Activity 2.3: Key Features of the Sustainability Competence

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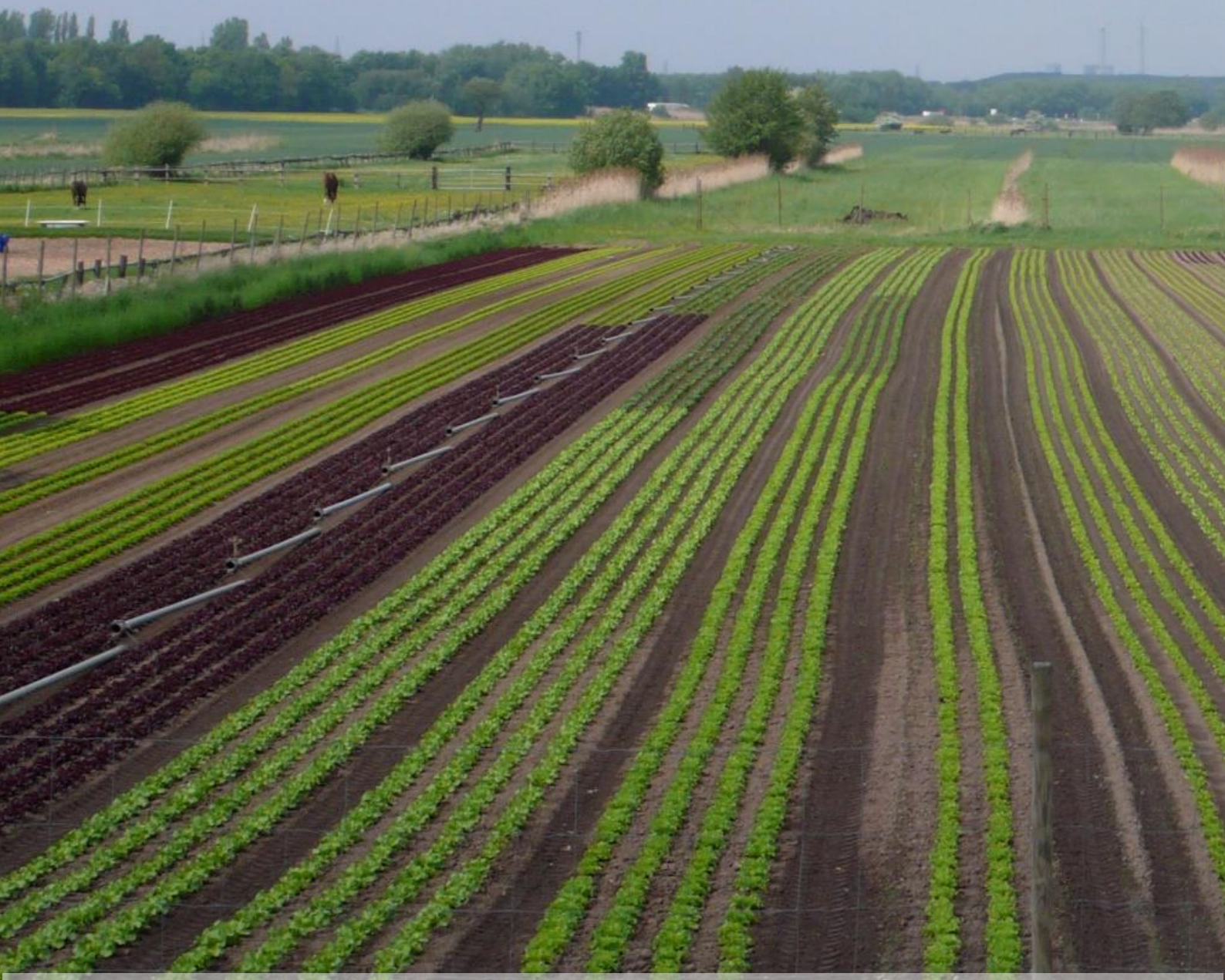

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FOODSHIFT Pathways

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Abbreviations

CORINE	Coordination de l'Information sur l'Enviroment
CSO	Civil Society Organisations
ESD	Education for Sustainable Development
EUISS	European Union Institute for Security Studies
FAO	Food and Agricultural Organisation
IAAC	Institute for Advanced Architecture Catalonia
INRAE	Institute national de recherche pour l'agriculture, l'alimentation et l'environment
JRC	Joint Research Centre
MUFPP	Milan Urban Food Policy Pact
NGO	Non-profit Organisation
RUAF	Resilient Urban Food Systems (organisation)
SC	Sustainability Competence
SEEA	Sytem for Environmental and Economic Accounting
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WUR	Wageningen University Research

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Executive Summary

As part of the Erasmus+ Project 'FoodSHIFT Pathways', this report addresses interdisciplinary learning and adopt an approach based on *Sustainability Competences* as an effective step towards creating more meaningful episodes of learning that focus heavily on skills. Being a conceptual spin-off from EU project 'FoodSHIFT2030' in support of a transition towards a more plant-based, circular, and low-carbon food system. FoodShift Pathways also revolves primarily around teaching pupils about sustainable food.

As a European project addressing teachers/educational staff and food system actors to raise awareness and cultivate students' Sustainability Competences (SCs), environmental literacy and global awareness/citizenship, our point of departure is the Joint Research Centre's 'GreenComp' Framework (JRC 2022) which puts forward a set of SCs to be considered when teaching sustainability. Following JRC's approach, we defined SCs at middle school level as *"a combination of knowledge, skills, attitudes, and values that enable teachers to effectively address real-world sustainability problems, challenges, and opportunities, taking into account regional and local circumstances"*. The underlying assumption is that teachers must be in command of a series of SCs that reflects the state of knowledge and insights which students need to take up if they want to actively – but also critically – engage in making our food system more sustainable.

Methodologically, this report draws mainly on a desktop study reviewing the relevant literature addressing SC as input to a survey among teachers and other educational experts in the six participating countries (the so-called 'Needs Analysis' (Activity 2.1). The underlying motivation for this decision was to make sure that the FoodShift Pathways approach builds upon the existing knowledge base while at the same time allowing participant to specify and add other competences. To be both effective and selective, we focussed largely on reports and articles which are of recent origin and which are based on wider literature reviews. Hence, further international references such as UNESCO's Source Book and a selection of scientific review papers addressing this topic from different angles, provided input in the light of important conceptional and policy-relevant issues.

As JRC's GreenComp framework took a central role in our approach, we review its four main categories (Embodying sustainability values, Embracing complexity in sustainability, Envision sustainable futures and Acting on Sustainability) in the light of recent research and policy developments in the field of sustainable food systems. This review offers teachers and education experts insights to a body of knowledge that is considered as state-of-the-art and hence relevant for (re-)defining their own horizon in this field.

Further literature such as from UNESCO but also the already mentioned review articles such as by Wiek et al (2011) and Tippman (2020) provide complementary insights, helping to position the GreenComp approach in the wider research context. These references as well as own insights deriving from the FoodSHIFT 2030 project prompted us to arrive at a scheme of 13 SCs as input for a questionnaire for ten teachers and education experts in the six participating countries Portugal, Spain, Sweden, Denmark, Netherlands and Greece inquiring on their perception regarding these SCs.

The 13 identified SCs are grouped into five categories are:

First Level	Second Level
Normative Concepts	Valuing the environment
	Understanding society
	Assessing economic aspects
System Thinking	Conceptualizing
	Critical Thinking
	Innovative problem solving
Forward looking	Envisioning future scenarios
	Developing creative solutions
	Experimenting and testing
Strategies & Actions	Navigating politics
	Collaborating and connecting
	Taking initiative
Pedagogical goalsetting	Interpersonal development

Having applied the above 13 SCs in the Needs Analysis, we used these results to further elaborate the 'takeaways for the pedagogical design' with special emphasis on those SCs which were considered of high relevance, namely:

Valuing the Environment

Critical thinking

Understanding society, and

Innovative problem solving

We further provided a set of brief teaching examples for the remaining SCs and summarise the findings in a short chapter on conclusions.

1. Introduction

Within the Erasmus+ project **Foodshift Pathways**, Work Package 2 on 'State of the Art & Pedagogical Design', has mainly the goal to perform a teacher training needs analysis to better understand the type of skills and knowledge base of teachers at middle schools (age group 11 – 16), for addressing the topic of sustainable food in class or during extra-curricular sessions such as field trips and site visits. A central element of the needs analysis is to address the expected Sustainability Competence (SC) levels of teachers – hence their ability to explain and demonstrate to children what – in this case – a sustainable food system is about and why there is need to change the current one.

1.1 Work Package Objectives

The results of the needs analysis will feed directly into the 'pedagogical design' addressing deeper and interdisciplinary learning as the ultimate goals of this work package. The description of WP2 specifies:

- *Perform a needs analysis on the basis of a user-driven incubation process with the key stakeholders;*
- *Start from the premise that schools can facilitate deeper learning in environmental education (emphasis on rigorous core content and the development of competences needed for university and career*
- *Introduce interdisciplinary learning and adopt an approach based on Sustainability Competences as an effective step towards creating more meaningful episodes of learning that focus heavily on skills.*
- *Interweave technology and critical thinking with climate change as an effective way of putting the acquired knowledge directly in use within a meaningful context*
- *Guide the project's Pedagogical Design to help students imagine new ideas in the field of SFS; to shift from "what is" to "what might be".*

These specifications make clear that improving or possible even introducing the 'sustainability competence' of teachers takes a central role in this work package which ultimate goal it is to put forward a pedagogical design – an undertaking with is at the heart of the project.

1.2 Definition, Goal and Approach

Definition
According to the Joint Research Centre (JRC), SC can be defined as: "the interlinked set of knowledge, skills, attitudes, and values that enable effective, embodied action in the world with respect to real-world sustainability problems, challenges, and opportunities, according to the context". This quote derives from JRC's 'GreenComp' report offering a 'European Sustainability Competence Framework' as one of the policy actions under the Green Deal. Its mission is to promote learning on environmental sustainability in the European Union and is hence aiming at providing European-wide guidance when it comes to teaching sustainability.

Given that FoodShift Pathways aims primarily at teaching middle school level pupils, we propose a slight amendment of the JRC definition to fit the propose of this project:

> *"Sustainability Competence at middle school level entails a combination of knowledge, skills, attitudes, and values that enable teachers to effectively address real-world sustainability problems, challenges, and opportunities, taking into account regional and local circumstances"*

Next to narrowing down SC in the context of teaching this topic at middle schools (specifically the age group between 11 and 16 year old pupils), the above definition puts emphasis on the regional and local context as an important aspect of teaching, namely demonstrating the concept of sustainability with the help of concrete and recognizable examples from the target group's socio-economic and geo-environmental surroundings.

Goal and approach

While the broader goal setting has been addressed in section 1.1., we want to explicitly mention here that this report is meant to arrive a short-list of key SC candidate terms/concepts that can be considered a reference to be further explored when talking with teachers.

Thus, this report draws mainly on two resources, namely: (1) a desktop study reviewing the relevant literature addressing SC, and (2) a survey among teachers and other educational experts in the six participating countries. The role of the literature review was in fact to provide targeted entries for framing sustainability competences for developing the survey. The underlying motivation for this decision was to make sure that the FoodShift Pathways approach builds upon the existing knowledge base while at the same time allowing participant to specify and add other competences.

The references that are considered as relevant for determining the types of SC is closely hinged upon the guiding role of a frameworks at the European level and some selected research articles which appeared to address the topic from the same angle as this project, and which offered a high degree of systematic rigor in line with the project ambitions. Since the project resources for this SC review have been limited and because our own survey is considered as a valuable input, the literature review had to focus on those examples which surfaced from expert exchange at project level. Having said this, it should be kept in mind that the key sources which are serving a guiding references here did undertake extensive literature surveys so that we are confident regarding the overall knowledge base for our approach.

2. Review of Sustainability Competence literature and frameworks

While there is growing body of scientific literature addressing the many dimensions of sustainability, references to SC regarding teaching the youth in the different educational institutions is still limited. A search under '*Sustainability Competence for Middle school teaching'* on Science Direct resulted in total of almost 6000 hits, roughly doubling every ten years (2000: 79 articles, 2010: 202 articles and 2022: 433 articles) with an exponential increase during the last three years. With a focus on food systems, the result show less articles: 1800 in total until 2023 – tendency also growing. Under the umbrella topic *sustainability teaching at middle schools*, a search results in around 23.000 articles, hence almost five times as much as compared to SC and even 13 times as much compared to searching on 'food system teaching'.

The recently growing scientific response rate is – to a certain degree – also reflected in the development of educational schemes addressed in policies. Our review under Task 2.2 of this Work Package shows that next to the UN's Sustainable Development Goal Nr 4 (especially Target 4.7 on Education for Sustainable Development and Global Citizenship), only the Milan Urban Food Policy Pact (MUFPP, 2015) and the Innovation Handbook by FAO and INRAE (2020) are stepping forward with more concrete goals. At the level of the European Union, it has been announced that the Farm to Fork Strategy will put forward an education-oriented policy paper by the end of 2023.

In the following we will subsequently introduce and discuss the following key references:

- **JRC 2022:** The European sustainability competence framework
- **UNESCO 2011**: EDS Source Book Teacher Education
- **Wiek et al. 2011**: Key competencies in sustainability: a reference framework for academic program development
- **Tippmann 2020**: Education for Sustainable Food and Nutrition – Towards Criteria for German Secondary Schools

Secondary sources that have been examined include:

- **Maliotou, MN & Liarakou, G. 2022**. Teachers' Perceptions and Educational Practices on Sustainable Nutrition in Cyprus
- **Janhonen, K. & Elkjaer, B. 2022**. Exploring Sustainable Food Education as Multi-professional Collaboration between Home Economics and School Food Catering
- **UNESCO 2012**. Exploring sustainable development: a multiple-perspective approach.
- **Corres et al 2020.** Competences in Sustainability Education: A Systematic Review of Frameworks. Sustainability
- **Schemenauer, J. 2020**: Teaching Sustainability (webpage)
- **Wascher, D. & Arciniegas, G. 2021**: Guidelines for handling Innovation Management. Deliverable 8.4 of the EU Project FoodSHIFT 2030

Table 1: Literature review regarding SC in different European frameworks and research papers (dark blue column are international references).

JRC 2022	UNESCO 2011	Wiek et al. 2011	Tippmann 2020
Embodying sustainability: • Valuing Sustainability • Supporting Fairness • Promoting Nature	• Purpose for Education • Relevance to Curriculum • Economic potential	**Normative Competences:** • Principles, goals, targets, thresholds • diversity of values, Empathy, compassion and solidarity • Risks, gains, win-win, trade-offs, prices, resource values,	• Empathy for and solidarity with the disadvantaged • Empathy for and solidarity with the disadvantaged
Embracing complexity in sustainability: • System Thinking • Critical Thinking • Problem Framing	•	**System Thinking Competences:** • Identifying connections • Reflexivity, Critique • Problem-solving capacity	• Idea of equity in decision-making and planning • Reflect upon one's own principles & those of others • Incomplete & overly complex info; cope with dilemma of decision making
Envisioning sustainable futures: • Futures literacy • Adaptability • Exploratory thinking	• Common Vision	**Anticipatory Competences:** • Anticipatory thinking • Path consistency, system resilience • Time, uncertainty, probability	• Think and act in a forward-looking manner
Action for Sustainability: • Political agency • Collective action • Individual Initiative	• Concrete examples • Saving Pupils' lives	**Strategic Competences:** • Transformative governance • Participation, inter- disciplinarity Instrumentalization & alliance • Social action/engagement	• Knowledge & acting based on inter-disciplinarity and cooperation • Motivate oneself as well as other to become active
		Interpersonal Competences: • cooperation & empathy, solidarity & ethnocentrism, team dynamics Trans-cultural understanding	• Empathy, idea of equity

The review of the above articles and webpages had the objectives of arriving at a core set of SC which are covered by many of these studies and frameworks. As mentioned earlier, the work undertaken by JRC (GreenComp) has been considered as authoritative in this respect.

This is also reflected in the fact that JRC's main categories for SC have been taken over in the first column of Table 1 summarizing the reviews of the key and the secondary references. The only addition which we propose as a category of SC is 'interpersonal competence' which is probably close related to 'attitude' in the overall definition of SC. According to our view, the latter following from Table 1, we will briefly discuss the key references and cross compare the different terms of concepts that have been used.

2.1 Reviewing GreenComp in the light of Sustainable Food Systems

As mentioned above, GreenComp (JRC 2022) is up to now the European Commission's most authoritative approach on the state-of-the-art regarding SC at the European level. Over a period of two years, the JRC team involved 75 experts and were holding two expert workshops and a stakeholder workshop as part of an iterative process leading from concept, (SC) proposal to framework refinement and publication. The final framework comprises four *competence areas* and 12 competences. The four competence areas correspond to Level 1 and the SCs themselves to Level 2 in Table 2.

The four (interrelated) competence areas/1st Level SCs are:

- Embodying sustainability **values** / **value**
- Embracing **complexity** in sustainability / **system**
- Envisioning sustainable **futures** / **scenario**
- **Acting** for sustainability / **action**

In Table 1, we discern between the international key references in the blue part and a selection of key science articles in the grey part of the table. In the last column we make reference to some selected science articles which are considered to be of relevance here as well. In the following we will highlight some of the underlying principles of the GreenComp CSs and explore how these link to the ongoing debate and research around the transition towards a sustainable food system.

2.1.1 Embodying sustainability values

With regard to sustainability, The concept of values can be understood in different ways. There is first of all the aspect of personally giving value to sustainability in the sense of appreciating its benefits for society at large and for the planet. Such a personal view is more associated with the SC dimension of 'attitude'. According to Stålhammar & Thorén (2019), there are next to the widely recognised axiological categories of *instrumental* (this includes monetary) and *intrinsic values* a third category, namely '*relational values*'. Relational values are considered to better capture how people and collectives perceive their wellbeing and make choices that involve the environment; including "preferences, principles, and virtues associated with relationships both interpersonal and as articulated by policies and social norms" (Chan et al. 2016, p. 1462).

The SCs which have been identified under this Level 1 are:

- **Valuing Sustainability**
  To reflect on personal values; identify and explain how values vary among people and over time, while critically evaluating how they align with sustainability values.
- **Supporting Fairness**
  To support equity and justice for current and future generations and learn from previous generations for sustainability.
- **Promoting Nature**
  To acknowledge that humans are part of nature; and to respect the needs and rights of other species and of nature itself in order to restore and regenerate healthy and resilient ecosystems

The first and third SC are more or less aligned with the 'intrinsic values' concepts, while 'supporting fairness' appears to address the notion of 'fair pricing' in the monetary context. This means e.g., that prices should *internalise* social-environmental costs, but also recognizing the value of work and knowledge that is related to producing food. Currently, business models at the farm level are geared towards mass production aiming at keeping production prices (cost price) as low as possible in order to be competitive on the world market. This leaves many small and traditional farmers behind and has led to an industrialisation of agriculture in which many individual skills and (tacit) knowledge as well regional conditions are undervalued.
Large efforts are being made to calculate the value of e.g., biodiversity in order to become accountable within a capitalist system. In fact, the term 'biodiversity' – hinting at the quantitative aspect of high diversity being of more value – has been established because 'nature' had been perceived as too being broad and *too intrinsic*. Prominently addressed in the 1995 report 'Taking Nature into account' by the Club of Rome, there are meanwhile a variety of initiatives such as UN's System for Environmental and Economic Accounting (SEEA) as part of "The Natural Capital Accounting and Valuation of Ecosystem Services" process that start with the Millinium Ecosystem Assessment (2005) addressing among others also intrinsic Cultural and Amenity Services, e.g., for landscapes.

In terms of our food system, a larger awareness of values associated with regional food, traditional (local) crop types, sustainable and organic farming methods and community engagement are issues to be considered when addressing both their intrinsic as well as their market (economic) values.

2.1.2 Embracing complexity in sustainability

The link between 'system approach' and the attribute of 'complexity' might not immediately come across as evident. However, there is inherent complexity in what can be considered a Sustainable Food System, which we have defined as follows:

> *A system of food production, processing, distribution and consumption that is actively seeking to* ***reduce*** *Greenhouse Gas Emissions (GHG emissions) and other negative impacts such as food waste, loss of biodiversity and lifestyle related diseases, while* ***contributing*** *towards effective food security, fair prices and nutritional wellbeing. Next to* ***circularity*** *and* ***plant-based food****,* ***cross-sector collaborations****,* ***citizen involvement*** *and the* ***education of future generations*** *are considered as key principles."*

System *complexity* is – along with diversity – considered as one of the main characteristics of ecosystems. But why embracing complexity? The reason is that in terms of risk management – hence the societal response to crisis situations – complex systems are considered to be more robust than simple systems because the presence of many and diverse system components allows them to re-arrange more rapidly than systems that are based on only (or dependent from) a few key components. The typical agricultural example here is that mono-cultures of just one crop (e.g., corn) are more

vulnerable to the impacts of insect calamities thana farming system with many different crops combined with ecological structures that provide habitat functions to species which are the natural enemies of the impacting insect. However, the food system is far more complex that a specific farming situation – see Figure 2.

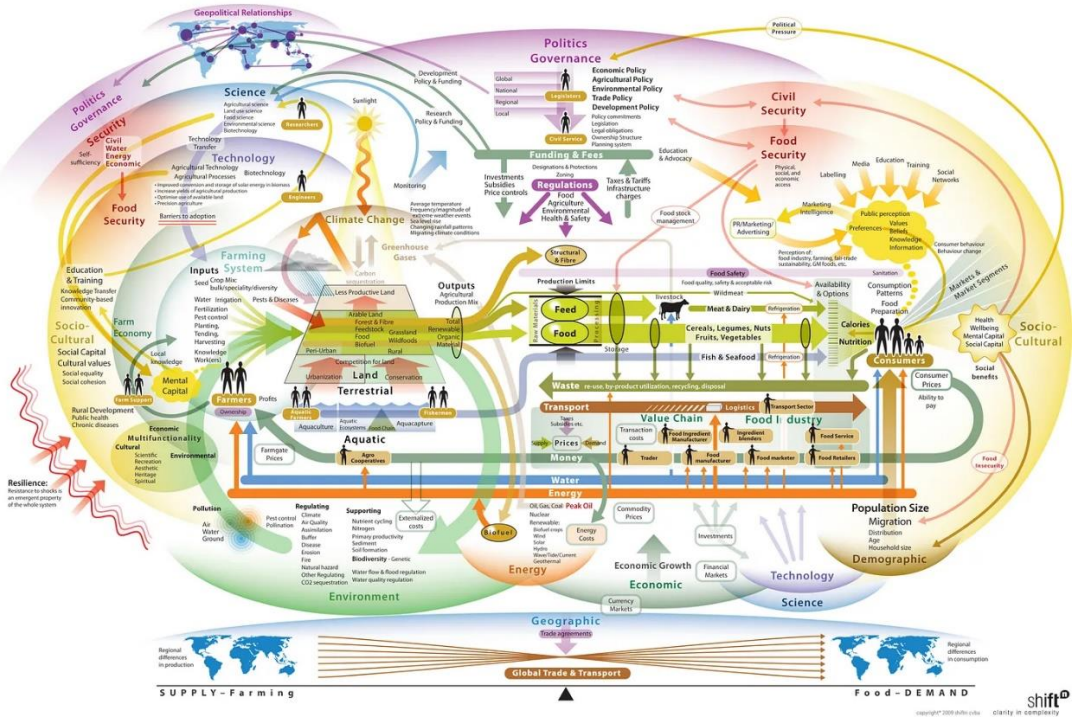

Figure 2: Depiction of the Global Food System (SHIFT – Clarity in Complexity)

The SCs which have been identified under this Level 1 are:

- **System thinking**
  To approach a sustainability problem from all sides; to consider time, space and context in order to understand how elements interact within and between systems.
- **Critical thinking**
  To assess information and arguments, identify assumptions, challenge the status quo, and reflection on how personal, social and cultural backgrounds influence thinking and conclusions.
- **Problem facing**
  To formulate current or potential challenges as the sustainability problem in terms of difficulty, people involved, time and geographical scope, in order to identify suitable approaches to anticipating and preventing problems, and to mitigating and adapting to already existing problems.

The above examples of how complexity and resilience affect the food security of countries and regions demonstrate, that 'critical thinking' and 'problem facing' are important SCs when considering the different dimensions of a problem before jumping to action.

2.1.3 Envisioning sustainable futures

This competence area requires – compared to addressing values and taking a system approach for managing complexity – very different skills, namely the ability to use the imagination and to take a step back from a status quo situation when creating images of the future. Creating images of a

sustainable future should not be confused with 'dreaming up' new realities – though a fair amount of openness and out-of-the-box thinking is certainly part of it. However, rather than entering the arbitrary road of adhoc imagination, the development of future scenarios (e.g., of a more sustainable food system) is following well established, *evidence-based* (= data-driven) and transparent methodological steps.

According to Boo at al. (2010), scenario planning considers the uncertainties and driving forces that may have impact on a certain regional development or the food system (see also the reference to DPSIR in Chapter 2 of the Task 2.2 report). Typical examples from environmental science are scenarios which predict flooding events according to historic data on changing water levels which are then extrapolated to the future. The climate change reporting process of IPCC on the expected CO2 emissions and associated impacts on world temperature or sea level rise is another case in point.

At the methodological basis of such scenario's are mathematical models which – like in the case of IPCC – are make use of very large statistical data on human activities and bio-geographic trends provided my monitoring stations around the whole world or located – like in the case of land cover change assessments – gathered by satellite data (see EU's CORINE programme). In the case of the European Union, model-based scenarios are requested by the European Commission for running (ex-ante) impact assessments and analysis of policies. A key part for the scenario modelling is the regular production of updated EU and Member State GHG emission data for developing policy scenarios.

The SCs which have been identified under this Level 1 are:

- **Futures literacy**
  To envision alternative sustainable futures by imagining and developing alternative scenarios and identifying the steps needed to achieve a preferred sustainable future.
- **Adaptability**
  To manage transitions and challenges in complex sustainability situations and make decisions related to the future in the face of uncertainty, ambiguity and risk.
- **Exploratory thinking**
  To adopt a relational way of thinking by exploring and linking different disciplines, using creativity and experimentation with novel ideas or methods.

Examples for the SCs 'adaptability' and 'explorative thinking' can also be found in the sister project FoodSHIFT 2030 which makes use of scenario developments for imaging the future land use under the impact of the EAT-Lancet diet proposing to substantially reduce the consumption of meat (see Figure 3).

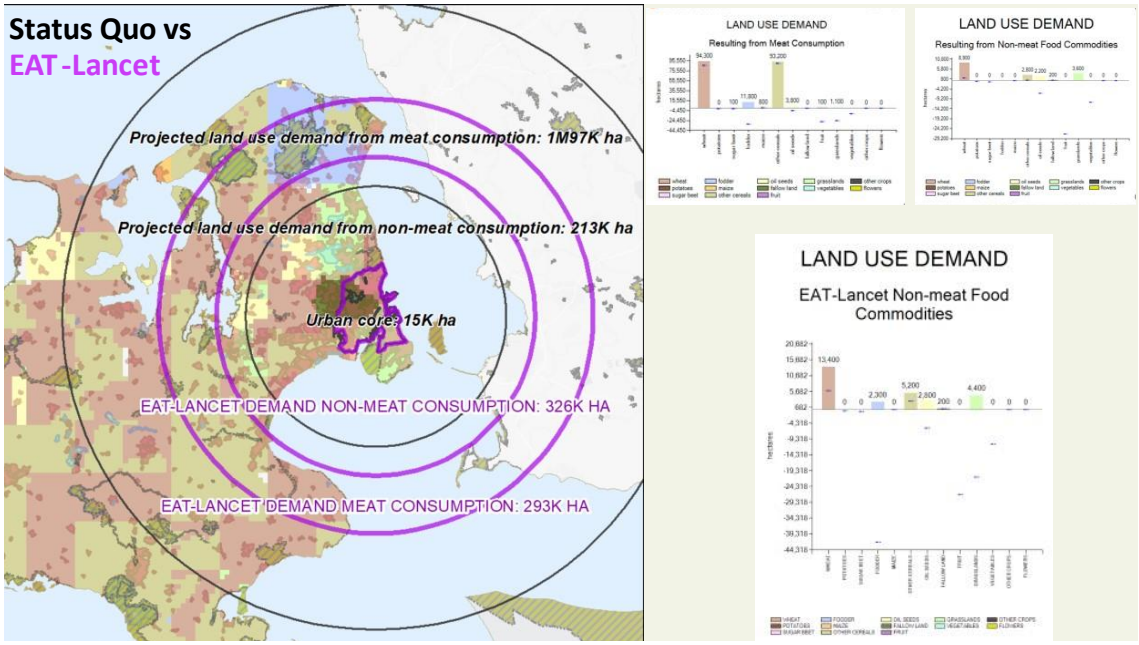

Figure 3: MFP Land use scenario on the amount of land needed for meat vs plant-based food consumption comparing the status quo (black line) with the EAT-Lanced diet plans (purple lines) Arciniegas et al. 2022.

In terms of 'adaptability', the EAT-Lancet dietary programme can be considered an adaptation strategy for humans in reaction to health and environmental problems. The Metropolitan Foodscape Planning tool is an example for how to apply exploratory thinking to problem solving at the scale of metropolitan region and by taking into account geo-referenced data on food consumption and land use to come up with a new future design.

2.1.4 Acting for sustainability

Taking action can be considered as the most radical approach in terms of manifesting a willingness to change the status quo. GreenComp differentiates here between three levels – namely from political/legislative decision making at the level of states and governments, collective action as democratic right and institutional movement, e.g., by CSOs or NGOs, and individual action focussing on personal contributions towards a more sustainable world – in the case of food this could be eating less or no meat.

The SCs which have been identified under this Level 1 are:

- **Political agency**
  To navigate the political system, identify political responsibility and accountability for unsustainable behaviour, and demand effective policies for sustainability.
- **Collective action**
  To act for change in collaboration with others
- **Individual initiative**
  To identify own potential for sustainability and to actively contribute to improving prospects for the community and the planet

The political dimension has been addressed in the corresponding Activity 2.2 report under the title 'Harmonizing with European policies'. This report summarised the recent developments of an emerging European food policy with main focus on the Green Deal and its Farm-to-Fork Strategy. JRC's

GreenComp framework is actually also a results from the Green Deal, but has the character of an expertise without any binding force.

With regard to the role of CSOs and NGOs, it should be acknowledged that many of them thrive upon public funding support, or financial help by philanthropy. Especially international organisations take the form of foundations and network organisations supported by public or semi-public partners. Their role as change-makers must be considered as essential when it comes to policy development and action taking. In the following we will briefly describe a couple of those European organisations that play a leading role in the transition process towards a sustainable food system.

- RUAF (Sustainable Urban Agriculture and Food Systems)
  Founded 1999 as 'Resource Centres on Urban Agriculture and Food Security', RUAF is active in the implementation of programmes on Multi Stakeholder Action Planning (MPAP), Resource Recovery and WASH, Value Chain Development, Climate Change, the City Region Food Systems and Urban Planning.

- EAT Forum
  The EAT Forum is a non-profit organisation founded by the Stordalen Foundation, Stockholm Resilience Centre and the Welcome Trust with the mission to catalyse the transition of the food system. The main focus is to end malnutrition in all its forms and to do so in holistical manner.

- Slow Food International
  Slow Food is a global, grassroots organization, founded in 1989 to prevent the disappearance of local food cultures and traditions, counteract the rise of fast life and combat people's dwindling interest in the food they eat, where it comes from and how food choices affect the world.

Next to this small selection on international collective initiatives, there are many national, regional and local initiatives engaged in food system transition. The FoodSHIFT 2030 project offers insights to a wide range of innovation-oriented collective groups from nine cities regions.

2.2 Further literature

While the European Sustainability Competence Framework developed under JRC's GreenComp is used here as the central reference, we were interested to see how this framework and the different SCs related to other frameworks at the policy and science level. We will highlight some of the commonalities and differences we came across and present a set of conclusions that have led our approach towards establishing an SC framework for the purpose of this project.

2.2.1 EDS Source Book Education for SD (UNESCO 2011)

UNESCO's Source Book for Education for Sustainable Development is just one of a series of source books that address this and related topics. The target audiences for Sourcebook are primary and secondary teachers and mid-level decision-makers, who have responsibility for primary and secondary education. Another primary audience is teacher educators who work with pre-service and in-service primary and secondary school teachers. The purpose of the publication is to describe ways in which

education for sustainable development (ESD) can be integrated into primary and secondary schooling. This collection of briefs is designed to complement other ESD materials published by UNESCO.

The book stresses the fact, that the topic of sustainability does not only require the support of educational engagement, but that also the reverse is true:

'*Sustainability improves education and has the potential to transform education. As countries and communities struggle to cope with contemporary challenges accompanied by major life-changing events (e.g. climate change-induced drought or the rise in sea level), the purpose and relevance of education itself have been questioned*.'

The UNESCO sees the following mechanism in place:

- *Sustainability adds purpose to education.*
- Sustainability gives a *common vision.*
- Sustainability gives relevance to the curriculum.
- Sustainability in the curriculum raises *economic potential*
- Sustainability gives *concrete examples of abstract concepts*
- Sustainability can *save pupils' lives*

With regard to the GreenComp SCs, the Source Book addresses mainly Sustainable Values (e.g. the above purpose for education), notably also the 'economic potentials' of sustainability. Here it is stated that: "….*If education were perceived as contributing to a child's or the family's current or future economic well-being in a tangible rather than abstract sense, some children would stay in school longer. Developing a curriculum that increases the economic potential of pupils is facilitated when sustainability as a crosscutting curricular theme is added. Creating and living in a more sustainable world requires knowledge and skills for living sustainably and having sustainable livelihoods. Preparing pupils to fill the "green jobs" of tomorrow is an important part of education*".

The connotation of an 'economic potential' offers actually an interesting and often underrated view on sustainability, namely that it not only holds a wide range of business opportunities and new business models, but that the application of sustainable principles will actually make life and production more effective and robust.

As regards the SC area of 'system complexity', the UNESCO considers concrete examples of sustainable problem solving – e.g. a 'school garden' just as a way of explaining abstract concepts, i.e. the food system as such.

Part of the UNSECO Source Book publications are also a series of videos as part of the teaching material on sustainability:

2.2.2 Key Competences in Sustainability (Wiek et al. 2011)

The full title is in fact: 'Key competencies in sustainability: a reference framework for *academic* program development' and is an American review of the relevant literature on key competencies in sustainability. As GreenComp at the international level, Wiek & Leeler synthesize the different contributions in a framework of sustainability research and problem-solving competence. Though this

review is mainly focussing on higher learning, there are interesting parallels with the GreenComp approach (see Fig. 5).

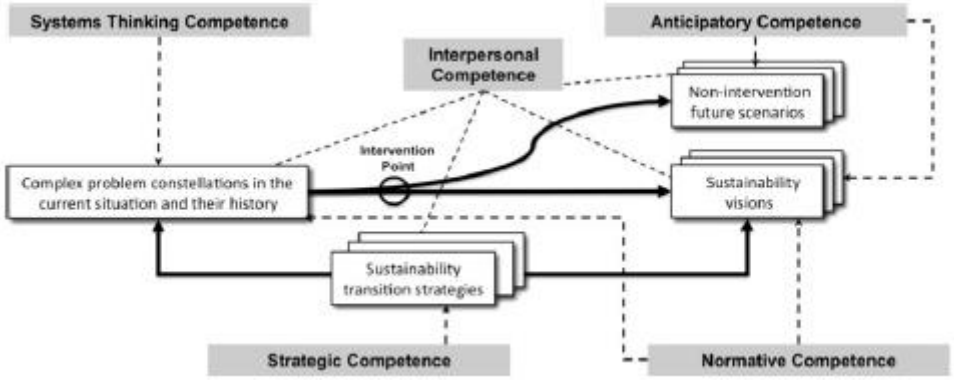

Fig. 5: Five key competencies in sustainability (shaded in grey) as they are linked to a sustainability research and problem-solving framework. The dashed arrows indicate the relevance of individual competencies for one or more components of the research.

The review describes these CS areas the following way:

Anticipatory competence
Definition: ability to collectively analyse, evaluate, and craft rich ‘‘pictures’’ of the future related to sustainability issues & problem-solving frameworks.
Link to other competencies: important in conjunction with sustainability assessments of future trajectories for the creation of transition strategies, as well as with testing and continuously adapting transition strategies in order to redirect path-dependent future trajectories toward the visions of a sustainable future.

Normative competence
Definition: ability to collectively map, specify, apply, reconcile, and negotiate sustainability values, principles, goals, and targets.
Link to other competencies: important for constructing direction and orientation about deliberative change. Transition strategies toward sustainability are based on identifying undesirable states and dynamics as well as envisioning desirable ones.

Strategic competence
Definition: ability to collectively design and implement interventions, transitions, and transformative governance strategies toward sustainability.
Link to other competencies: closely to the previous three competencies as strategies for transformative change attempt to effect the transition from the current state of the social-ecological system toward sustainable states and dynamics, taking into account existing path dependencies that might lead to undesirable future states.

Interpersonal competence
Definition: ability to motivate, enable, and facilitate collaborative and participatory sustainability research and problem solving.
Link to all other competencies, as all rely on collaborative approaches to create ownership, to build joint capacity to cope with complex sustainability challenges.

As the GreenComp approach, Wiek et al. (2011) put forward a secondary level for each of the SC areas (see extractions in Table 1 and full references in Annex X).

2.2.3 Education for Sustainable Food and Nutrition (Tippman 2020)

The full title is 'Education for Sustainable Food and Nutrition – Towards Criteria for German Secondary Schools'. We decided to include this study because of its focus on (1) secondary schools, (2) on sustainable food and nutrition, and (3) because it is offering a national perspective – which we consider to be complementary to the international references.

This research explored the conceptual framework of shaping competences, known as 'Gestaltungskompetenzen', introduced by De Haan in 2010: gather knowledge in a spirit of openness to the world, integrating new perspectives;

1. think and act in a forward-looking manner;
2. acquire knowledge and acting in an interdisciplinary manner;
3. deal with incomplete and overly complex information;
4. cooperate in decision-making processes;
5. cope with individual dilemmatic situation of decision-making;
6. participate in collective decision-making processes;
7. motivate oneself as well as others to become active;
8. reflect upon one's own principles and those of others;
9. refer to the idea of equity in decision-making and planning actions;
10. plan and act autonomously; and
11. show empathy for and solidarity with the disadvantaged.

Many of the above 'Gestaltungskompetenzen' reflect different aspects of the GreenComp SCs. The study had been carried out at a secondary school in Berlin, observing 15 students in grade 12 – hence a more advanced group than the middle school level which is object of this project.

Reflecting some of the outcomes of our curriculum survey (see report 2.1) the authors stress the fact that there is minimal to **no engagement in the topic of sustainable food and nutrition at the moment**. When the topic is introduced or discussed in a school, this is mostly done in a theoretical way (E. Carceller, personal communication, April 03, 2020). Environmental schools that engage in environmental protection, environmental education, and ESD seem to cover it most extensively. For example, some aspects of ESD can be seen in school gardens, veggies days, beehives, or project days where the topic was addressed. According to Braun-Wanke (personal communication, March 27, 2020), **authenticity when teaching sustainable food and nutrition is crucial.** A change in behaviour has to come from inside of the student. The students need to have the space to build their own opinions; practitioners should not pressure the students or try to persuade them.

2.3 Establishing the final Sustainability Competences framework

Following up from the review of the GreenComp SC areas and competences in the light of (1) food systems and (2) other European and national studies as well as frameworks, we have compiled a SC framework that we consider reflects the different perspectives and the special context of the FoodSHIFT Pathways project.

The guiding aspects and principles for doing so are:

- A structure that takes up the concept of 1st level and 2nd level SCs in order to group SCs under umbrella headings
- A wording/terminology that reflects the food system literature and knowledge components as reviewed for this report;
- A description of food-related issues that has the character of a key-word list for helping respondents when filling out the questionnaire.

Table 2: FS Pathway Sustainable Competence framework Level 1 and 2 (input to questionnaire)

First Level	Second Level	Key issues
Normative Concepts	Valuing the environment	Principles, goals, measurable targets, thresholds, cultural norms or personal values
	Understanding society	Diversity, cooperation, inclusion, compassion and solidarity, well-being, happiness
	Assessing economic aspects	Job perspectives, profit, food-chain, trade-offs, prices, resource values, competition, up-scaling
System Thinking	Conceptualizing	Dealing with complexity, holistic approach, circularity, resource efficiency, LCA, resilience
	Critical Thinking	Reflexivity, critique, multi-criteria decisions, problem solving, multiple perspectives, out-of-the-box
	Innovative problem solving	Problem-solving capacity various dimensions of food chain (process, product, governance, social)
Forward looking	Envisioning future scenarios	Developing visions, think and act in a forward-looking manner, what-if thinking, different future
	Developing creative solutions	Co-creation, idea of equity in decision-making/planning, power of the visual, maps & media
	Experimenting and testing	Time, uncertainty, probability, test, living labs, exploration, field work, gardening & farming
Strategies & Actions	Navigating politics	Transformative governance, transition management, incentives, food councils, legislation
	Collaborating and connecting	Participation, Interdisciplinary work, instrumentalization & alliance, Identifying connections
	Taking initiative	Social action, engagement, business planning, empowerment, cooking, leadership, blogging
Pedagogical goalsetting	Interpersonal development	Cooperation & empathy, solidarity & ethnocentrism, team dynamics, leadership, trans-cultural understanding, serious gaming, tools

While building largely on the rational and structure of JRC's GreenComp framework, we undertook some amendments which we will briefly explain in the following:

Normative Concepts: here we felt that the underlying value system should address the three pillars of sustainability, namely environment, social and economy. All of these disciplines are associated with value system which can be integrated into an 'holistic' approach, but which are frequently in competition with each other. We consider it important, that children get an understanding of the co-existence of different normative concepts.

- **System thinking:** though systems can be complex and abstract, we felt that 'embracing complexity' is somewhat misleading as it suggests and the complexity as such is something to adhere to. Instead we think that 'understanding and managing systems' is pointing at the essence of what the transition in food matters is about: away from incremental change towards a system change. Understanding systems is hence key to triggering change. Part of system thinking is also the challenge to develop 'innovate problem solving''.
- **Forward looking:** this is addressing the world of scenarios and co-creation processes, imagining the future and being able to make it concrete and plausible (e.g. by mapping and drawing). Scenarios are hence part of this and they related to impact assessment and to the question 'what if…?'
- **Strategies and actions:** here we stayed actually quite close to the GreenComp framework, but used different wording. By focussing on 'taking initiative', this approach goes beyond 'individual action' which is mainly related to the personal level.
- **Pedagogical goalsetting:** we added this SC since it has been addressed in various other frameworks and studies and links back to the pedagogical framework of this project.

3 Takeaways for Pedagogical Design Principles

This section intends to translate the findings from the above sustainable competences review to a set of 'design principles' when addressing pedagogical challenges and opportunities when addressing the transition towards a more sustainable food system. Addressing the key SCs which are standing out in the perception of the interviewed teachers, we are going to illustrate the implications at the example of an actual agri-environmental conflict in the Netherlands. By doing so, we will make use of Table 3 cross-comparing these four key SCs against typical issues relevant in the food system.

3.1. Insights from the Needs Analysis

The so-called 'Needs Analysis' carried out as part of this project – inquiring among ten teachers/education experts per participating country regarding the role and needs associated with teaching sustainable food – made use of the SCs presented in Table 2 to inquire about priorities and preferences. The results showed that most SCs are actually considered as relevant in current teaching in most countries (scoring above '3' in a scale from 1 to 5). The highest scores have been given to "Valuing the environment" (3.9) and "Critical thinking" (score 3.7) are the most highly rated in the current education system. On the other side, SCs such as "Navigating politics", "Assessing economic aspects" and "Collaborating and connecting" score under or barely a score of 2,75. It is notable that respondents from Denmark and the Netherlands score much lower on most SCs compared to the average of all respondents and Portugal, Sweden and Spain score well above average for nearly *all* competences. It is unclear whether this results from socio-cultural differences along attributes such as modesty/honesty, optimism/pessimism or objectivity/bias or if these competences are actually really less represented in the respective countries.

When asked to select the three competences that are considered most important in educating about SFS, the following competences came out on top:

1. **Valuing the environment**
2. **Critical thinking**
3. **Understanding society**
4. **Innovative problem solving**

It is interesting to see that the two competences selected as most important are the same that were selected as best represented in the respondents' current work, implying a certain balance between ambitions and practice.

Further analysis of the data gathered among teachers and educational experts allowed the following observations:

- a real high valuation for both Normative Concepts and System Thinking – especially with 'valuing the environment' and 'critical thinking', all clustered above 3.64. The cluster is led by Portugal, followed by Spain and Sweden. Greece and Netherlands are clearly under-represented here.

- though 'understanding society' and 'interpersonal development' are taking also a clear higher position, their mean score is clearly lower that 'critical thinking' and 'valuing the environment'.
- 'Understanding the society' has most extreme range from all SC spanning over almost 2 scoring points.
- The category 'Forward Looking' is clustered mid-range between 3.6 and 3.2 (led by Portugal and Sweden) and below 3.2 (Denmark and Greece). Among the three CSs, 'developing creative solutions' takes a leading role.
- The SC 'innovative problem solving' takes up a relatively high position led by Portugal – represented my innovation minded IAAC.

With valuing the environment as a normative concept first and 'critical thinking' of the system thinking domain second, the findings of the Needs Analysis clearly express a preference when developing a suitable pedagogical design proposal for teaching sustainable food. At the same time, 'understanding society' (another more normative type) and interpersonal development as the only pedagogical SC are next, closely followed by 'innovative problem solving.

Table 3: Food issues in the light of key SCs (✓ = small connection, ✓✓ = reasonable connection, and ✓✓✓ = strong connection)

Food issues	Valuing the Environment	Critical thinking	Understanding Society	Innovative Problem Solving
Circular Economy	✓	✓✓✓	✓✓	✓✓✓
Innovation	✓✓	✓	✓✓	✓✓✓
Food System	✓	✓✓✓	✓	✓✓✓
Food Security	✓✓✓	✓✓✓	✓	✓✓✓
Food Waste	✓✓✓	✓	✓✓✓	✓✓✓
Nutrition/Food Safety	✓	✓✓	✓✓✓	✓✓
Production	✓✓✓	✓✓✓	✓✓	✓✓✓
Animal welfare	✓✓✓	✓✓	✓✓✓	✓✓
Cultural landscapes	✓✓✓	✓✓	✓✓✓	✓✓

In the current debate in the Netherlands about the implementation of the EU's Nitrate Directive (91/676/EEC), it appears that is not clear to many people, why too much nitrate in air and water is a bad thing. And interestingly, the conflict – there are massive farmers' protests and a recent regional election which threatens to put conflict resolution into a lock-in – unveils a wide-spread lack of understanding why nitrate is bad for the environment. It might now be possible to argue that this is not a value problem, but a knowledge problem.

3.1.1 Valuing the environment

Valuing the environment starts with *knowing* the environment. Any value system is only as good and effective as the degree of understanding *why* something is valuable. One example – from the food world – is the economic value of caviar. 100gr of American caviar has a price of about €100. For someone who does not about caviar or how it tastes, this food item might easily be discarded as an obscure and strange smelling product. The same applies obviously to wines where an appreciation requires knowledge and even training. These example illustrate how closely knowledge and values are actually intertwined.

In the case of valuing the environment, the lay person might think that there is actually nothing wrong with the Dutch countryside as you still can have great cycling trips through the landscapes which – with the exception of more wind energy turbines – doesn't seem to change much. However a close look at the drainage ditches along the fields, or recognizing rare and protected plants in the grasslands unveils that the vegetation has changed dramatically and that both the insect fauna as well as a wide range of meadow birds have disappeared over the last decades (see WUR 2019).

The problem is the increase of ammonium due to livestock farming. The most serious consequences of increased ammonium availability have been found in previously weakly to moderately buffered nature types, such as fens, sparse grasslands, species-rich heathlands and forests on slightly loamy soil. In short, in those situations where the vegetation was adapted to nitrate as the dominant form of nitrogen, but where it is now mainly offered ammonium. Many lichens and mosses have also rare species such as sundew are on the decline.

Figure 8: Sundew (Drosera), a threatend insect-eating plant of low-nutirient bogs

Sundew (see Fig. 8) is one of the plants which being threatened by too much nitrates in the soil and water. It will disappear after only a few years of exposure. The plant is only a few centimetres high and can be quickly oversee or stepped on if not known. Valuing the environment means to know that this plant exits, is special (because of its insect-eating characteristics) and is endangered.

3.1.2 Critical thinking

The above example also requires 'critical thinking' competences from the category of 'system thinking'. In this case in will be necessary to understand the links between eating meat, the excessive livestock farming that is impacting on our landscapes, the role of ammonium as a non-natural nitrate and the effects that it has on the above plants. These system functions are illustrated in in Figure 9.

Here, critical thinking means to question whether it is necessary to take up meat-based proteins in the way we do – whether there are other options and what the agro-industry is doing to promote the consumption of meat. After all, meat eating is a lifestyle matter and there are more consequences for the environment and human health then just the decline of the little plant sundew:

- Eutrophication of our ground waters and runoff waters
- Excrement odours in larger regions of livestock rearing
- Animal transports over longer distances and poor conditions in mass farming
- Methane emissions contributing substantially to climate change
- Severe health impacts (hart and vessel diseases)
- Large portions of our agricultural lands are needed for feeding animals.

In Figure 9 it is shown what dimensions the impact of meeting has in a UK perspectives.

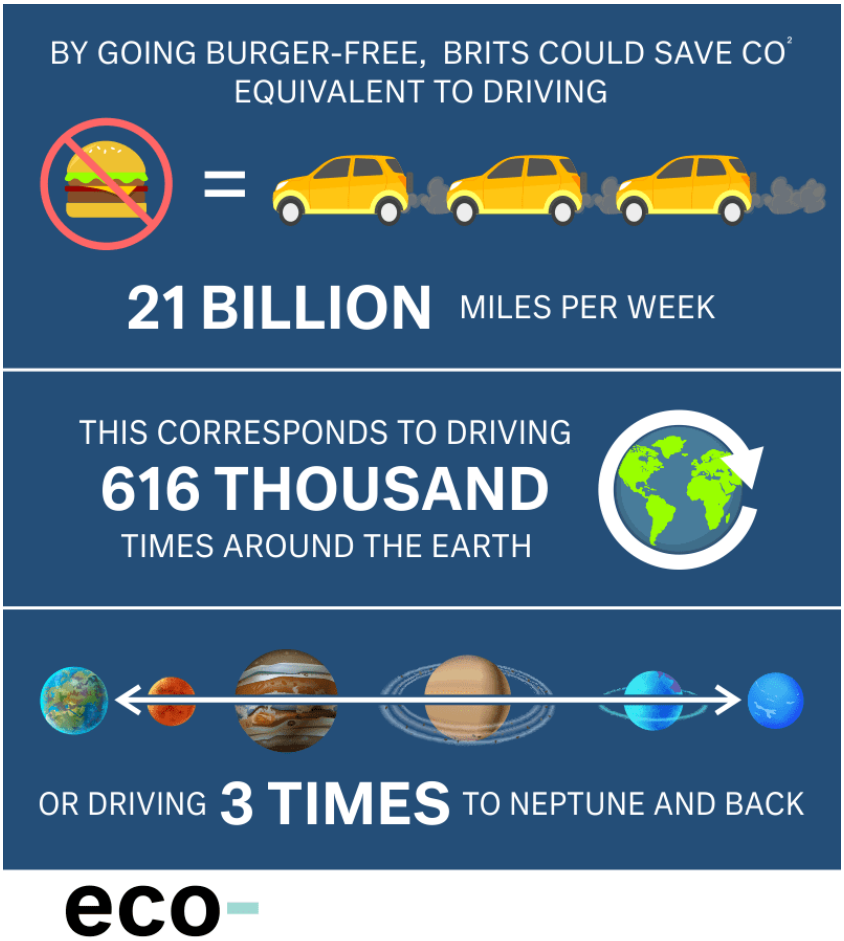

Figure 9: The impact of meat eating on the environment – a UK perspective

Critical thinking means to take the different dimensions into account and to make *informed* decisions regarding food consumption. But also to be critical about the sources – e.g. in the case of Fig. 12 – are these figures right? Where do they come from. But of course also when politicians argue for protecting the meat industry as an employer… how big are actually the health costs associated with meat consumption?

These and other questions can best be addressed in the context of regionally concrete example – allowing fieldtrips and discussing environmental reports.

3.1.3 Understanding society

An important part of teaching sustainable food systems is to understand the human dimension of a problem. In cases like the conflicts around the nitrogen policies in the Netherlands the society tends to rather quickly jump into the polarised vie points of being in favour of or against something, a law, a party or a group. The farmers received both, wide societal support like recently during the provincial elections, but also blame for having destroyed the environment, turning recreational landscapes into stinking industrial plains or for blocking the traffic with their protests (see Fig. 10).

Figure 10: Dutch farmer protest against nitrogen policies, reading: 'Because of DenHaag's lack of brain – NL is going down the drain' (Source: DutchReview/Depositphotos)

Same is happening these days with the protest actions of the so-called 'Last Generation' which attacks museums and blocks highways as well as airfields. For many, these types of protests are going too far, others consider is as a legitimate gesture in the face of a political failure. Whatever the position is, it is important to understand the different arguments and look behind the clichés.

Understanding farmers means to take account of their efforts and investments to comply with international and national legislations, to recognize that the current food system is not paying for extra environmental efforts and that many old farmers can't find family members to take over the farms, because working conditions and economic prospects is not considered to be attractive for many young people. It is good if teachers are able to visit farmers to listen to them and to experience their world on locations.

At the same time, farmers are only one part of the food system. The feed, fertilizer and food processing industry has enormous power and are able to make large profits – in a world of global competition. Also here, the companies are not only acting as individual players, but are part of a larger system that is driven by external forces such as access to resources, energy prices and international policies such as the Common Agricultural Policy (CAP), see Figure 11.

A recent phenomenon in the wider societal processes around the transition towards a sustainable food system is the increasing role of the citizen. Citizen – just as democratic activists, but also as consumers – are expressing their preferences more and more on dedicated platforms or through their choices. The retail markets are very aware of these trends and are offering more regional food and more information on the sustainability via labels and products descriptions.

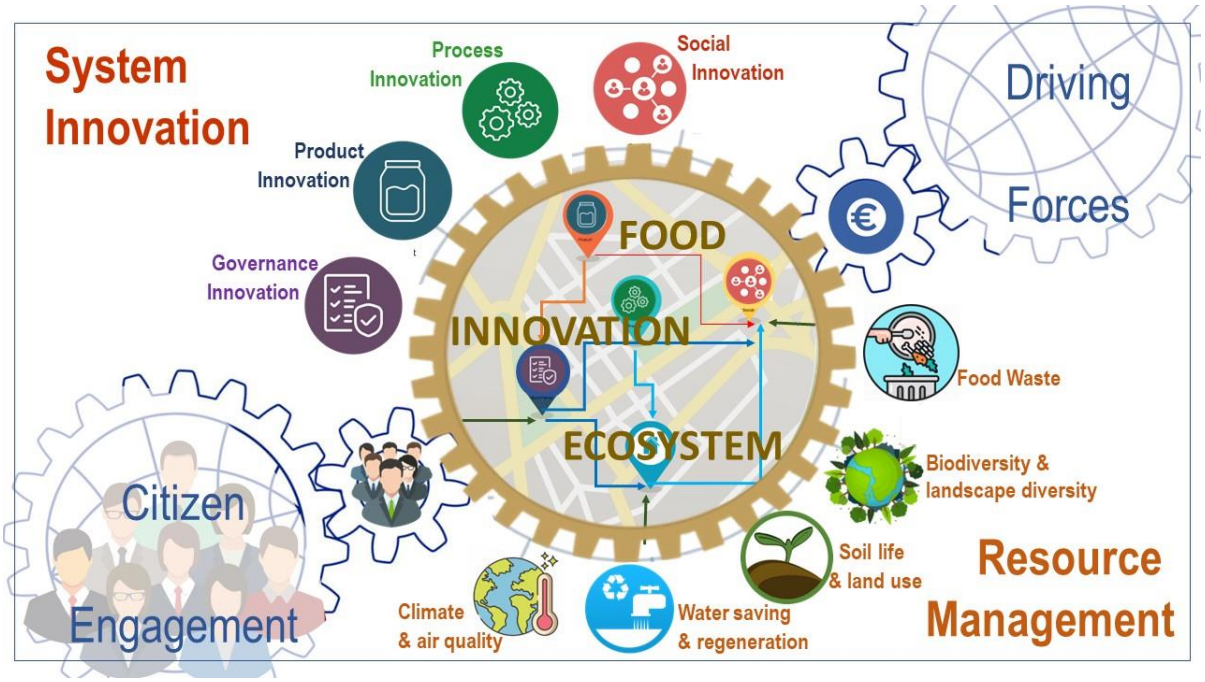

Figure 11: The four cornerstones of a Food Innovation Ecosystem: System Innovation, Resource Management, Citizen Engagement and Driving Forces (Wascher in: Eyre et al. 2022)

3.1.4 Innovative problem solving

System innovation is playing a role along the full food chain and entails the following dimensions: governance, process, social and product innovation (Wascher et al. 2015). The innovation examples that have been identified in the FoodSHIFT 2030 project show that they are often brought to life by relatively young people and are based on out-of-the-box thinking, inventiveness and experimenting. Therefore food system innovation appears to be a perfect vehicle for triggering the explorative mind of young people and let them join the join the expedition into new possibilities in terms of materials, procedures and ways of doing things. Certain innovations (e.g. fermentation processes) can be demonstrated in the school, other might need field visits at the locations of innovators or in science centres.

Food security is a topic that can actually be quite challenging. Food security addresses the availability of food – hence also its shortage or non-accessibility (e.g., so-called 'food deserts' in certain regions or cities, where there are no shops or outlets). Food security is also something that relates to global trade and the vulnerability of food supply according to transport problems, military conflicts, oil/energy prices, pandemic events and/or extreme weather events associated with climate change. Though food security can be rather abstract, there are ways of illustrating it by means of serious gaming, e.g., the Metropolitan Foodscape Planner (Arciniegas et al 2022) . With this tool, student can make use of a digital table when (playfully) allocating new land use in order to improve the security of a (their) city region.

Health is another issue that lends itself for exploration since is related to our daily diets and consumption attitude. Especially young people are vulnerable for (fast/sweet) food advertisement, obesity is on the rise throughout Europe and to salty and meat-based food is affecting our health. Field trips to supermarkets, exploring the role of food labelling and cooking lessons to try out new healthy ingredients can form interesting lessons. There is a whole wealth of food innovation practices from aquaponic farming in urban settings, satellite-driven precision farming supporting farmers in their daily decisions on the field and new plat-based protein sources in the super-markets.

Many of these innovation cases a exciting and stimulating. They offer great inspiration for students to eventually try out new things or take a different look at the world.

3.2 Practical teaching examples for other SCs

In the following we will briefly highlight possible approaches regarding teaching approaches for the remaining SCs.

- **Assessing Economic Aspects**
  This is probably a more challenging item as it requires to define, for example, the notion of fair prices with regard to the food system: what is a fair price? Who is able to buy expensive biological food? Why is it more expensive? Should less healthy food with big impacts on our health and environment not be more expensive? This and similar questions can help to frame the issue.

- **Conceptualizing**
  To approach a sustainability problem from all sides; to consider time, space and context in order to understand how elements interact within and between systems. Children should understand the underlying principle of system thinking, e.g. that *changing* one part of the system (e.g. the climate, the price or technology) *can have tremendous effects* on other parts of the system (e.g. income of farmers, health or efficiency of the food chain). This can be explained in classes by means of graphic displays of a food system (e.g. visuals. Videos) and through field trips when talking to farmers or bee keepers etc.

- **Innovative problem solving**
  To formulate current or potential challenges as the sustainability problem in terms of difficulty, people involved, time and geographical scope, in order to identify suitable approaches to anticipating and preventing problems, and to mitigating and adapting to already existing problems. This should encourage children to use their creativity and imagination, but also good examples from other fields to make constructive proposals for solving a problem.It is important that children are not just confronted with problems as unsurmountable issues, but that they *feel empowered* to act and overcome problems, if possible in a community and by good communication.

- **Envisioning future scenarios**
  To envision alternative sustainable futures by imagining and developing alternative scenarios and identifying the steps needed to achieve a preferred sustainable future. Here, pupils should be encouraged to use their imagination when developing visions of the future. In principle, a large degree of freedom should be offered while offering structural references for orientation and discussion. This means that future visions can be radically different, but should build upon an analysis of the current and past trends (see here e.g. EUISS 2020). For children of the target group, practical approaches could use drawings, Lego-stone or Minecraft constructions)

- **Developing creative solutions**
  This SC relies more strongly on developing solutions that requires to adjust current approaches, increase the elasticity and flexibility of a system. This means in the case of food, e.g. to develop other diets and thereby adapt to a different climate or to the need to preserve our resources. Actually, circular economy is – to a certain degree – also an adaptation strategy, namely by avoiding waste and coming up with new value chains.

- **Experimenting and testing**

Here, pupils could be invited to explore possibilities, knowledge and techniques from different classes (e.g biology, geography, mathematics) to come up with new ideas or concepts. The ecological footprint approach offers here a string of knowledge fields which pupils could be practically explore (see Figure 3)

- **Navigating politics**
  The context of the school and school food ('procurement') could effectively be used to demonstrate how new policies can reduce food waste and offer more healthy food to children. Policies such as reducing the amount of fast food chains near schools could be other points in case.

- **Collaborating and connecting**
  Children could be encouraged to organise events around the topic of nature protection and different land use – e.g. taking picture of nice landscapes and organising an exhibition in a public place to attract attention to an environmental issues or problem.

- **Taking initiative**
  This follows the philosophy of changing the world by starting to change one's own habits and preferences. In a school class, pupils could be invited to try out a different eating habit for about a week or two and observe the changes, but also the likely impact on the environment and or on their family budget.

4 Conclusions

The review of literature and concepts addressing Sustainable Competence levels of teachers giving lessons on sustainable food to primary school children in the age group from 10 to 16 years old is confirms the expectations and motivations of this project: *relatively little material could be found.*

The observed deficits are even more extreme – not to say dramatic – when it comes to the representation of sustainability as such, but even more so sustainable food, in the national curricula of the participating six countries Portugal, Spain, Denmark, Sweden, Netherlands and Greece. There is reason to assume, that the situation is not much different in other European countries. Same accounts for the Sustainable Competence levels – the questionnaire made clear that most of these competences addressing aspects of our food system are not really present and that teaching this topic is almost entirely dependent on initiatives and the personal ambition of individual teachers.

The review of international and national scientific literature has shown, that the recently developed 'European Sustainability Competence Framework' (JRC 2022) can be considered the most authoritative guidance in these respects. Our analysis, however, pointed at a couple of food system -specific aspects such as 'innovative problem solving' and 'assessing economic aspects' which we considered as relevant when shortlisting SCs for teachers.

The questionnaire among teachers resulted in clear preference for the SCs 'Valuing the Environment' and 'Critical Thinking' – two items which are probably also competences where current pedagogical staff relate to quite strongly. Interestingly, the SC's 'Understanding Society' and 'Innovative problem solving' also received relatively high scores, followed by 'interpersonal development'. With this 'handful' of key SCs we think that there is a rich and solid ground for developing a pedagogical design proposal in this project.

In support of the latter, this report points at different opportunities for how this can happen, by illustrating different teaching methods at the example of the concrete agricultural-environmental and European-regional conflict revolving around the Dutch case of nitrogen polices addressing livestock farming and its severe impacts on health, nature and landscapes.

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Annex 1: JRC 2022: GreenComp

The European sustainability competence framework

Regarding competence areas, experts highlighted the importance of sustainability values in relation to other competences. They highlighted the need to change vocabulary for the area focused on problem solving and finding solutions, in favour of action-based competences and the acknowledgement that 'wicked' sustainability problems, i.e. highly complex and ill-structured problems9, cannot, strictly speaking, be solved.

GreenComp has adopted the following statement to define a sustainability competence:

*A **sustainability competence** empowers learners to embody sustainability values, and embrace complex systems, in order to take or request action that restores and maintains ecosystem health and enhances justice, generating visions for sustainable futures.*

The platform provided by UN Decade of Education for Sustainable Development (DESD, 2005-2014) helped highlight this message at the global level. This led to education for sustainable development being embedded in **Target 4.7 of SDG 4**, whose objective is to ***"ensure that all learners acquire the competences, such as knowledge and skills needed to promote sustainable development".*** SDG 4 is understood to be a critical goal that must be achieved in order for the other 16 SDGs to be achieved.

AREA	COMPETENCE	DESCRIPTOR
3. *Envisioning sustainable futures*	3.1 **Futures literacy**	To envision alternative sustainable futures by imagining and developing alternative scenarios and identifying the steps needed to achieve a preferred sustainable future..
	3.2 **Adaptability**	To manage transitions and challenges in complex sustainability situations and make decisions related to the future in the face of uncertainty, ambiguity and risk.
	3.3 **Exploratory thinking**	To adopt a relational way of thinking by exploring and linking different disciplines, using creativity and experimentation with novel ideas or methods.
4. *Acting for sustainability*	4.1 **Political agency**	To navigate the political system, identify political responsibility and accountability for unsustainable behaviour, and demand effective policies for sustainability.
	4.2 **Collective action**	To act for change in collaboration with others.
	4.3 **Individual initiative**	To identify own potential for sustainability and to actively contribute to improving prospects for the community and the planet..

Annex 2: Wiek & Keeler 2011

This article presents the results of a broad literature review. The review identifies the relevant literature on key competencies in sustainability; synthesizes the substantive contributions in a coherent framework of sustainability research and problem-solving competence; and addresses critical gaps in the conceptualization of key competencies in sustainability. Insights from this study lay the groundwork for institutional advancements in designing and revising academic programs; teaching and learning evaluations; as well as hiring and training faculty and staff.

Specifically, our study pursued three objectives, namely, (1) to identify the relevant literature on key competencies in sustainability; (2) to synthesize identified competencies into a coherent framework, and (3) to identify critical gaps in the conceptualization of these key competencies.

Concepts, methodologies, and peer-reviewed "classics" for anticipatory competence

Concepts	Methodologies	Peer-reviewed "classics"
Concepts of time including temporal phases (past, present, future), terms (short, long), states, continuity (dynamics, paths), non-linearity Concept of uncertainty and epistemic status including possibility, probability, desirability of future developments (predictions, scenarios, visions) Concepts of inertia, path dependency, non-interventions Concepts of consistency and plausibility of future developments Concepts of risk, intergenerational equity, precaution	Scenario methodology Forecasting from statistical and simulation models Backcasting and envisioning methods Multi-methodologies Participatory anticipatory approaches (e.g., Delphi, Future Workshop)	Prominent scenarios and predictions (e.g., IPCC's *Special Report on Emission Scenarios*: Nakicenovic et al. 2000) Prominent visions and "backcasts" (e.g., "The Great Transition": Raskin et al. 2002)

Concepts, methodologies, and peer-reviewed "classics" for normative competence

Concepts	Methodologies	Peer-reviewed "classics"
(Un-)sustainability of current or future states Sustainability principles, goals, targets, thresholds (tipping points) Concepts of justice, fairness, responsibility, safety, happiness, etc. Concept of risk, harm, damage Concept of reinforcing gains ("win–win") and tradeoffs Ethical concepts	Multi-criteria assessment methods (normative component of assessment methods, including Life-Cycle Assessment, Multi-Attribute Utility Theory, etc.) Risk analysis Sustainability efficiency analysis Envisioning methods[3] (e.g., backcasting) Participatory methods (e.g. negotiation methods, consensus conference)	Prominent (value-laden) tipping points of social-ecological systems (cf. Rockström et al. 2009) Prominent sets of sustainability principles (cf. Brundtland report: WCED 1987; Gibson, 2006).

Concepts, methodologies, and peer-reviewed "classics" for strategic competence

Concepts	Methodologies	Peer-reviewed "classics"
Intentionality Transitions and transformation Strategies, action programs, (systemic) intervention, transformative governance Success factors, viability, feasibility, effectiveness, efficiency Adaptation and mitigation Obstacles (resistance, reluctance, path dependency, habits) and synergies Instrumentalization and alliances Social learning Social movements	Methods to design governance arrangements, policies, institutions Planning methodologies Decision support methodologies Transition management methodology Methods to support learning and reflexivity Organizational (change) management Methods to support behavioral change	Prominent transition strategies (e.g., Lester Brown's "Plan B 3.0": Brown 2008) Prominent transformations (e.g., socio-technical transitions in The Netherlands: Loorbach 2007)

Concepts, methodologies, and peer-reviewed "classics" for systems-thinking competence

Concepts	Methodologies	Peer-reviewed "Classics"
Variables/indicators, sub-systems, structures, functions	Qualitative and quantitative modeling	Prominent comprehensive analyses of social-ecological systems (e.g., Millennium Ecosystem Assessment report: MEA 2005; Turner et al. 2003; Ostrom 2009); socio-technical systems (Perrow 1984; Collingridge 1980; Geels 2005)
Feedback loops, complex cause-effect chains, cascading effects, inertia, tipping points, legacy, resilience, adaptation, structuration, etc.	Institutional, decision, governance, social systems analysis	Prominent models (e.g., World3: Meadows et al. 1974)
Across/multiple scales: local to global	Multi-methodologies ("thick" description)	
Across/multiple/coupled domains: society, environment, economy, technology, etc.	Participatory systems approaches (e.g., participatory modeling)	
People and social systems: values, preferences, needs, perceptions, (collective) actions, decisions, power, tactics, politics, laws, institutions, etc.		

Annex 3: Tippmann 2020

Education for Sustainable Food and Nutrition – Towards Criteria for German Secondary Schools

This research was conducted for the KMGNE, a Berlin-based research educational institute. This research explores criteria that can be used to incorporate the topic of sustainable food and nutrition in German secondary schools. Through a mix of qualitative methods, the concept of shaping competences, outcome-based learning was explored, and based on the research results, a set of criteria were determined. The research shows that transformative learning changes behaviour, as it allows internal change about assumptions and beliefs in students. This is why transformative learning works best to bring a change in behaviour. It is essential that schools not only teach about sustainable food and nutrition but also teach by example *through the food they offer*. Practitioners need to receive training to integrate sustainable food and nutrition-related topics into their lessons.

German secondary school system

One example is the pilot project of shaping competences in German schools. If these are having the desired outcomes, there is a slight chance that a federal state decides to include a method or topic in their school curricula (De Haan, 2007). For sustainable food and nutrition to be incorporated into every secondary school in Germany, every federal state would need to make the decision to take up the topic in their educational concepts (Biewen & Tapalaga, 2016). As described before, education for sustainable food and nutrition fits into the concept of ESD.

The key goal of ESD is to transform the student's worldviews. It enables them to understand their responsibilities towards the planet and to develop a consciousness about global problems (Garcia Alvarez, 2020). ESD, therefore, also deals with the topic of sustainable food and nutrition.

Observations were conducted for seven hours (including breaks), observing 15 students in grade 12 of the Fritz-Greve-Gymnasium, a partner of the Collegium for the Management and Design of Sustainable Development (KMGNE), a Berlin-based research educational institute carrying out research. They have a project farm in rural Germany where the observation took place. The observation helped to explore the concept of the shaping competences by De Haan (2010)

According to experts, in German secondary schools, there is minimal to **no engagement in the topic of sustainable food and nutrition at the moment**. When the topic is introduced or discussed in a school, this is mostly done in a theoretical way (E. Carceller, personal communication, April 03, 2020). Environmental schools that engage in environmental protection, environmental education, and ESD seem to cover it most extensively. For example, some aspects of ESD can be seen in school gardens (K. Braun-Wanke, personal communication, March 27, 2020), veggies days (Practitioner 3, personal communication, April 15, 2020), beehives (Practitioner 5, personal communication, April 16, 2020), or project days where the topic was addressed. C. Schulze, programme manager at BildungsCent, sees that in

case a school engages in the topic, it differs per school how sustainable food and nutrition is implemented (personal communication, April 06, 2020).

According to Braun-Wanke (personal communication, March 27, 2020), **authenticity when teaching sustainable food and nutrition is crucial.** A change in behaviour has to come from inside of the student. The students need to have the space to build their own opinions; practitioners should not pressure the students or try to persuade them (M. Singer-Brodowski, personal communication, March 25, 2020).

Some experts suggested using the transformative learning theory within education for sustainable food and nutrition. **Transformative learning is essential for students to question their assumptions** and beliefs. People first need to look at their patterns of perception and status of perspectives to transform through education. Planting the seed for transformation during secondary education is important to ensure a starting point for students to change their behaviour.

The final criteria for education for sustainable food and nutrition in German secondary schools that were determined in this research are:

1. Continuously update the topic
2. Use a transdisciplinary approach when teaching about sustainable food and nutrition
3. Give students the space to build their own opinions
4. Embed sustainable food and nutrition in practitioner training
5. Collaborate with external partners and use external learning places
6. Adapt education for sustainable food and nutrition according to the student's situation and the location of the school
7. Institutionalise sustainable food and nutrition by making school meals more sustainable.

Annex 4: Corres et al 2020.

Educator Competences in Sustainability Education: A Systematic Review of Frameworks

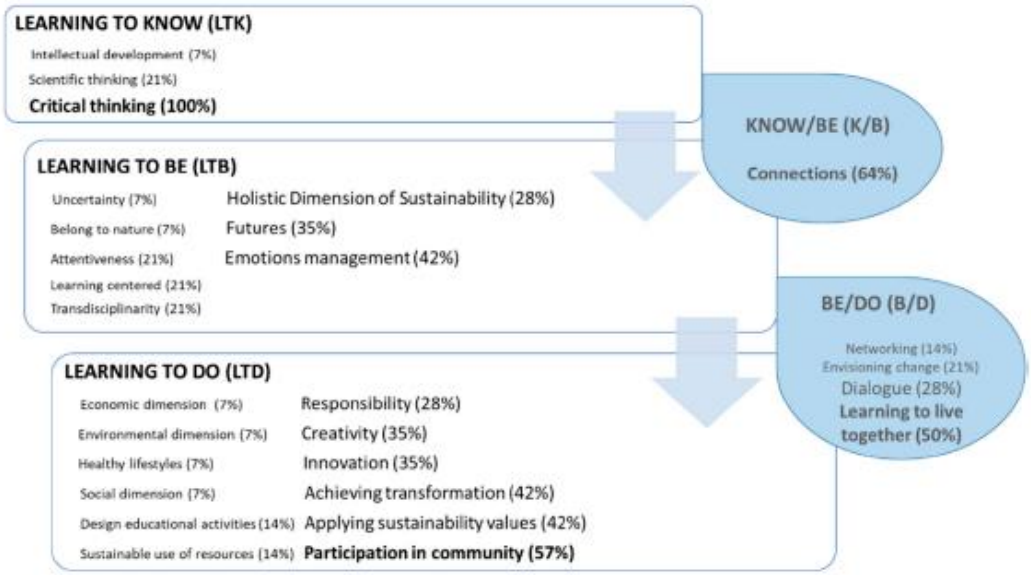

Figure 2. Typology of competences and percentage of their presence in the reviewed frameworks, by groups of competences.

Abstract

The design and use of competence frameworks and models for educators in Sustainability 3iEducation is a growing field of study that seeks to guide their professional development while identifying, examining, and assessing the competences they need. In this article we conduct a systematic review of the frameworks and models of sustainability competences addressed to teachers and other educators to shed light on (a) the backgrounds of the analyzed frameworks, (b) the conceptual and pedagogical approaches towards sustainability and competences behind them, (c) the different types of educators' competences included and particularly those addressed to promote transformational perspectives, and (d) the pedagogical strategies applied to develop them. We analyzed 14 papers out of an initial sample of 437. Findings show that all are developed in Europe. Most of them rely on the United Nations Economic Commission for Europe (UNECE) framework and its guiding approach of Education for Sustainable Development. A few others critically approach sustainability and recognize its contradictions even though they subscribe within this broad sustainability approach. The most common competences are Critical Thinking, Participation in Community, and Connections, which have been identified as those that educators need to face current sustainability challenges from a critical and transformative perspective. However, other competences significantly associated with transformational education such as Emotions Management, Futures and Achieving Transformation are less addressed and receive less attention in terms of the pedagogical strategies needed to promote them. We discuss how the different ways of understanding and operationalizing sustainability and competences behind these frameworks can shape educators' transformational capacities in Sustainability Education. Further research should address the identified challenges and provide educators with practical and suitable tools for transformative education.

Table 5. Competences name, group and definition, and the studies naming them (*).

Competence Name	Competence Group	Broader Definition Chosen	Study/ies and Original Competence Name
Intellectual Development	LtK	Putting emphasis on the intellectual development of students (D8) [29] (p. 2775).	D8-*Transversal competencies* [1]
Scientific Thinking	LtK	Explaining and interpreting phenomena scientifically and identifying appropriate explanations and predictions (D8) [29] (p. 2775)	D4 [2] D8-*Science education competencies* [1] D10-*Research Comperency* [1]
Critical Thinking	LtK	Critical contextualization of knowledge establishing interrelationships between social, economic and environmental, local and/or global problems (D9) [30] (p. 19)	D1-*Criticality* [1] D2 [3] D3 [2] D4 [2] D5-*Sust1* [1] D6-*C1* [1] D7 [2] D8 [2] D9 [2] D10-*Sust1* [1] D11-*EC5* [1] D12 [2] D13 [2] D14 [2]
Connections	K/B	To know the main concepts and principles in connection with the Earth as a biophysical system and in connection with the relationships and interactions between society and the environment (D11) [32] (p. 4)	D1-*Systems* [1] D2 [3] D4 [2] D5 [2] D8 [2] D10-*SC1* [1] D11-*EC1/EC2* [1] D13 [2] D14-*Systems Thinking* [1]
Futures	LtB	It offers ways of addressing and helping to shape the future […]. It enables individuals to recognize relations and possible evolutions between past, present, and future and envision possible or thinkable futures alternatives and their impact (D1) [22] (p. 10).	D1 [3] D8-*Future/alternative scenarios visioning* [1] D9 [2] D10 [2] D14 [2]
Attentiveness	LtB	This competence relates to knowledge about sustainability issues while emphasizing the difference between information and understanding. Our pre-existing knowledge determines how we see the world and what we notice in our environment […] The goal of an educator is to help learners to process new knowledge explicitly and not to simply be exposed to information about the world (D1) [22] (p. 11).	D1 [3] D12 [2] D14 [2]

Table 5. *Cont.*

Competence Name	Competence Group	Broader Definition Chosen	Study/ies and Original Competence Name
Holistic Dimension of Sustainability	LtB	It takes into account the historical perspective of sustainability, analyzes different dimensions, promotes creativity and innovation, reflects on new ways (D6) [27] (p. 8)	D3-*Holistic approach* [1] D5 [2] D6 [3] D10 [3]
Transdisciplinary	LtB	Working towards sustainability calls for the ability to collaborate with a diverse group of people. Educators are challenged to promote this competence among their learners and model it by, for example, facilitating school-community collaborations […] (D1) [22] (p. 11)	D1 [3] D7 [2] D8-*Transversal competencies* [1]
Uncertainty	LtB	The educator works with others from a perspective of uncertainty as an ethical, social and political attitudes to seek social construction and with an open view of the future (D2) [23] (p. 777).	D2 [3]
Emotions Management	LtB	To manage emotions and concerns: promoting reflection on one's own emotions as a means to reach a deeper understanding of problems and situations (D8) [29] (p. 2771).	D1-*Empathy* [1] D8-*Manage emotions and concerns* [1] D9 [2] D10 [2] D13 [2] D14 [2]
Learner centered	LtB	To provide student-centered education to promote the development of critical thinking, active citizenship and participation (D14) [34] (p.313)	D7 [2] D12 [2] D14 [2]
Belong to nature	LtB	Fostering in students a sense of belonging to the environment (D8) [29] (p. 2775).	D8-*ESD competencies* [1]
Envisioning change	B/D	Meaning the time perspective for change toward sustainable development (…) understanding the reasons for unsustainable development, its actual development and also its future prospective. It also refers to motivation for learning out of those experiences and raising awareness for the need of developing shared visions among the different perspectives of scientific and societal stakeholders (D3) [24] (p. 749).	D3 [3] D9-*Visioning* [1] D12 [2]
Learning to live together	B/D	A way of coexisting. The educator works with others in such a way that (…) norms, values, attitudes, beliefs and assumptions guide our perceptions, our thinking and our decisions and actions. Cooperation, interdependence, pluralism, understanding, equality, freedom, uncertainty as an ethical attitude all foster the move towards ESD (D2) [23] (p. 777).	D2 [3] D3 [3] D5-*Sust 3* [1] D7 [3] D10-*SC 3* [1] D11-*EC 3* [1] D14+

Table 5. *Cont.*

Competence Name	Competence Group	Broader Definition Chosen	Study/ies and Original Competence Name
Dialogue	B/D	That which facilitates acceptance and approaches multiple ways of understanding the world and promotes the exchange of ideas, cooperation, negotiation and understanding (D2) [23] (p. 776).	D2 [3] D7 [2] D8-*Establish a dialogue between disciplines* [1] D14 [2]
Networking	B/D	As one requisite competence, ESD teachers must be able to organize and moderate cooperation with non-formal educational institutions, in order to arrange for learning opportunities for pupils in and with extramural institutions (D9) [30] (p. 21).	D9 [2] D10 [2]
Communicating	B/D	Ability without which all other areas are inconceivable. While communication is a *sine qua non* for planning, organizing and networking, it is not a matter of course for the more individual areas (D9) [30] (p. 20).	D9 [3] D10-*Research Comperency* [1]
Achieving Transformation	LtD	Related to transformation approaches in education, pedagogy and for educators and education systems in all the levels (Lk, Llt, Lb, Ld) (D3) [24] (p. 740).	D1-*Action* [1] D3 [3] D8 [2] D12 [2] D13 [2] D14 [2]
Healthy Lifestyles	LtD	Developing habits and attitudes favorable to the promotion of healthy lifestyles, at the personal and community level (D8) [29] (p. 2775).	D8-*Transversal competencies* [1]
Economic Dimension	LtD	[The teacher] is capable of successfully carrying out the economic management (amortizations, fixed costs, variable costs, planning budgets, detect deviation, make a business plan) of a project (D6) [27] (p. 10).	D6 [3]
Creativity	LtD	That which generates imaginative processes that involve a specific result, be that an action, idea or object. Enables the creation of spaces for shared learning and promotes the visualization of sustainability scenarios (D2) [23] (p. 776).	D2 [3] D5 [2] D6 [2] D10-*Competency Unit 1.2* [1] D13 [2]
Innovation	LtD	Educators will need to reflect on their practice and renew their methods as they adapt to new situations while understanding that "new" is not necessarily better (D1) [22] (p. 11).	D1 [3] D2 [3] D4 [2] D6 [2] D8-*Establish a dialogue between disciplines* [1]

Table 5. *Cont.*

Competence Name	Competence Group	Broader Definition Chosen	Study/ies and Original Competence Name
Responsibility	LtD	[. . .] the educator of ESD will have a range of tools, through which to develop their learners' abilities to act responsibly. In this way, they will encourage long-term thinking about what kind of human beings we want to be and what kind of world we want to live in (D1) [22] (p. 11).	D1 [3] D4 [2] D6 [2] D8-*Transversal competencies* [1]
Social Dimension	LtD	[The teacher] takes into account the social impact (social justice, equity, diversity, transparency, gender perspective, needs of the most vulnerable groups, strategies against corruption) of his/her work (D6) [27] (p. 10).	D6 [3]
Participation in Community	LtD	Participation in community processes that promote sustainability (D6) [27] (p. 6)	D1-*Participation* [1] D5-*Sust 3* [1] D6-*C3* [1] D8-*Science education competencies* [1] D10-*Sust 3* [1] D11-*EC6* [1] D12 [2] D14-*Interpersonal competence* [1]
Environmental Dimension	LtD	Takes into account the environmental impact (reuse, reduction, recycling, minimization of the natural resources and residues, the concept of ecological footprint) of his/her work (D6) [27] (p. 10).	D6 [3]
Applying Sustainability Values	LtD	To apply ethical principles related to sustainability values in personal and professional behavior (D10) [31] (p. 2).	D6-*C4* [1] D9 [2] D10-*Sust 4* [1] D11-*EC3 and EC5* [1] D13-*ESD competence aspect motivation and volition* [1] D14-*Normative competence* [1]
Sustainable Use of Resources	LtD	Sustainable use of resources and prevention of negative impacts on the natural and social environment (D6) [27] (p. 6).	D6-*C2* [1] D10-*Sust 2* [1]
Design Educational Activities	LtD	Ability to choose possible teaching topics and to evaluate their aptitudes for ESD regarding their economic, ecological, social and cultural design as well as their relevance for sustainability (pedagogical content knowledge) (D13) [20] (p. 5076).	D10 [2] D13-*ESD competence aspect knowledge and ability* [1]

(*) Meaning of the superscript numbers next to the studies: [1] The competence was named in a slightly different way, but the main idea agrees with the broader definition of the competence, there is an explicit indication of the original name. [2] The competence was not named under any particular name, but the main idea agrees with the broader definition of the competence. [3] The competence was exactly named as the typology offered.