, circular economy, agri-food systems	Primarily technical assessments	Low – limited structured soft skills training	Low – optional Erasmus+, study visits
D. Univ. of Leeds (UK). MSc. Sustainable Food System and Food Security	Develop policy, governance, and intervention design capacities in food security contexts	Strong in food governance and public health	Practice-oriented, applied policy	Moderate – presentations, group projects	Medium – global food security lens, field visits
E. NMBU Norwegian Univ. of Life Science (Norway). MSc. In sustainable Food Systems	Build capacity to address sustainability challenges in food and agriculture systems	Strong systems focus, sustainability & SDG alignment	Fieldwork-based, policy simulation	High – integrated in interdisciplinary teamwork	Medium – Erasmus+, field placements
F. MFS: EIT Food, Lund Univ. Warsaw Univ. Univ. of Turin, Reading Univ., Aarhus Univ., and Hohenheim Univ. MSc. In Food Systems	Foster innovation, entrepreneurship, and leadership in sustainable food systems	Explicit EIT competencies: innovation, systems change	Portfolio, co-creation projects, venture labs	High – innovation skills, entrepreneurship, communication	High – mandatory 3-country mobility

Highlights from the comparative curricula analysis.

- Learning Outcomes & Systems Competencies
- ✓ Programs such as Aeres, NMBU, and MFS provide clearly articulated, future-ready competencies aligned with Food2030, Horizon Europe, and Farm to Fork strategies.
- ✓ Technical programs (e.g., Pavia, Radboud) present limited information on food systems framing and sustainability integration.
- Systems thinking and interdisciplinarity in food systems
- ✓ The programs from Aeres show a deep integration of systems thinking, emphasizing transition design, food chain complexity, and real-world system innovation. It adopts a practice-based approach, linking food systems knowledge with stakeholder-driven interventions.
- ✓ The program MFS (EIT Food) offers one of the most comprehensive systems approaches, aligned with EIT's innovation framework. It integrates systems thinking at various levels, connecting food, health, sustainability, entrepreneurship, and societal change.
- ✓ The rest of the programs present a moderate to less explicit approach to systems thinking integration
- Assessment methods and criteria
- ✓ Innovative assessment models (MFS, Aeres) include reflective portfolios, co-creation with stakeholders, and practical interventions.
- ✓ More traditional programs use technical exams or reports, limiting real-world integration.
- Soft Skills Integration
- ✓ High-performing programs (Aeres, NMBU, MFS) embed training in collaboration, leadership, stakeholder communication, and entrepreneurship.
- ✓ Other programs often rely on group work without structured skill development or tracking.
- Mobility Structures and international integration
- ✓ Programs like MFS lead with structured, multi-country academic rotation.
- ✓ Others (e.g., Pavia, Radboud) offer limited or optional mobility, reducing exposure to diverse systems.

The curricula analysis of food systems Master's programs in Europe reflects a growing alignment with complex, interdisciplinary, and sustainability-driven education. Programs like

MFS, Aeres, and NMBU serve as benchmarks, integrating mobility, soft skills, and real-world engagement with systems-level learning outcomes.

Challenges and Opportunities for Curriculum Development in Food Systems Science Master's Programs

A comparative review of six European Master's programs in Food Systems reveals significant potential for enhancing curriculum design to better address emerging global challenges and policy expectations. While many programs exhibit strong foundations in applied learning and interdisciplinary ambitions, the analysis highlights critical structural and pedagogical gaps that must be addressed to align with the transformative goals set by many international frameworks.

Table 4 summarizes the challenges and opportunities identified in each program, based on publicly available curricular documents. It is important to note that this analysis reflects the formal content of the written curricula and may not capture additional experiential or extracurricular activities that occur in practice. Nevertheless, the absence of such elements from the documented curriculum suggests an opportunity to enhance transparency and intentionality in program design.

Table 4. Gaps, challenges, and Opportunities for Curricula Development in Food Systems Science Master's Programs.

Program	Gaps and Challenges	Opportunities for curricula improvement
A. Aeres University (Netherlands). MSc. in Food Systems Innovation	Lack of traditional disciplinary modules like economics, food law, or public health. Limited mobility/international exposure via curriculum. Assessment is not aligned with conventional research pathways.	Choice of core modules that provides exposure of policy and law-based modules. Diversification of learning via optional mobility windows or exchange opportunities. For students interested in academic careers, a clearer research methodology training could be provided.
B. Univ. of Copenhagen (Denmark). MSc. In Integrated Food Studies	No incorporation of entrepreneurial modules. Soft skill development are not linked to assessments.	Applied learning can be encouraged further via entrepreneurial innovation or real-world system redesign challenges. Also, the introduction of structured soft skill evaluation like presentations, leadership skills, etc.

C. Univ. of Pavia (Italy). MSc. In Agri-Food Sustainability	No active learning strategies beyond exams and projects, industry engagement is optional, soft skills like teamwork and communication are not explicitly assessed.	The addition of problem-based learning modules or real-world case studies could enhance active learning. The encouragement of soft skill training and industry exposure can also be taken into account.
D. Univ. of Leeds (UK). MSc. Sustainable Food System and Food Security	Lack of structured international mobility component, which may limit global contextual learning. No stakeholder collaboration modules within coursework.	Introducing a stakeholder engagement challenge, possibly tied to dissertation work, would deepen experiential learning.
E. NMBU Norwegian Univ. of Life Science (Norway). MSc. In sustainable Food Systems	Lack of entrepreneurial and FoodTech innovation modules, decreasing relevance to industry needs. Less focus on modules that are related to stakeholder engagement.	Entrepreneurial and stakeholder related modules can be introduced that are aligned with food system innovations.
F. MFS: EIT Food, Lund Univ. Warsaw Univ. Univ. of Turin, Reading Univ., Aarhus Univ., and Hohenheim Univ. MSc. In Food Systems	Lack of core modules based on systems thinking/dynamics, social impact. The inter-institutional mobility may limit continuity in mentorship and long-term networking that may lead to lack of substantial access to projects/career information in the last semester at the home university.	The addition of modules based on ethics, and inclusive policy-making, ensuring a balance between innovation and equity. Developing a flexible, thesis-track option for students interested in academic or policy research careers may widen its appeal.

From the above comparative analysis, we can highlight the following **opportunities for Curricula Development:**

- ✓ Balance Innovation with Critical Systems Perspectives:
  Programs can expand innovation modules by also incorporating content on ethics, governance, food justice, and power dynamics in food systems. This ensures students can both design new solutions and critique existing structures.
- ✓ Embed Entrepreneurial and Soft Skill Training:
  Formalize modules that build entrepreneurial thinking, stakeholder communication, and leadership, and link these skills directly to graded assignments such as project presentations, innovation labs, or stakeholder simulations.
- ✓ Diversify Disciplinary Exposure:
  Offer elective or core modules in food policy, public health, law, environmental

economics, and social sciences to strengthen interdisciplinary literacy and align with global policy frameworks like Food2030 and the EU Green Deal.

- ✓ Expand Structured Mobility and Exchange Pathways:
  Develop Erasmus+ partnerships, double-degree options, or short-term international intensives to allow all students access to transboundary perspectives on food system challenges.
- ✓ Strengthen Stakeholder Co-Creation Models:
  Incorporate living labs, multi-actor projects, or challenge-based learning modules that are co-supervised by academic and non-academic partners. This deepens both relevance and employability.
- ✓ Offer Flexible Thesis Tracks:
  Design dual thesis options, one academic/research-oriented, the other professional/practice-based, each with tailored supervision, methodology training, and policy or publication potential.

As a concluding remark the reviewed programs offer a solid foundation for future food systems professionals. However, there is a clear opportunity and responsibility to align curricula more closely with the competencies required for system transformation, innovation, and inclusive governance.

3.2 Mapping of Educational Levels: An Informatics-Based Approach Using Bloom's Taxonomy

One approach for analyzing and evaluating food systems education is to assess the cognitive depth and pedagogical orientation of selected programs. The study presented here examines how effectively selected curriculum descriptions from European Master's-level food systems programs promote higher-order thinking using an informatics-based approach grounded in Bloom's Revised Taxonomy of Educational Objectives (Anderson and Krathwohlm, 2001). Bloom's framework categorizes cognitive processes into six hierarchical levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating.

Due to practical and scope-related reasons, we focused on the cognitive domain of Bloom's taxonomy, a common approach in initial curriculum analysis. While the affective domain—encompassing levels such as Receiving, Responding, Valuing, Organizing, and Characterizing—was excluded, future development may consider it, particularly in relation to professional values and judgment.

Using a vocabulary-mapping technique, we identify and quantify action verbs associated with each cognitive level across course descriptions. For instance, a predominance of lower-order verbs (e.g., remember, understand) may signal an emphasis on factual recall, whereas a greater presence of higher-order verbs (e.g., evaluate, create) suggests a stronger focus on critical thinking and problem-solving. By analyzing the frequency and distribution of these verbs in the 22 course descriptions from the WP5 dataset (Appendix A1) as well as in a larger

dataset of Master's program websites (Appendix A3), we uncover patterns in the cognitive demands embedded in the curricula.

This method also allows us to cross-reference our findings with the FoSSNet conceptual framework vocabulary developed in Work Package 4. By integrating the Bloom's-based cognitive analysis with this conceptual vocabulary, we can evaluate whether courses that promote advanced thinking skills also embody the core values of FoSSNet—bridging pedagogical depth with thematic relevance.

Bloom's Vocabulary in the Course Documents

To assess the cognitive complexity of educational content in the 22 food systems course documents identified under Work Package 5 (WP5), we conducted a lexical analysis based on the Bloom's Revised Taxonomy. A curated list of action verbs representing Bloom's six cognitive domains—Remember, Understand, Apply, Analyze, Evaluate, and Create—served as the basis for identifying and quantifying relevant vocabulary across the course texts.

The results were visualized using a network-based layout (networkx.spring_layout), where node size and proximity to the central node reflect the frequency of verbs associated with each cognitive level within the course texts (Figure 1A). For comparative purposes, the same analytical procedure was applied to a broader reference corpus of 1,303's-level program descriptions compiled by Burleigh and Jönsson (2024) (Figure 1B).

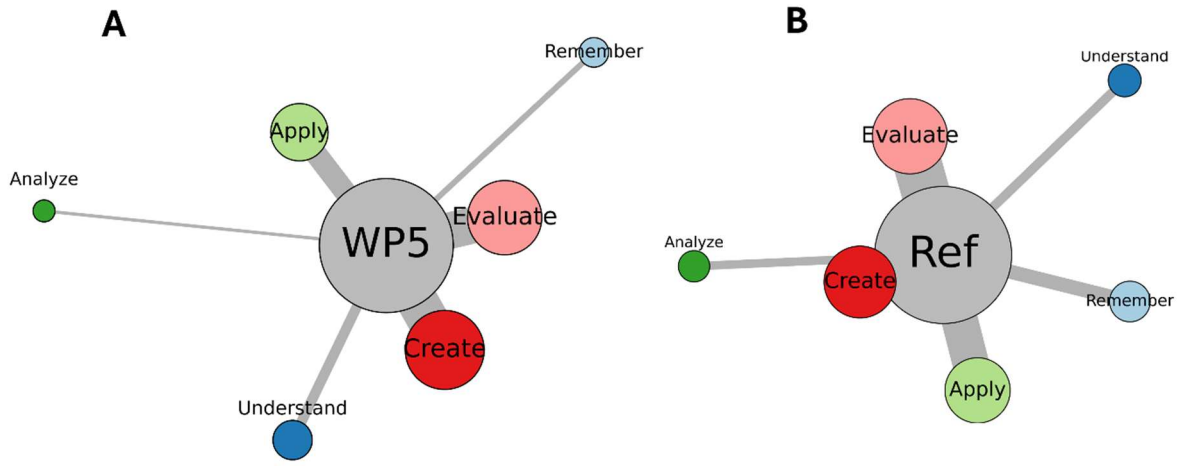

Figure. 1 A+B. Network of Bloom's vocabulary frequencies for the WP5 course documents (A) and reference texts derived from Burleigh and Jönsson, 2024 (B). In the visualization, node size and proximity to the central hub reflect the frequency of domain-specific keywords in the texts (based on 22 and 1303 texts, respectively). The networks were created using networkx.spring layout.

The network analysis reveals that the WP5 course documents generally align (similar network layout) with broader trends in European Master's-level education. Both corpora exhibit a pronounced emphasis on higher-order cognitive processes, particularly those associated with the Create and Evaluate domains. These domains are frequently targeted in learning outcomes that promote critical thinking, innovation, and synthesis—core competencies in interdisciplinary food systems education.

In contrast, the domains Analyze, Understand and Remember are underrepresented in both datasets, suggesting a relative de-emphasis on foundational or lower-order cognitive tasks. Notably, the WP5 course documents may even show a lower incidence of Analyze and Remember verbs compared to the reference corpus. While this pattern may reflect a deliberate pedagogical choice to prioritize advanced competencies, it also raises the possibility of gaps in foundational learning support. Specifically, the limited presence of lower-order domains could result in insufficient pedagogical scaffolding/support for students, particularly those entering from diverse academic or professional backgrounds. Without adequate emphasis on knowledge recall and conceptual understanding, learners may struggle to fully engage with more complex analytical or creative tasks.

Bloom's Vocabulary in Research Agenda Mapping Documents

Work Package 4 (WP4) focuses on mapping research agendas in food systems-related literature using the FoSSNet conceptual framework. The corpus analyzed includes high-level academic and policy-oriented texts: Horizon Europe call documents (retrieved via Cordis), Scopus-indexed review articles, and descriptive content from Food2030 project websites. While these texts are not educational curricula, they reflect the research and conceptual environments in which advanced food systems education is embedded. As such, they serve as a useful proxy for the intellectual discourse shaping university-level instruction and are appropriate for comparative analysis using Bloom's cognitive framework. Thus, they help us assess whether the pedagogical language found in academic programs aligns with prevailing research and policy narratives in the field.

To examine differences in domain-level representation of Bloom vocabulary across the three WP4 document types, we counted relevant keywords in each text and analyzed the results using Partial Least Squares (PLS) regression. PLS plots visually highlight how strongly each Bloom domain associates with a given document type, revealing patterns in cognitive emphasis. Cognitive domains positioned closer to a document type indicate stronger relative association, while those further away—or on opposing axes—suggest weaker or negative associations. To ensure a robust and unbiased assessment, the analysis employed 10-fold cross-validation (repeated measures) with balanced samples of 87 randomly selected documents per category. As shown in Figure 2, the cognitive domains *Evaluate* and *Create* are more strongly associated with Food2030 documents compared to Scopus and Cordis, suggesting a greater emphasis on higher-order thinking within that dataset.

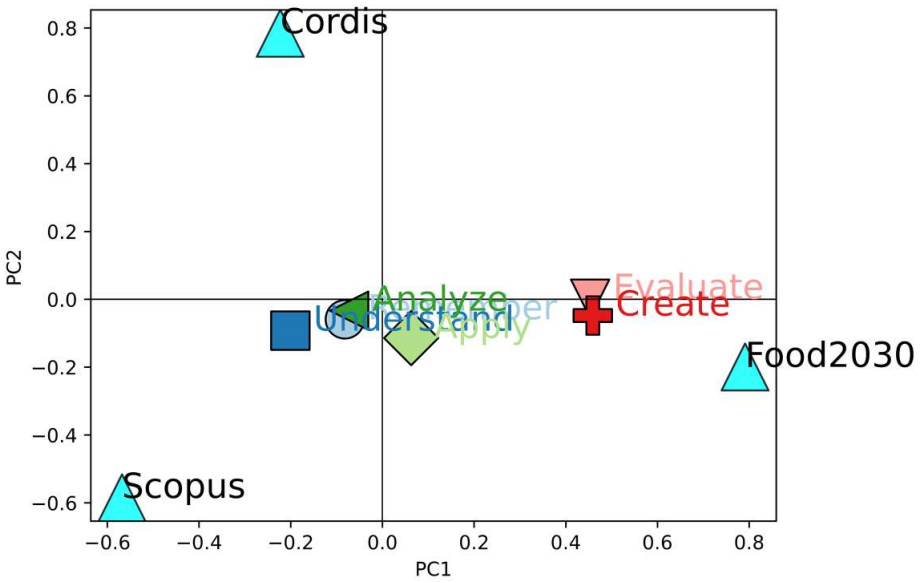

Figure 2. PLS Plot of Bloom domains across Cordis, Scopus, and Food2030 documents.

Keyword counts were normalized by total words per document. The analysis was cross-validated using 10-fold splits of 87 randomly selected documents from each document type. The PCs of a PLS plot represent major, though undefined, sources of variation in the dataset. Created using sklearn.PLSRegression.

To evaluate which associations visualized in the PLS plot are meaningful, a Variable Importance in Projection (VIP) analysis was conducted to identify elements that significantly contribute to the classification of each document type. Figure 3 A shows a VIP plot for the Food2030 dataset, highlighting elements with the highest contributions—those with VIP scores greater than 1. To further interpret these relationships, a coefficient analysis was performed to assess both the direction and significance of each association. Figure 3 B displays the coefficient plot for Food2030 documents as an example, where positive values indicate stronger associations with specific elements and negative values indicate inverse associations. A summary of significant associations across all three document types is provided in Table 5.

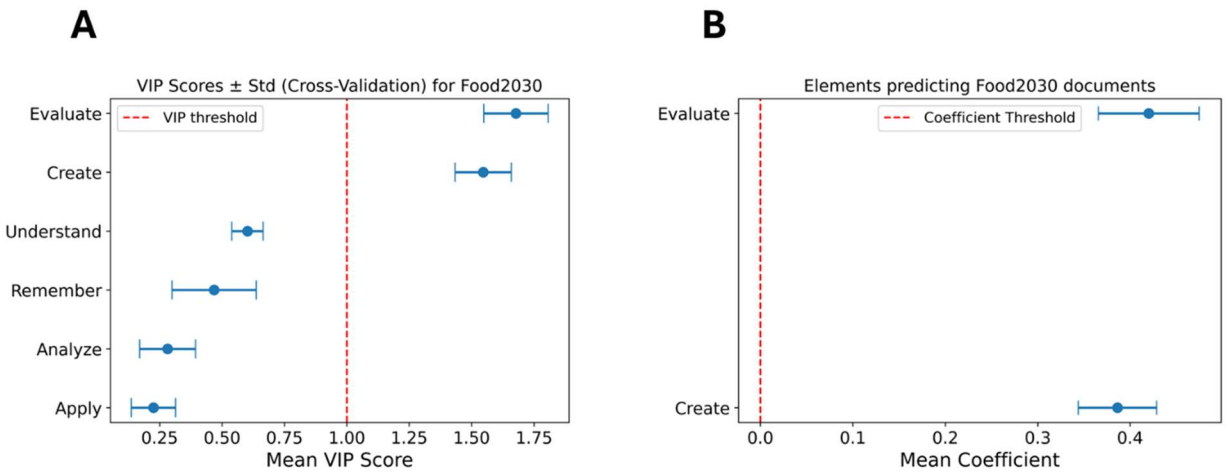

Figure 3. Identification of Bloom domains associated with document types using Variable Importance in Projection (VIP) and coefficient plots, exemplified with the Food2030 data. VIP plot highlighting elements with significant contributions to classifying Food2030 documents (VIP scores > 1) (A). Coefficient plot showing the direction and statistical robustness of associations, where positive values indicate positive associations and error bars not crossing zero indicate statistical significance (B). Keyword counts were normalized by total words per document. For reproducibility, the analysis was cross-validated using 10-fold splits of 87 randomly selected documents from each document type. Created using sklearn.PLSRegression and statsmodels.ols.

Overall, the results suggest that Food2030 documents are most closely aligned with the Bloom domains Evaluate and Create relative to the Scopus and Cordis documents.

Dataset	Systems	Elements	Score
Cordis	Blooms	Create	-1
Food2030	Blooms	Create	1
Food2030	Blooms	Evaluate	1
Scopus	Blooms	Create	-1
Scopus	Blooms	Evaluate	-1

Table 5 Bloom domains associated with the three document types. Only elements with clear PLS associations, VIP scores greater than 1, and statistically significant coefficients are included. Elements scoring '1' indicate significantly positive associations relative to the other document types, while elements scoring '-1' indicate significantly negative associations. Analyses were cross-validated using 10-fold splits of 87 randomly selected documents per document type.

Summary of the informatic approach

This analysis identifies where Bloom's domain vocabulary is well represented—and where it may be underutilized—in a select group of Master's-level food systems courses. The higher-order domains of Evaluate and Create are used more frequently than lower-order domains such as Remember and Understand, a pattern also observed in a broader sample of European Master's programs.

A similar emphasis on higher-level Bloom domains appears in Food2030 policy-related texts, which show greater use of Evaluate and Create vocabulary, compared to Horizon Europe (Cordis) projects and Scopus-indexed review articles. Separately, as shown in the WP 4 research agenda study (D4.1) Food2030 texts also demonstrate a stronger alignment with the FoSSNet conceptual framework vocabulary, suggesting that these documents are not only cognitively ambitious, but also more thematically aligned with the systems-oriented concepts promoted by FoSSNet.

However, two concerns emerge. First, the underrepresentation of lower-level domains in academic curricula may signal a lack of foundational language that supports the development of higher-order thinking. This gap may hinder students' ability to build the necessary conceptual scaffolding, making it more difficult for them to engage effectively with complex,

integrative tasks later in the program. Second, despite the strong presence of advanced vocabulary in Food2030 texts, this does not appear to carry over consistently into research outputs, namely funded projects (Cordis) and peer-reviewed publications (Scopus), suggesting a potential disconnect between policy intentions and implementation in academic research. These observations offer testable hypotheses for future work and can be further explored through qualitative methods such as interviews and surveys with educators, students, and policymakers. This study was conducted using documents and a controlled vocabulary developed in English. Given potential country- and region-specific variations in the use of Bloom's-related terminology in educational materials (e.g., syllabi, course descriptions, and Master's program websites), our findings should be interpreted as applicable only to English-language texts. Further research could investigate cross-country and regional variations more systematically.

3.3 The Educators Perspective – Results from the Survey

The purpose of the FoSSNet survey was to systematically explore the current state and future directions of food systems education across Europe. As food systems science rapidly evolves in response to complex global challenges—such as climate change, food security, sustainability, and shifting patterns in consumption and production—there is an acute need to assess and enhance existing educational approaches. By soliciting input from educators and stakeholders actively involved in teaching food systems topics, the survey aims to identify best practices, innovative teaching strategies, and existing strengths within the discipline.

Moreover, the survey sought to uncover critical gaps and unmet needs in current educational programs, ensuring that the field remains responsive to emerging scientific knowledge, societal priorities, and skills required by future professionals. It also placed a particular emphasis on areas where educational development is most pressing, ranging from interdisciplinary collaboration and integration of new technologies to the promotion of diversity and inclusion. In doing so, the survey not only maps the present landscape but also helps to inform a forward-looking research agenda and roadmap for advancing food systems science education throughout Europe.

The FoSSNet survey captures input from a cohort of experienced educators, primarily from institutions such as the University of Bergen, University of Helsinki, and University of Catania, reflecting both geographical spread and disciplinary span. The research survey remains ongoing and represents work in progress, with the number of responses currently low—only a handful received so far—but we anticipate that future milestones of the project will significantly enrich and expand this preliminary analysis. This will be presented in the upcoming milestone form the project, to be published January 2026.

From the survey, it can be seen that respondents demonstrate significant expertise, with the majority possessing over ten years of experience in food systems education and operating mainly at the postgraduate level. This community teaches a wide array of topics, yet there are clear thematic concentrations; "Climate change impacts" and "Sustainable production methods" are the most frequently addressed elements, underscoring the pivotal intersection between environmental change and food systems. Other core areas include "Food security," "Policy and governance," and "Nutrition and health," showing insights of a curriculum striving to capture the multi-dimensionality of the food systems landscape.

Despite these strengths, participants identify a need for even greater integration of emerging and underrepresented topics. For instance, respondents highlight subjects such as "sustainable paradigms in food systems" and "Urban Food policies," questioning that these areas "*are not receiving adequate attention*" in current courses or education programs. The call for a new generation of system thinking and agroecology is particularly notable, with one participant listing "system thinking" as the top priority, followed by "agroecology" and "urban food policies," suggesting a desire to move beyond fragmented, discipline-specific teaching toward holistic and transformative approaches.

The perceived quality of current food systems education in the EU is alarmingly low: most respondents rate it as "Very poor" or "Poor," attributing this to "prevailing disciplinary barriers, especially in agricultural sciences/applied universities" and to a general sense that "it is fragmented." Another critical gap is the "lack of cross-border collaboration" and the uneven presence of food systems education across European countries; some respondents remark it is "not yet present/developed well in many countries".

Yet, within these critiques, educators pinpoint several promising strengths that could serve as levers for advancement. Curricula's "flexibility enabling interdisciplinarity," increased "mobility," and the establishment of "new dedicated master programs" are identified as important assets. One respondent highlights the *"curricula flexibility enabling interdisciplinarity"* as an outright strength, while others pinpoint new Master's programs dedicated specifically to food systems science, signaling institutional readiness for cross-disciplinary engagement and student mobility.

In terms of disciplinary inclusion, educators recommend amplifying the roles for agricultural, environmental, and social sciences, as well as the educational sciences, with supporting word clouds further emphasizing local, cultural, and destination-linked knowledge, all of which extend the traditional boundaries of food systems science.

A forward-looking analysis of necessary resources points to the urgent need for robust platforms, digital networks, and stakeholder-driven event spaces to support food systems education. The skills set for future professionals is defined by adaptability and orientation toward complexity: "*working with diverse perspectives while not losing the sight of sustainability principles; working across disciplines; system thinking.*" Digital proficiency, and the ability to engage with hybrid and collaborative models of learning, are identified as crucial, with "*novel technologies for hybrid learning and collaborative learning, models of cross- and trans-disciplinary master programs*" and digital innovation seen as core drivers for change in the coming decade.

In terms of diversity and inclusion, only a few initiatives were reported, with "types of knowledge and/or expertise" and "geographic representation" cited as the most frequently included categories. However, the survey results indicate a general lack of formalized policies or widespread action, and the need for more comprehensive interventions to promote equity across gender, ethnicity, social status, and career stage within food systems education becomes evident.

Based on the survey, Europe's food systems education is rich in disciplinary legacy and expertise but constrained by persistent fragmentation and slow adaptation to emerging trends.

3.4 Integrated findings – Key elements of the Curricula mapping

The mapping demonstrates a growing diversity of Food systems programs and courses. The pedagogical approaches are skills oriented, emphasizing real-world Learning. Many programs use interdisciplinary, problem-based, and experiential learning strategies. They are also embedded in the world outside academia, and use field visits, stakeholder collaboration entrepreneurship tracks, and case-based methods. The educational programs are geographically distributed and internationally networked, with several programs structured as European joint or double degrees with cross-border mobility. However, there is an underrepresentation of programs from widening countries in Europe. In addition to the academic programs, specialized professional and short courses are offered, with Wageningen as key driver. Nevertheless, there is a clear opportunity to develop more food systems courses dedicated to professionals, with a lifelong learning approach, in other countries than The Netherlands.

The curricula analysis of food systems Master's programs in Europe reflects a growing alignment with complex, interdisciplinary, and sustainability-driven education. Programs integrating mobility, soft skills, and real-world engagement with systems-level learning outcomes are already in place. There is inevitably a clear path toward the integration of the different sets of "Skills for the future" described in the Background section.

The informatics study of Bloom's taxonomy confirmed that the Food systems programs generally align with broader trends in European Master's-level, with an emphasis on higher-order cognitive processes, particularly those associated with the Create and Evaluate domains. These domains are frequently targeted in learning outcomes that promote critical thinking, innovation, and synthesis—core competencies in interdisciplinary food systems education. There is a relative de-emphasis on foundational or lower-order cognitive tasks. While this may reflect a deliberate pedagogical choice to prioritize advanced competencies, it also raises the possibility of gaps in foundational learning support with insufficient pedagogical scaffolding/support for students, particularly those entering from diverse academic or professional backgrounds. This calls for a clear focus on practices for inclusion of students from underrepresented backgrounds, as well as for food systems professionals who may have been outside formal education structures for several years.

The Educators' survey further underlined the importance of inclusion and suggested actions to be taken. One such action is the inclusion of more disciplines. Agricultural, environmental and social sciences, educational sciences as well as emphasizing local, cultural, and destination-linked knowledge are recommended to broaden the traditional boundaries of food systems science. A broadened geographic representation is also important for achieving a more inclusive education. Finally, the survey indicates a need for more comprehensive interventions to promote equity across gender, ethnicity, social status, and career stage within food systems education. The Educators' survey also provides a nuance of the vision of the overall progress of food systems education. From their perspectives, the educators themselves do not have a very positive view of the quality of current food systems education in the EU. Prevailing disciplinary barriers, and a general sense of fragmentation are challenges to be taken seriously.

4. Conclusion and next steps

The mapping demonstrates that food systems education in Europe is growing and developing in a promising way. For further development, there is a clear opportunity and responsibility to align curricula more closely with the competencies required for system transformation, innovation, and inclusive governance. Strategic curriculum reform should prioritize interdisciplinarity, applied systems thinking, stakeholder engagement and the development of human-centered competencies, ensuring that graduates are equipped to lead the transition toward sustainable and equitable food futures. While the higher academic level (Master's degree) is well represented, there is a lack of undergraduate programs and courses that explicitly deals with food systems education. The development of more "basic" food systems literacy could potentially also be widened to upper secondary schools and other education for younger cohorts. Furthermore, there should be more efforts to provide courses and modules for professionals, to give them the tools to apply food systems thinking in their everyday work in the food sector.

Efforts must focus on reducing disciplinary silos and fostering environments where cross-border and cross-institutional collaboration become routine rather than exceptional. Embracing digital transformation by developing platforms that enable hybrid, flexible, and collaborative learning will prepare future professionals not only to navigate but also to lead rapid changes in the sector. Institutional policies must also be crafted and enacted to ensure that diversity and inclusion become embedded features of all educational practice, moving beyond voluntary or ad hoc measures. As future food systems professionals face increasing demands for cross-sector collaboration and innovation, the most resilient curricula will be those that combine global perspective, stakeholder interaction and critical self-reflection with technical excellence.

Opportunities for such Curricula Development include, but are not limited to:

- Balancing innovation with critical systems perspectives by incorporating content on ethics, governance, food justice, and power dynamics in food systems.
- Embedding entrepreneurial and soft skill training and linking these modules directly to graded assignments.
- Further integrating systems thinking in all parts of the food systems curricula.
- Diversifying disciplinary exposure to strengthen interdisciplinary literacy and align it with international policy frameworks like Food2030 and the EU Green Deal.
- Expanding structured mobility and exchange pathways through Erasmus+ partnerships, double-degree options, or short-term international intensives.
- Strengthening stakeholder co-creation models through living labs, multi-actor projects, and challenge-based learning modules.

- Offering flexible thesis tracks – academic/research-oriented and professional/practice-based.
- Further developing mechanisms to enhance the inclusion of perspectives and knowledge from people outside higher educational institutions.
- Continuously working with all three pillars of the learning outcomes and facilitating an integrated learning of Knowledge and understanding, Skills and competencies, and Judgment and approaches.

Establishing a sustainable, pan-European network for educators and learners who can continually integrate feedback, promote best practices, and engage in joint innovation will facilitate such curricula development. As next steps, FoSSNet in Collaboration with CLEVERFOOD, FoodCLIC, Food Paths and other related projects will continue the development of a Higher Education network for Food systems education and Literacy, and join forces in the upcoming work, which includes but is not limited to:

- Collaborative curriculum design based on the priorities in this report, further complemented by stakeholder consultation and the ongoing educators' survey. In workshops where educators, professionals, and students co-create food systems science curricula, achieving skills for the future. As a method for doing this, the NextFood audit tool will be used for a structured process.
- Targeting a diversity of educational groups (undergraduate and graduate level at universities and lifelong learning education). These workshops will make use of the "Educational persona", developed by the Wageningen team.
  Personas are (visual) representative evidence-based archetypes based upon the profiles of the FoSSNet target groups including professionals. The profiles provide information on educational background, current profession, experience in food systems, and learning needs (knowledge and skills) on food systems science. Working with personas in curriculum development is a useful way to identify diverse learning needs and keep the learners in mind throughout the design process.
- Pilots: Educators will implement new curricula and provide feedback for refinement. In the final stage of the project, ready-to-use curricula will be launched. These curricula are yet to be defined and should not be confused with a launch of new program/s or courses. Rather, the ambition is to present a set of learning material that can be used in different contexts, both for University programs and for lifelong learning.

- Workshops on learning outcomes to define progression in food systems literacy for different groups, based on the FoSSNet conceptual framework and the EIT Food Competency framework's learning outcomes per competency level
- Co-developing the WP 3 tools for food systems thinking and inclusion to fit educational settings.

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List of appendices

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A3 Dataset European Master's Programs

B1 Education Mapping and Curricula analysis
B2 Curricula of selected Master's programs