UNISECO

UNDERSTANDING & IMPROVING THE SUSTAINABILITY OF AGRO-ECOLOGICAL FARMING SYSTEMS IN THE EU

WP4 Scenario Development – Milestone Report MS15

Description scenario storylines

AUTHORS:	Elin Röös (SLU) Adrian Muller (FiBL) Andreas Mayer (BOKU) Karl-Heinz Erb (BOKU) Rob Hart (SLU) Pete Smith (UA) With input from all partners

APPROVED BY WORK PACKAGE MANAGER OF WP3 and WP4	
DATE OF APPROVAL:	X.X.2019
APPROVED BY PROJECT COORDINATOR:	

CALL H2020-SFS-2017-2	Sustainable Food Security-Resilient and Resource-Efficient Value Chains
WORK PROGRAMME Topic SFS-29-2017	Socio-eco-economics - socio-economics in ecological approaches
PROJECT WEB SITE:	www.uniseco-project.eu

This document was produced under the terms and conditions of Grant Agreement No. 773901 for the European Commission. It does not necessary reflect the view of the European Union and in no way anticipates the Commission's future policy in this area.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

This page is left blank deliberately.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

TABLE OF CONTENTS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

ACKNOWLEDGEMENTS

This document has been prepared with the assistance of colleagues in the UNISECO project and members of the PAG, EU-level MAP and SRG. This work is funded by the European Union's Horizon 2020 research and innovation programme and its funding of the H2020 UNISECO project under grant agreement N° 773901.

1. INTRODUCTION

This Milestone document describes the scenario development process that has been carried out to date within Task 4.3 in the UNISECO project. The overarching confronting question in UNISECO scenario development corresponds to one of the objectives of WP4 - what are the territorial effects of a large-scale implementation of agro-ecological farming innovations in the EU? Since the scenario development process is iterative (see section 3) descriptions of storylines and case study integration is subject to change as knowledge about the system under study increases as results from the modelling are gained.

The report is structured as follows: First, a short description of the use of scenarios and scenario development is given (section 2.1). A few existing studies based on the type of biophysical models that will be used in UNISECO are described shortly to give an understanding of the type of modelling that will be performed (section 2.2). In section 3, the methodology and models used in UNISECO are described including an overview of the stakeholder interactions to date and the main outcomes of these. Section 4 contains the five storylines, starting with an overview and summary in section 4.1, and description of the five storylines in sections 4.2-4.6. Section 5 describes the case study integration process, i.e. how UNISECO case studies will be integrated into the scenarios. In section 6 finally, next steps are outlined.

2. BACKGROUND

2.1. The use of scenarios

Scenario development and other foresight activities have the common goal of enabling a structured way of thinking about the future and enable effective decision making (Wiebe et al., 2018). Scenarios are descriptions of plausible, possible and desired futures that help investigate outcomes of different actions implemented today. The IPCC define a scenario as "*plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships*". Scenarios are also useful for engaging with stakeholders to increase knowledge and awareness of a certain issue and of outcomes of certain actions. They are also used for highlighting and discussing trade-offs and synergies, and handle conflicts of interest.

There are many different types of scenarios. A useful typology is that presented by Börjeson et al. (2006) which divides the scenario types into *predictive*, *exploratory* and *normative* corresponding to the following questions "What will happen?", "What can happen?" and "How can a specific target be reached?". Predictive scenarios try to predict what a likely future will look like, using for example historic data, and are most useful for planning purposes. A common assumption for predictive scenarios is that the existing governing systems stay constant within the period studied. When it comes to the agricultural sector, this could for example be agricultural policies and prices. A risk with predictive scenarios is that they can contribute to preserving past trends which might hinder desired goals. For example, predictive scenarios are often used for infrastructure planning based on historic data which might lead to increased investment in road infrastructure which often increase traffic and associated negative impacts instead of paving the way for alternative mobility systems.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

In order to study how the future could develop, one can use exploratory or normative scenarios instead of predictive scenarios. Explorative scenarios are similar to predictive scenarios, but are to a lesser extent based on how the situation is today and instead provide alternative situations where major changes are possible. Normative scenarios are based on reaching a clear target (e.g. GHG reduction targets) in one or more areas. In order to realise exploratory or normative scenarios, larger trend breaks are often needed.

2.2. Recent scenario work related to food and agriculture

Several scenarios have been developed that focus on the agricultural and land use (see e.g. Audsley et al. (2006), Stürck et al. (2018) and Wolf et al. (2015)). Recently, scenario development has also expanded beyond agriculture to take a food systems approach i.e. including both production and consumption in order to be able to determine how different aspects 'add up' on the regional scale, e.g. the whole of the EU. The importance of including the consumption level has become increasingly clear during the latest years in which several such studies using this approach have been published. For example, as organic production requires more land than conventional production, the impression could be that it would not be possible to feed the world on the existing cropland using organic production. However, this conclusion rests on the assumption that food consumption patterns stay constant, i.e. the same amount of food will still be needed. If consumption changes (which is the case when prices change), a number of options for high shares of organic production emerge, also without increasing land use or encroaching into forests (Erb et al., 2016). Conversely, if European organic agriculture expands and consumption does not change that would mean that agricultural production would be pushed into other regions, possibly creating negative effects there. Therefore, in UNISECO we aim at taking a broad food system approach. Below, three previous studies performed by UNISECO team members are shortly described.

A recent study from the Nordic countries used an extensive stakeholder process to develop scenarios of a future food system, including both production and consumption (Karlsson et al. (2017)). Researchers worked together with five NGOs over a period of a year to iteratively develop a vision for the future of food production in the Nordic countries (Sweden, Norway, Finland and Denmark). The final vision was based on organic farming and lower meat consumption with livestock fed on pasture and by-products from food production. Stakeholders designed the future food vision by pinning down for them important principles which were translated into consequences for the food system and hence the assumptions relevant for subsequent modelling. The researchers modelled the outcomes of such a scenario for the Nordic food system (in terms of land and energy use, greenhouse gas emissions, foods produced, N and P flows). The results were then shown to and discussed with stakeholders in several workshops and the scenarios were refined based on these discussions. Results were then disseminated mainly by stakeholders and used for communication and advocacy purposes e.g. at two COP-meetings and at several national seminars.

Muller et al. (2017) investigated how high shares of organic production perform regarding a number of environmental indicators covering land use, deforestation, GHG emissions, N and P surplus, soil erosion, pesticide use, cumulative energy demand and water use. They found that a switch to 100% organic production would result in large land use increases, by 30% in comparison to a business-as-usual scenario from FAO for 2050 (while not increasing GHG emissions). If combined with additional strategies, such as a reduction in food-competing feed (i.e. feed from arable land: cereals, forage maize, etc. that could be consumed directly) with

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

correspondingly reduced shares of animal products in diets, and with reduced waste levels, food systems with 100% organic production are possible, and feasible across all the indicators investigated. A particular challenge for high shares of organic production is nutrient supply, as mineral nitrogen fertilizers cannot be used anymore.

Erb et al. (2016) developed a diagnostic model to assess the biophysical feasibility of 500 different scenario combinations of the global food system in 2050 without encroaching forests. Thus, they systematically combined realistic assumptions on future yields, agricultural areas, livestock feed and human diets. For each scenario, they determined whether the supply of crop products meets the demand and whether the grazing intensity stays within plausible limits, which they indicated as a feasible scenario. They found that many options exist to meet the global food supply in 2050 without deforestation, even at low crop-yield levels. Results showed, that within the option space, individual scenarios differ greatly in terms of biomass harvest, cropland demand and grazing intensity, depending primarily on the quantitative and qualitative aspects of human diets, and that grazing constraints strongly limit the option space. However, their model (BioBaM) is only taking into consideration biophysical factors, while e.g. economic costs and social desirability were beyond the scope of this study.

Apart from the above-mentioned studies there has been an increasing number of similar scenario development studies which all explore and attempt to predict what future developments could look like. These have been reviewed in the UNISECO project and some will be used as input in the scenario development process.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

3. SCENARIO DEVELOPMENT IN UNISECO

3.1. Overview of methodology and models

Scenario development in UNISECO follow a 'story and simulation' approach (Figure 1). This means that stories (here after called storylines) that qualitatively describe possible future developments are first articulated. The storylines as they stand today are presented in section 4 of this document. To have more information regarding a range of quantitative parameters, for example greenhouse gas emissions, land, water and energy use etc. these storylines are then described and modelled that describe these futures in numbers. Results are then again presented to stakeholders and their input is used to refine the scenarios.

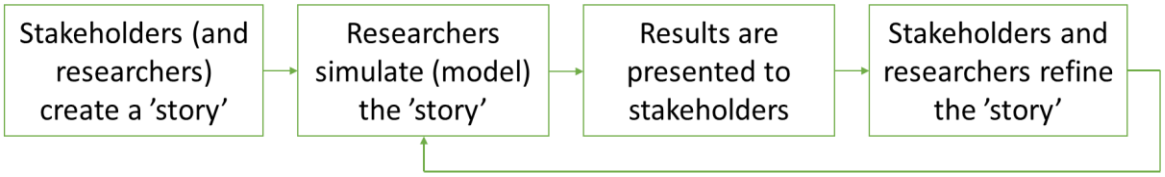

Figure 1: Scenario development approach in UNISECO.

Two biophysical mass- and nutrient-flow models – BioBaM and SOLm – are applied in UNISECO to model the outcomes of the storylines. In these models the EU is divided into 227 regions (NUTS2-level) and the models are calibrated with general data and assumptions derived from the data collected and analysed in the case studies. The aim of applying BioBaM and SOLm is to understand the wider scale implications and feasibility of the diffusion of agro-ecological farming systems at different spatial scales and across a range of consumption levels. BioBaM is spatially explicit and thus provides the basis for detailed spatial assessment and allows for integration of the impacts of land use change induced by the diffusion of agroecological farming systems. It covers (1) changes in the flows of biomass from cropland and grasslands and induced land use changes (2) GHG emissions from agricultural production including upstream flows and land use change (3) biodiversity pressures as indicated by the HANPP (human appropriation of net primary production) framework. SOLm in turn follows a similar approach, it is however not spatially explicit, but relies on more detailed modelling of agronomic aspects of the production systems (e.g. for animal production systems with herd structures and correspondingly differentiated feed supply, nutrient excretion and emissions), thus providing the basis for detailed assessment of various production systems.

As mass- and nutrient-flow models, BioBaM and SOLm do not include an endogenous decision structure, such as an assumption of profit-maximizing farmers. They serve to line out the option space of potential agro-ecological futures with a focus on potential synergies and trade-offs between different aspects. This allows for assessment of the biophysical viability of various storylines developed in participatory workshops without any restriction on how farmers may make their decisions on farming operations. Evaluation of the consequences of these scenarios in a political and economic context is thus not part of these two models but is assessed separately by complementary macroeconomic modelling. This then indicates how compatible certain scenarios in the option space are with common economic incentive and decision structures. This approach facilitates transparent analysis of the system-specific trade-offs and synergies and to identify the option space within which societally acceptable solutions then have to be found (using the participatory scenario development).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

3.2. Summary of stakeholder interactions

Table 1 summarises the stakeholder interactions that have been taking place so far in the scenario development process in UNISECO. Under the table the main outcomes of the stakeholder interactions are shortly summarised – a fuller description will be given in the deliverable D4.2.

Table 1. Overview of the stakeholder interactions in the scenario development process in WP 4.

Time	Activity	Participants
1rst of March 2019	First stakeholder workshop in Brussels with the following objectives: • Develop a shared understanding of the scenario development purpose and process • Create an understanding of which analyses are possible with the models that will be used in UNISECO and their relevance for EU policy assessment and development • Collect input from stakeholders on what should be explored in the scenarios	13 stakeholders representing the European Commission, farmer organisations and environmental NGOs, and 5 UNISECO researchers
9th of May 2019	Second workshop with stakeholders in Helsinki with the objective to further discuss the identified critical uncertainties; the level and type of implementation of agro-ecology and the level of trade.	14 stakeholders (PAG members and EU level MAPs), and UNISECO project members
July-Aug 2019	Written feedback from all project partners on the storylines, answering the following questions: • In what way (if any) do you find this scenario interesting and relevant? • Do you find this scenario plausible i.e. could the future develop in this direction? Are there current evidence of developments in this direction in your country? • As the scenario is described now do you see any major inconsistencies? • What kind of policy developments would be likely in this scenario? • How would your case study play out in this scenario?	All UNISECO project partners
14th of Nov 2019	Third workshop with stakeholders in Basel to gather feedback on the storylines and further discuss issues of trade, case study innovations and policy.	19 stakeholders (PAG members, EU level MAPs and local MAP members), and UNISECO project members

At the first workshop in March 2019, the first discussion centred on the usefulness of the scenario approach in general, its pros and cons, and potential limitations to overcome. The purpose of this discussion was to gain insights that would make the scenario development in UNISECO relevant to stakeholders. Issues raised here included the necessity to include many environmental aspects, not just greenhouse gas emissions as has many previous studies, but aspects such as eutrophication and pollution of oceans, impact on biodiversity, as well as social and economic aspects. One limitation to date in modelling that was highlighted was the lack of spatial resolution. Another challenge to overcome is to include also social and economic sustainability aspects, most current food systems studies focus on environmental sustainability. However, stakeholders acknowledge the difficulty in modelling outcomes of policy implementation over long time periods. Stakeholders brought up the difficulty in building realistic and interesting dietary scenarios and the need for dietary scenarios to be country specific. Next, time horizons were discussed and there was quite strong consensus among

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

stakeholders that a time horizon of 2030 would be the most relevant although 2050 was also deemed interesting in order to cover more long term developments. However, stakeholders justified using 2030 by alignment with the Sustainable Development Goals and the 2030 Agenda. There were quite strong opinions that 2030 is much more relevant and that UNISECO should definitely include 2030, at least as a linear development until 2050 and including 2030 as a mid-point.

In order to find the critical uncertainties on which to base the scenario development, stakeholders were further asked to give their view on the most important uncertainties related to the future supply and food in the context of the UNISECO project. Food security/food sovereignty in relation to open-trade was a key issue raised by several stakeholders. There were differing views on what is preferable here and to what degree food should be traded internationally. This is relevant on an EU scale i.e. self-sufficiency of the EU versus global trade, but also within the EU. For example, investigating the benefits of keeping supply chains short. However, stakeholders highlighted that scenarios have to be plausible to be relevant (for example, closed border scenarios are not relevant), while they can show a range of trade options. In addition, as agro-ecology supports food sovereignty and EU is for open borders, there are concerns with agro-ecology for that reason. Other uncertainties that were mentioned included climate change and loss of biodiversity (e.g. pollinator) impacts on yields, the level of bioenergy production, biotechnology, the level of segmentation of markets (local foods, expensive luxury foods etc.) and implementation of precision farming.

Based on the discussions at the first stakeholder workshop it was decided by the WP4 team to continue with the following two critical uncertainties as the main focal issues in the scenario development; 1) the level of implementation of agro-ecological farming practises, and 2) the localisation of food system (i.e. level of trade within the EU and globally). Therefore, in Helsinki a short workshop was held in which stakeholders were asked to give their view on these issues. Based on these discussions the WP4 team drafted four initial storylines (qualitative descriptions), see section 4.1 for an overview. These storylines were sent out to all project partners which were asked to reflect upon the relevance, plausibility and consistency of the storylines, and to consider how their case study would play out in the different scenarios. Based on this feedback, the storylines were refined and thereafter sent out to stakeholders participating in the Basel project meeting in November 2019. Here the storylines were discussed in a large group among participants. The major critique raised my several stakeholders and also some project members was the nationalistic framing of the future in which local food systems developed in combination with a low level of implementation of agro-ecology. However, other stakeholders and project members found that future highly relevant and interesting. To cater for this, a fifth storyline was added (see section 4.1 and 4.5). Based on these discussions, the WP4 team also further refined storylines and also aligned them more with the SSP scenarios.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

4. THE STORYLINES

4.1. Overview

The storylines form the qualitative context (i.e. narratives) in which the qualitative outcomes from the modelling should be interpreted. The development of the storylines builds on the input gathered through the stakeholder participation process (see section 3.2), and literature data (review of recent scenario studies). The storylines were developed in an iterative manner.

The storylines are formed out of the following two uncertainties, which were identified as some of the main ones by stakeholders:

- Level of implementation of agro-ecological farming practises
- Localisation of food system (i.e. level of trade within the EU and globally)

Out of these uncertainties, five storylines are drawn up as illustrated in Figure 2. The first one, 1) **Business-as-usual**, extends the dynamics and critical aspects of current agri-food systems into the future and highlights policy barriers to the expansion of agro-ecology. The second storyline, 2) **Agro-ecology-on-export**, depicts a future in which medium-large agricultural farms and large companies in the food processing and distribution sectors promote the agro-ecological approach as a marketing strategy. This brings out the duality between niche markets and those of low-cost food. Hence, this storyline is a case of industrial ecology, in which a weak level of agro-ecology is widely implemented. The third storyline comes with two specifications, Localisation-for-protection and Localisation-for-sustainability, and both arise out of the same basic assumptions (i.e. that food systems are more localised but implementation of agro-ecology is low) but for different reasons. In both these storylines, local foods, regardless of production methods, are given priority over agro-ecological farming practises, why production practises remain similar to current ones or further intensify. 3a) **Localisation-for-protection** do this for reasons of rising nationalism and protectionism, and calls the centrality of the EU into question and promotes the re-nationalization of agricultural policies. The 3b) **Localisation-for-sustainability** on the other hand promote local food system in an ambition to increase food system sustainability and resilience by cutting food miles and diversifying production systems. The fourth storyline, 4) **Local-agro-ecological-food-systems,** reflects the implementation of more advanced stages of agro-ecological transition – redesign. This future might be difficult to implement given the forces that today block changes in production systems including large agri-food companies and stakeholder interests for the current structure of the CAP. A radical change would be needed to reach the future described in storyline five. The storylines are further described in section 4.2 to 4.6.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

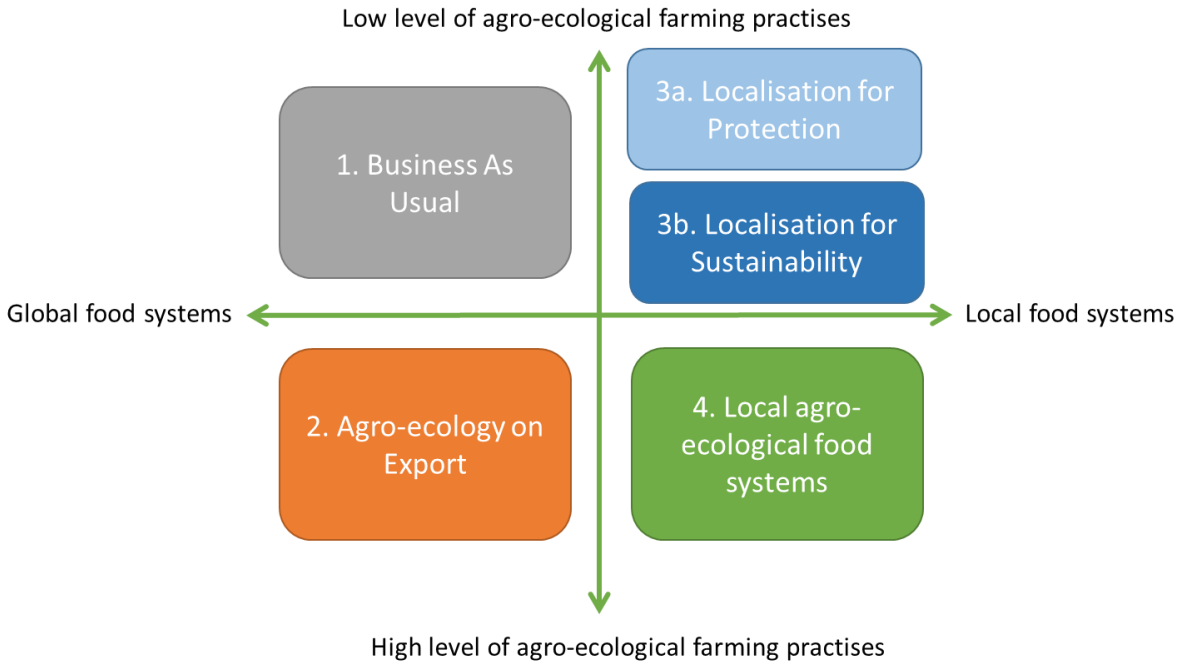

Figure 2: The UNISECO storylines.

The UNISECO narratives build on the Shared Socioeconomic Pathways (SPP) developed by the climate change community and commonly used as a basis in recent scenario development, e.g. in the latest FAO scenarios (FAO, 2019). The SSP narratives are described in O'Neill et al. (2017). The SSPs are qualitative descriptions of socio-economic future developments that can be combined with greenhouse gas concentration trajectories known as the Representative Concentration Pathways (RCPs) to be run in Integrated Assessment Models (IAMs). SSP deliberately do not give all numerical information, which gives modellers freedom of interpretation (Riahi et al., 2017). SSPs do not directly include any effect of climate change or any climate change policies, but are consistent with various RCPs.

An overview of the main characteristics of the storylines are given in Table 2.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

Table 2. Storyline overview

	1 Business-as-usual	2 Agro-ecology for exports	3a Localisation for protection	3b Localisation for sustainability	4 Local agro-ecological food system
Global socio-economic context	SSP2 – Middle of the road	SSP5 - Fossil-fuelled Development – Taking the Highway	SSP3 - Regional Rivalry – A Rocky Road	SSP1 – Sustainability – Taking the Green Road	SSP1 - Sustainability – Taking the Green Road
Corresponding FAO scenario	BAU (builds on SSP2 with elements of SSP3)	BAU (builds on SSP2 with elements of SSP3)	BAU (builds on SSP2 with elements of SSP3)	TSS (builds on SSP1)	TSS (builds on SSP1)
Trade	Increased trade between member states and with non-EU countries	Even higher level of trade compared to the BAU-scenario	Decreased trade between members states and with non- EU countries, protective trade policies	Decreased trade between members states and with non- EU countries due to deliberate support for local food systems	Decreased trade between members states and with non- EU countries, protective trade policies
EU agricultural policy developments	A continuation of current policies	A continuation of current policies, but with a heavy focus on investments to expand exports.	A continuation of current policies, but a less centralised CAP	A continuation of current policies, but a less centralised CAP	Integrated food policy, heavy focus on local agro-ecological food systems
Type of agro-ecological practises in the EU	Mainly weak	Mainly weak	Mainly weak	Mainly weak	Mainly strong
Technological developments	SSP2: Moderate developments, tech developed in high-income countries only slowly shared	SSP5: Widespread technology optimism	SSP3: Very slow tech developments, including agricultural tech with limited tech transfer to developing countries	SSP1: Rapid tech development focussed on energy efficiency, clean energy and yield-enhancing tech for land, including in agriculture	SSP1: Rapid tech development focussed on energy efficiency and clean energy, however, more nature based solutions in agriculture
Energy system developments	SSP2: Slow decrease in fossil fuel dependency, growing energy demand	SSP5: Low investments into renewable energy, major investments in fossil	SSP3: Maintaining domestic energy supplies, unconventional fossil fuel resources	SSP1:Increase in energy efficiencies, phase out of fossil fuel subsidies	SSP1:Increase in energy efficiencies, phase out of fossil fuel subsidies

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

Food consumption patterns (EU)	As now, develop according to current trends	As now, develop according to current trends	As now, develop according to trends, but with more local foods	Less impacting and more local, more high-tech and more local	Less impacting (reduced animal consumption), more local foods
Food waste in the EU	As now, or slightly decreased	As now, or slightly decreased	Slightly decreased	Decreased by 25-50%	Decreased by 25-50%

*The rates will be different between different member states, scaled up for different products based on current shares, environmental awareness or similar. TBD.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

4.2. Storyline 1: Business-as-usual

Globalised food systems - low level of implementation of agro-ecological farming practises

The SSP2 scenario, Middle of the Road, provides the overall context for this storyline. In the SSP2 scenario, it is assumed that the historical social, economic and technological trends are sustained, income growth develops unevenly and there is slow progress towards reaching sustainability goals (O'Neill et al., 2017). Technological developments are moreover modest and only slowly shared with developing countries. Low-income countries continue to experience food and water insecurity. There is a slow decrease in fossil fuel dependency and a growing energy demand (SSP2).

Based on this, storyline one describes a future in which globalisation of the EU food system continues[1]. In this system, farmers are incentivised to produce low value commodities leading to further specialisation of farming systems and regions. As for production and consumption trends, these are assumed to continue as described by the EU Agricultural Outlook[2] which assumes:

"• a continuation of current agricultural and trade policies;
• normal agronomic and climatic conditions;
• no market disruption".

In summary, the outlook is as follows: *The utilised EU agricultural area will continue to decrease by 0.2% per year reaching 172 million ha by 2030. Although total sugar consumption decreases by 5% by 2030 because of increased health concerns, total sugar production increases by 12% by 2030, making the EU a net sugar exporter. Cereal production also increases to 341 million tons by 2030 while oilseed production will decrease due to decreased demand for biofuels. The production of feed is expected to rise due to increases in poultry, dairy and intensive beef production. Dairy exports to China are expected to increase considerably with the EU supplying 30% of the increase in dairy products mainly as cheese and skimmed milk powder. Dairy consumption increases also within the EU up to close to 900,000 tons of milk per year, mostly consumed as cheese, other processed dairy products and included in convenience foods. Milk drinking meanwhile decreases. Meat consumption per capita first slightly increases but then decreases to current levels in 2030. Beef production decreases slightly while pigmeat will increase marginally (consumption in the EU stabilises and exports increase somewhat). Poultry meat production increase by 5% until 2030.*

It is assumed in this storyline that the same trends continue beyond 2030 until 2050.

It is assumed that consumer interest in healthier and more sustainably produced foods including organic foods and locally produced foods increases somewhat in the EU in this storyline. However, due to lack of major public investments in, or support for the implementation of agro-ecological farming methods, these remain close to

[1] The organisation of the EU food system is in this scenario well described by Therond et al. (2017) socio-economic context for farming called "Globalised commodity-based food systems" in which increasingly efficient industrial processes are used to "*produce large amounts of food that are inexpensive, convenient, safe and attractive*".

[2] https://ec.europa.eu/agriculture/sites/agriculture/files/markets-and-prices/medium-term-outlook/2017/2017-fullrep_en.pdf

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

current levels (the share of organic farming area was 6.7% in 2016[3]) or increase slowly (reaching an average of somewhere between 5-15% of agricultural land in 2050). Certified organic products, produced using mainly weak agro-ecological practises, dominate the output from the agro-ecological farming systems in the EU; these come in the form of high-value products like wine and other alcoholic beverages, cheese and charcuteries, jams and juice etc. sold in niche markets to high-income urban citizens, as well as cheaper bulk commodities sold in ordinary supermarkets. Diversity in crops produced in the EU are constant from current levels or somewhat further decreased (following trends in Kummu et al. (2020)).

In this storyline, trade increases both between member states and between the EU and global markets - specialisation in production in different regions continues (SSP2). A few multinational food industries dominate the global food market. Diets and the range of products on offer become increasingly homogeneous both with the EU and globally. Obesity levels continue to rise as do its associated health problems.

On a global level there is weak cooperation between international and national institutions, the private sector and civil society (SSP2). Access to global markets are slowly opening up for developing countries. The structure of the EU agricultural policy remains similar to the current CAP and continues to drive specialised, large-scale and export-oriented agricultural production. The EU budget is somewhat decreased due to Brexit; however, most member states push for keeping the EU agricultural budget constant and rather decrease expenses in other areas. The agricultural policy landscape is similar to today; Pillar 1 has low requirements for greening. Although Pillar 2 includes support for e.g. organic production and other agro-ecological practises, variation in the implementation rate of such agro-environmental policies is large between countries, efforts uncoordinated and only half-heartedly supported by national governments and the EU. There is a constant discussion on the ability of agro-ecology to "feed the world" and a push from large multinational agro-chemical and seed companies to implement more industrialised types of agriculture. There is only weak or no policy targeting demand in Member states, such as taxes on unhealthy or high-impacting foods, restriction on advertisements and similar – these have been effectively counteracted by powerful lobbying groups. Food waste levels remain similar to current levels or decrease somewhat in countries in which waste reduction policies are implemented.

[3] https://agridata.ec.europa.eu/extensions/DashboardIndicators/OrganicProduction.html

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

4.3. Storyline 2: Agro-ecology for exports

Globalised food systems - high level of implementation of agro-ecological farming practises

The SSP 5 scenario, Fossil-fuelled Development – Taking the Highway, forms the basis for this narrative. In this future, focus is on competitive markets, innovation and participatory societies with the goal of reaching sustainable development through rapid technological progress and diffusion, including geo-engineering if needed (O'Neill et al., 2017). Integration of global markets continues with further removal of trade barriers, including giving access to disadvantaged actors, leading to high levels of international trade. The increased global wealth leads to the adoption of resource and energy demanding lifestyles by the growing global middle-class as developing countries follow the resource and fossil energy demanding developments of industrialised countries. Faith lies in solving the environmental consequences of this with different types of engineered technical solutions (SSP5). There is low investments into renewable energy while major investments in fossil energy continues (SSP5).

Following this storyline, food systems, as other sectors, have become increasingly globalised with high trade both within the EU and across the globe. In the EU specifically, strong support for and investment in agro-ecology led to a large increase in land managed with (weak) agro-ecological practises and the total area reach somewhere between 20-50% in 2050[4]. The main driver for this development has been using agro-ecological approaches as a means to produce high-value foods for trade between Member states but also for exports to the newly affluent economies where a rapidly growing middle class (SSP5) is demanding "clean and healthy" foods. However, most trade takes place within the EU, cf. e.g. the recent strong trends of Spanish exports of organic products such as fruits, vegetables, wine, oil and nuts, continue due to the strong boom in demand by consumers from the middle-northern countries of Europe.

Several export-oriented policies and initiatives have been put in place in Member state in order to meet the consumer demand for "clean and healthy" foods[5]. Most agro-ecological farming systems are more of the 'substitution' rather than the 'redesign' variant and policy focus mainly on the substitution of problematic inputs. Products are sold on global and EU markets under third-party verified certification schemes – digital technologies (SSP5) has enabled the efficient control and management of such certification systems. Increased cooperation on global level to facilitate trade (SSP5) has led to the development of a global standard for organic production based on mainly weak agro-ecological principles (input substitution). Focus is on the ban of pesticides to prevent potential negative effects on human health. Apart from increased investments in export oriented strategies, the agricultural policy in the EU is similar to that of today. However, payments for certified organic farming and other similar certifications that have export market potential are at first increased to stimulate this production, but are then gradually phased out. In this future, small-scale agro-ecological producers have a hard time competing with large companies that have a much greater capacity to invest heavily in promotion of 'greener' products on global markets.

[4] An example of this being a plausible future development of EU agriculture is the Swedish food strategy launched in 2017 which suggests increased organic production (goal for 2030 is 30% of agricultural land), including exports, to increase rural employment and economic growth.

[5] See for example Danish goverments investments in export activities related to organic foods. https://www.foedevarestyrelsen.dk/english/SiteCollectionDocuments/Kemi%20og%20foedevarekvalitet/Oekologiplan%20Danmark_English_Print.pdfc

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

Since most commodities are traded on the EU or global markets which require large-scale production able to deliver stable volumes to large food industries, large-scale farms dominate both the conventional and agro-ecological farming in Europe. Infrastructure and other support for local markets are not prioritised, which further drives small-scale farmers out of business. Imports into the EU of cheap, bulk commodities like soy for feed, palm oil and wheat increase to supply low-price food to large low-income population groups in the EU. Globally, EU agriculture's large share of land under agro-ecological practises is an exception, supplying a global niche market. In general, global agriculture is dominated by input and technology intense high yielding conventional production practises (SSP5). A growing share of food is also produced in entirely industrialised systems that require little or no agricultural land for its feedstock[6].

Eating patterns develop according to current projections, staying rich in meat other resource intense food products and unhealthy foods in developed counties, with increasing meat and dairy consumption in developing counties , but with variations between income groups. Policy targeting demand to support healthy or sustainable diets is non-existent. Current developments with low-income populations struggling with diet-related diseases continue while the eating patterns of high-income populations improve somewhat[7]. That is, a highly segmented food market is evident in this storyline in which anonymous agro-ecological products are consumed by the informed well-educated populations and exported outside the EU, while the majority consumes conventional low quality food. Food waste levels remain similar to current levels or decrease somewhat in countries where waste reduction policies are implemented.

[6] See for example https://solarfoods.fi/#vision

[7] https://academic.oup.com/ajcn/article/87/5/1107/4650128

https://www.cambridge.org/core/journals/british-journal-of-nutrition/article/prospective-associations-between-socioeconomic-status-and-dietary-patterns-in-european-children-the-identification-and-prevention-of-dietary-and-lifestyleinduced-health-effects-in-children-and-infants-idefics-study/CAD97E2AC8B25B513F5D8C9797D2BCD1

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

4.4. Storyline 3a: Localisation for protection

Local food systems - low level of implementation of agro-ecological practises

This scenario plays out in the future described in the SSP 3, Regional Rivalry – A Rocky Road, scenario. The world experiences a rise in nationalism and regional conflicts which pushes countries to focus on national security issues which includes trade barriers particularly in energy and agricultural markets (O'Neill et al., 2017). Countries aim to reach energy and food security goals within their own nation or region - global cooperation and trade is low (SSP3). The world is separated into several regional blocks of countries that have little exchange between them, which prevents efficient action to reach sustainability goals (SSP3). Reaching environmental sustainability goals have very low priority in this future (SSP3).

In this storyline, we see a development in which nationally or locally produced foods, regardless of production methods, are prioritised over foods produced in agro-ecological farming systems. In some Member states, this development is a consequence of a continued rise in nationalism and protectionism. Some countries are also experiencing discontent with EU membership and aim for greater independence (cf. Brexit). Global trade wars and global political tendencies for less international cooperation and increased competition between regions (SSP3) add to the sensation of the importance of self-sufficiency in food supply. In the wake of this, some Member states are putting policies in place to promote more national food production based on arguments like supporting local farmers and/or reducing the dependency on imported foods e.g. to be prepared for cut-off situations due to conflicts or interruptions due to trade wars.[8]. In other Member states, nationalism is not as pronounced and support for continued EU-cooperation (including a large CAP budget) is maintained. However, these countries are also affected by the global political situation and strategies for food production emphasize the need for high level of self-sufficiency and independency from large food imports. Many countries look to Finland for inspiration. Finland has managed to maintain high market shares for Finnish products due to explicit goals, strategies and policy investments into strengthening the competitiveness of Finnish farming and the promotion of Finnish foods[9].

In terms of agricultural production in the EU, focus is on increased output of bulk commodities and continued growth of the agricultural sector to supply primarily the national population, but also to achieve gains on a growing world market through exports of surplus to countries mainly outside the EU. Although national/local food is commonly marketed as more healthy and sustainable (and perceived as such by consumers) concern for negative health or environmental outcomes is in general secondary. Local production is prioritised over implementing agro-ecological practices or other more sustainable ways of farming, which are often seen as in-efficient use of land. The influence of multinational agro-input and food companies has remained strong but their influence has gradually decreased somewhat for a number of reasons. In countries with nationalist influences for example, people are increasingly suspicious and negative towards anything that relies on cooperation across countries and tend to prefer buying from national companies. New national food companies therefore arise and existing ones are strengthened - however power in the food chain continues

[8] Example from Sweden of a municipality which might abandon their policy to purchase organic food in favour for locally produced and seasonal foods. https://www.sydsvenskan.se/2019-10-28/lunds-kommun-kan-helt-stryka-krav-pa-ekologisk-mat?redirected=1&fbclid=IwAR0KxVmGLKlvIn53HCMX8wqMVNFWO_KPpMBjWZ51mVYlv3c_v5qMmDdfV1o

[9] https://mmm.fi/en/food-and-agriculture/policy/food-policy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

to be concentrated to a few large food industries and retailers in each country. Due to the focus on national food production and nationalistic trends, local food cultures thrive in many countries. Still, most citizens continue to eat a highly environmentally impacting diet with high levels of animal products, as there are few consumer side policies put in place to steer consumption in a different direction and additionally continued investments and support for intensive livestock production. Food waste decreases slightly due to somewhat higher food prices.

The implementation of agro-ecological practises hence remains low or increase only slightly (maximum 15% of agricultural area in 2050) to support mainly three niches of citizens; 1) those who oppose current nationalist trends and relentlessly, but not very successfully, continue to fight against environmental pollution 2) those that use nationalist arguments for "saving our national environment" and therefore see an interest in agro-ecology[10], and 3) rich consumers outside the EU. Agro-ecology is limited to weak agro-ecological practises as the focus on high-yield is prevailing in the agricultural discourse. In the EU, there is a strong push to intensify national agricultural production (both in fertile and marginal areas) with the demand for increased food output overruling objectives to reduce environmental pressures. Globally, investments and development of agriculture is slow (SSP3).

Due to the conflicting views on the role of EU institution between Member states, the centrality of the EU CAP and the contrasting re-nationalization of agricultural policies is heavily debated. The EU has continuously been losing centralised power. However, there is still a common agricultural policy in 2050 but with a smaller budget and Member states are left to make most decisions on how it is to be implemented, i.e. EU-level policies are weak. Member states keep agriculture strongly protected and financially supported. Member states manage to keep up with the international competition due to mainly protective trade policy but also by, although to a lesser extent, consumer willingness to pay a considerable price premium for domestic products. On the demand side, most countries implement policies to promote consumption of local foods, e.g. requiring that public meals are "based on local traditions" and made out of domestically produced commodities and information campaigns to promote local food. Member states find creative ways to put up inter-EU trade barriers, e.g. referring to health effects etc. There is an increasing amount of publicly-funded projects and initiatives to support local production, including labelling schemes[11] and policies to support short supply chains.

[10] Potentially this organisation is such an example http://www.ecopop.ch/de/

[11] E.g. http://euskolabel.hazi.eus/es/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

4.5. Storyline 3b: Localisation for sustainability

Local food systems - low level of implementation of agro-ecological practises

This is an alterative storyline which emerges in the same scenario corner (Figure 2) as Localisation for protection, i.e. out of a combination of a high degree of local food systems and with a low level of implementation of agro-ecological practises. Compared to the previous scenario whiched played out in SSP3 scenario; Regional Rivalty – A Rocky Road scenario, **Localisation for sustainability** plays out the SSP 1 scenario: Sustainability – Taking the Green Road.[12] In the SSP 1 sustainability scenario, the growing evidence of the multi-faceted cost of inequity and environmental breakdown is pushing for the prioritisation of reaching sustainability goals, with a shift in focus from economic growth towards improvements in well-being, especially in developing countries (O'Neill et al., 2017).

In this storyline therefore, local food systems do not arise for reasons of nationalism and protectionism, but rather as an outcome of a deliberate policy goal of creating truly sustainable and resilient food systems. Support of local food production to sustain and develop rural communities is one important socio-economic sustainability goal that is given high priority in this narrative, but other advantages with local food production also acts as important drivers. These include cutting food miles[13], closing nutrient cycling and avoiding further regional specilisation and concentration of food production which leads to water stress, loss of soil carbon, the spread of pests and negative outcomes for biodiversity. Thus, within the framework of the CAP (which design stays close to the post 2020 one), Member states prioritise policies that steer towards local production systems (cf. Finland which has achieved that within the current CAP system).

At the same time as local food systems are promoted by global, European and national institutions, global agricultural markets are opened to developing countries (SSP1) to promote greater equity. However, due to the promotion of local and regional food systems for reaching sustainability goals, trade volumes are not substaintially increased. It is mostly high value specilised cash crops that are imported into the EU, e.g. coffee, tea, cocoa, nuts, tropical fruits etc., while the EU is a net exporter of some surplus mainly bulk commodities (cereals, legumes, milk powder) but also some limited amounts of high value foods (wine, spirits) to regions which does not have enough agricultural land to sustain their populations (e.g. the Middle East), and to regions and consumer groups (e.g. urban middle-class) that can afford and demand these high value foods. International, as well as EU internal trade exchanges, are important for increased reslience as different regions are affected by climate change aggravated extreme events.

The main difference between this storyline and the Local-agro-ecological-food-systems-storyline (see next section), which both include a transition to local food systems, is that the Local-agro-ecological-food-systems-storyline has a strong focus on agro-ecological food systems, including more 'nature' based practises and redesign of agricultural systems, while this scenario here focuses on the localisation aspects and relies more on technical solutions aligned more with the 'sustainable intensification' perspecive on agriculture (ref SI). For example, in this scenario, using mineral nitrogen fertilisers produced using renewable energy[14] would be seen

[12] This scenario was added after the third workshop as several stakeholders had strong opinions on the negative framing of Localisation for protection. They argued that local food systems could be established without the negative connotations of nationalism.

[13] https://www.euractiv.com/section/agriculture-food/news/sr-agri-local-zero-kilometre-products-start-to-take-spain-by-storm/

[14] First renewable fertilisers will be on the market in 2022. https://lantmannen.com/newsroom/press-releases/lantmannen-and-yara-lead-the-way-towards-worlds-first-fossil-free-food-chain/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

as a sustainable practise, while in the Local-agro-ecological-food systems-storyline nitrogen fixation using legumes would be the preferred option.

A prerequisite to 'the pursuit of a sustainable and resilient food systems' is a shift in diets to increased seasonality, determined by local availability of foods. Depending on location, eating patterns in the EU hence stratify. In the southern parts of Europe, climate change induced droughts drive up prices of crops and the economic viability of feeding cereals to livestock dimishes and diets hence become mainly plant-based. In the northern parts of Europe, variation in climatic conditions increase markedly, making the availability of fruits, vegetables and cereals volatile. Increased use (and dependence) on low-cost grazing on marginal lands however makes milk and ruminant meat more abundantly available. Rapid technological advancement additionally introduces an array of novel food products stemming from sources with low environmental impact, e.g. synthethic extration of protein from inedible biomass, insects and lab-cultivated foods.

High investments in health and education and an accelerated demographic transition (SSP1) result in larger shares of the global population demanding fresh and seasonal foods, which acts as a postivie feedback loop on health. Due to the low implementation of agro-ecological practices, supply is however continously dominated by a narrow range of foods such as wheat, maize, rice, tomatoes, apples etc. and few local and/or traditional crop types are cultivated. That is, current trends of reduced nutrient content in globally widespread crops continue which hamper some of the positive outcomes for health.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

4.6. Storyline 4: Local agro-ecological food systems

Local food systems - high level of implementation of agro-ecological farming practises

This scenario plays out in a global context as laid out in the SSP1 scenario: Sustainability – Taking the Green Road. Here growing evidence of the multi-faceted cost of inequity and environmental breakdown is pushing for the prioritisation of reaching sustainability goals, with a shift in focus from economic growth towards improvements in well-being, especially in developing countries (O'Neill et al., 2017). A rapid increase in climate and environmental concerns among large population groups in the EU and fierce campaigning for stricter policies to prevent climate and environmental breakdown drive change in this storyline. The first sign of this development was seen in 2019 with the Friday for Future movements and in the 2019 election to the European parliament when the green parties increased their mandates by 40%.

Globally, cooperation between national and international institutions are strengthened, and new global institutions arise to reinforce the rule of law and decrease corruption in order to effectively work towards greater sustainability on the global level (SSP1). In the EU, a common EU policy on sustainable food systems based on agro-ecological practices, much influenced by the iPES report[15], has been put in place. This integrated approach to EU food security, rather than the silo approach of separate agricultural, environmental and health policies, has been largely adopted by most member states in the year of 2028. The focus of the food strategy is on establishing more localised agro-ecological food systems to overcome multiple problems including nutrient and chemical pollution, soil erosion and soil carbon loss, high use of antibiotics and poor animal welfare and to enhance social sustainability by promotion of more small-scale and diverse farming and food production practises. Different types of alternative food systems are rapidly expanding including different types of community supported agriculture and short supply chain/direct sales online systems. To enable more localised food systems, support is also given to the establishment of small-scale processing. International markets are opened up to developing countries but trade stays limited due to the focus on regional production (SSP1). European farmers are protected from the international competition primarily by industry and retail introducing local produce as a base criteria due to consumer demand, but also by trade agreements that implement sustainability criteria, e.g. for countries lacking tax on CO_2 emissions duties on imported goods are introduced (ref). In combination with, and actually proceeding the changes in policy, many Member states experience an explosion in bottom-up initiatives fostering agro-ecological farming practises and local food systems. Local town councils and regions play an important role here. In developing countries, yield increases are accomplished thanks to rapid introduction of best practises and effective technologies, alleviating food security challenges in these regions (SSP1).

As for the CAP, this is now handled under the umbrella of the integrated food policy and has in 2050 radically changed. Already in the 2030 there are systems in place for e.g. Results Based Payment Schemes and such system are largely expanded between 2030 and 2050. Greater consumer awareness is achieved by coherent marketing campaigns, and with the dissemination of clear, accurate and complete information about the benefits of agro-ecological production systems for society. Programs for knowledge transfer among practitioners and producers in rural areas have also been implemented and are available for most farmers. The investment in agro-ecology is also used as a strategy to adapt to unavoidable effects of climate change.

[15] http://www.ipes-food.org/_img/upload/files/CFP_FullReport.pdf

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

Pillar 1 support is thus reformed from purely area-based to being based on several sustainability criteria. One important example is the recognition of the inefficiency of feeding human edible crops to livestock that lead to the implementation of incentives to feed ruminants more grass and forage and to the rapid rise in poultry production to level off. Intensive pork production also decreases.

The concept of locally adapted agro-ecological food systems in this storyline also includes striving for more healthy and sustainable consumption patterns. This includes a view that excess intake of "unnecessary" unhealthy foods (sugar-sweetened foods and beverages), excess consumption of livestock products, especially from animal species consuming human edible feed (i.e. pigs and poultry), and excess intake of food in general is a waste and should be prevented by powerful policy measures[16]. As should of course ordinary food waste which is reduced between 25-50% mainly as a result of food becoming more expensive but also through a range of different policies. The EU common food strategy includes an initiative to make policy targeting demand and production coherent, directing the CAP support towards the production of foods desired in a healthy and sustainable diet. As suggested in the iPES-report, in order to receive CAP funding, Member states have to develop and implement certain health promoting policy such as fiscal and social policies to promote healthy eating.

An important success factor of the rapid transition to strong agro-ecology at a large scale has been food retailers' and industries' commitment and involvement in the new food strategy. Driven initially by consumer demand[17] and as a result of the societal discourse, food industries have started to work actively with farmers to enable the implementation of agro-ecological schemes and then bit by bit incorporated this into their company strategies[18]. In 2050, on average across member states, between 20-50% of land is farmed with strong agro-ecological practises serving mostly local markets.

[16] For example, taxes on unhealthy foods and policies that steer away from using grains for animal feed.

[17] Example of recent developments of consumers driving change: https://www.politico.com/news/2019/10/10/food-industry-consumer-brands-association-043892

[18] Dairy company Danone is an example of a large multinational company already promoting agro-ecology, in their case under the concept of "regenerative agriculture" https://www.danone.com/impact/planet/regenerative-agriculture.html

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

5. INTEGRATION OF CASE STUDY INNOVATIONS

In the project partner consultation we asked how the case studies would play out in the different described futures (see section 3.2). An initial analysis of this in relation to the different storylines is found a Table 3. This will serve as input to the integration of case studies into the modelling. Partners are currently (February 2020) asked to provide the necessary data and information of agro-ecological innovations observed in the case studies in such a way as to represent them in the two food system models and do the upscaling and territorial analysis. Thus, WP4 have distributed guidelines that ask them to describe the information that is needed and how to present it to achieve this upscaling.

Partners do not need to cover all levels of innovations (plot, farm, landscape, food systems level) – they can also choose to suggest 2 plot level innovations and nothing else, for example. Sources to identify the innovations are the different case-study related documents, i.e. the social-ecological systems (SES) and farm level Decision Support Tool (DST) assessment from WP3 and the actor and policy analysis from WP5, as well as literature data, if necessary. To describe the innovations and their impacts, WP4 basically needs the following information:

- general description of the innovation
- context, in which the innovation can be applied (e.g. FADN farming system (i.e. farm type, farm size), pedo-climatic conditions, share within high natural value lands, etc.)
- indicators for assessing the characteristics, performance and impacts of innovations (e.g. on fertilizer and labour input use, yields, emissions, impacts on soils, etc.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

Table 3. Summary of UNISECO case studies and how they play out in the different scenarios.

	Business-as-usual	**Agro-ecology for exports**	**Localisation for protection**	**Local agro-ecological food systems**
AUSTRIA (BOKU) Intensive arable farming. **Key dilemma**: How to combat climate change (e.g. water scarcity), ***increase carbon sequestration***, prevent soil degradation and reduce the loss of soil fertility of arable land, whilst maintaining or enhancing social and economic sustainability?	Production as today or according to current trends.	Increased uptake of weak agro-ecological practises (input substitution but also improved crop rotations that could lead to C sequestration) for export oriented production systems.	As in BAU.	Moving towards re-design, more diversified production, introduction of animals
CZECH REPUBLIC (UZEI) Dairy farms in the Vysocina Region **Key dilemma:** How to maintain and ***expand*** good performance of arable land management in organic dairy farms in the Vysočina region to ***reduce arable soil degradation and water pollution by pesticides*** while ensuring their economic viability?	Production as today or according to current trends.		Further intensification to increase domestic production.	Toward redesign - less human edible food in ruminant diets -> more human edible foods produced and dairy yields decrease somewhat. More grazing etc. depending on how production looks currently.
FINLAND (LUKE) Towards carbon neutral diary **Key dilemma:** How to reduce harmful climate, water and soil impacts of dairy farming without sacrificing economic viability of the local dairy sector, by means of a multipurpose bio-product plant, with the aim of ***producing bioenergy (mainly biogas) and organic fertilizers*** from manure.	Installation of biogas sites continues according to current trends (Scarlat et al., 2018) and/or plans.	As in BAU – not affected by export strategies	As in BAU but potentially higher rates of implementation in countries with a tradition of biogas investments. From LUKE: *"Our case study contributes mostly to the local economy (local agro-ecological symbiosis)"*	Increased installation rates compared to BAU From LUKE: "*This is by its contents describing our case study best."*
FRANCE (ISARA) Grape production in Cumas **Key dilemma:** How to ***reduce dependency on external fertilisers and to reduce pesticides use*** (especially glyphosate) through agro-ecological practices increasing soil ecological services (soil biology) while maintaining the economic profitability of farms?	Fertiliser and pesticide use as today in grape production. Agro-ecological wine develops according to current trends (organic) or stays as today?	Higher share of implementation of agro-ecological practises in grapes compared to staple crops because it is a high value product which might be traded more in this scenario?	As in BAU. No change in trade for wine.	Increased agro-ecological practises in grape production; no pesticides (or only a few used today in organic?), no mineral N. Can case study be used to look at yield levels? Level of implementation?

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

	Business-as-usual	Agro-ecology for exports	Localisation for protection	Local agro-ecological food systems
GERMANY (TI) Arable farming in Nienburg county **Key dilemma:** How to integrate agro-ecological practices on arable land in highly market-oriented farming systems to ***reduce biodiversity loss and water pollution threats*** without significant negative impacts on the economic viability of farms?	Production stays as today. From TI: "*Most of the farms in the German case study are conventional market-oriented farms that produce for the domestic and global market. In other words, for many of the farms this scenario would reflect a continuation of business as usual."*	Implementation of weak agro-ecological practises. From TI: *"A scenario with a weak agro-ecological transition is very close to the transition stage we are looking at in the German case study. Initiatives of cooperative environmental management and developing regional brands does not seem to be reflected in the scenario, but would in our case still be part of a weak agro-ecological transition of farms."*	Production stays the same.	Over the years these farms slowly transition towards re-design. From TI: *"Parts of it are relevant for the German case study. In a way the German case study combines elements of scenario 2 and 4. It mainly focuses on initiating transitions, but also integrates aspects of regional brands and short supply chains."*
GREECE (AUA) Peach production in Imathia **Key dilemma:** ***Eliminate the use of chemical pesticides*** in permanent crops (peach orchards) and produce pesticide-free products of high quality.	Production stays as today. From AUA: *"Provided, social capital continues to accumulate locally at the Case Study area it is not a scenario that would cause significant problems."*	Higher share of implementation of agro-ecological practises in grapes compared to staple crops because it is a high value product which might be traded more in this scenario? From AUA: "*Quality assurance, in this case strict control of pesticide residues is going to be more important than environmental improvement e.g. natural resource use, biodiversity, landscape etc."*	As in BAU or production is reduced due to reduced demand. From AUA: "*It is going to be a difficult situation since a large part of the production is exported."*	Implementation of agro-ecological practises increases – From AUA: *"Farmers participating in the agroecological initiative could adapt their production to a scenario like that, it is not sure for the rest."* Fruit production in Mediterranean countries might have to decrease in general because of more local food systems.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

	Business-as-usual	Agro-ecology for exports	Localisation for protection	Local agro-ecological food systems
HUNGARY (GEO) Soil conservation in arable farming **Key dilemma:** How to integrate agro-ecological practices on arable land in highly market-oriented arable farming systems to maintain and ***improve soil quality*** without significant negative impacts on the economic viability of farms?	Continuation as today, but with some implementation of soil conservation practises. From GEO: *The farmers we work with, tend to follow the mainstream developments and trends. If they want to survive they must adapt – mainly because of the size of their land - to the global market…. Even this scenario the uptaking of soil conservation practices will increase as it can contribute to the economic performance of the farms."*	Increased implementation of soil conservation practises for export products. From GEO: "*The farmers in our CS will likely be able to adapt to this scenario. They can take up relatively easily the agroecological practices as they have the economic background to invest and to finance the transition."*	As in BAU. From GEO: "*For our case study this scenario does not make much difference. The ecological pressure will be there to stress the need to change soil cultivation. Maybe if the regional values become more important then soil as a national treasure would get more reflection. It is important how the structure (average size) of farms will change. Will farmers have enough background to invest in machinery to start with soil protective cultivation?"*	Implementation of soil conservation measures at some rate. Which ones and how to model? From GEO: *"It is not sure that small scale is better for soil protective cultivation as small scale farms normally strive for survival and have no economic background to invest in the machinery or in soil tests etc. If they get support and necessary knowledge, there is more chance to make them take care of their soil. The cooperation among farmers could also help."* In this scenario, production units can still be large scale but they implement more agro-ecological practises and sell more on local markets.
ITALY (CREA) Chianti biodistrict – wine **Key dilemma:** How to develop a more diversified cropping system in a highly specialised and market-oriented winegrowing area through the adoption of agro-ecological practices, in order to ***improve the biodiversity and landscape management*** of the area while maintaining the profitability of farming through local value chains.	Fertiliser and pesticide use as today in grape production. Agro-ecological wine develops according to current trends (organic) or stays as today? From CREA: *"Chianti is strongly export-oriented, especially for wine and medium-large sized farms. This scenario would confirm the current trends in which the growing demand for high-quality organic wine on international markets is rewarded."*	As in BAU. The case study is already export-oriented. From CREA: "*The situation would not be so different from the BAU scenario. There would be further development for medium-large organic farms that already export an important share of wine. Some problems for small business prospects."*	Production is reduced due to reduced demand. From CREA: "*Serious problems for companies that export wine but in part could stimulate crop diversification and the activation of chains other than wine and tourism (UNISECO challenge). There would be a tendency to curb the change towards biological and agro-ecological approaches."*	Production diversify – to what crops? To what extent? From CREA: "A strong development of the biodistrict is expected in which the activities move from agricultural production at farm level to the territorial coordination of the Chianti supply chains." [Ask CREA for clarification.]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

	Business-as-usual	**Agro-ecology for exports**	**Localisation for protection**	**Local agro-ecological food systems**
LATVIA (BEF-LV) Dairy farming **Key dilemma:** How to ***increase the economic viability*** of conventional and organic, largely grass-based, dairy farms while preserving biodiversity in grasslands and water resource quality? How to ensure that all organic milk is processed into organic dairy products?	Grass-based production declines according to current trends.	As in BAU	As in BAU without support (compare with Finland), assuming that investments in national food production prioritizes high productivity bulk production. Or, maintained or increased production due to investments.	Increases due to national support for such systems. Here we could compare the Nordic countries in which Sweden has been relatively more successful in preserving grasslands than Finland.
LITHUANIA (BEF-LT) Small scale dairy and cheese **Key dilemma:** How to maintain and encourage ***extensive management (grazing) of grassland habitats***? How to become (or remain) competitive in the market without intensifying the farming practice and increasing the farm in size?	Grass-based production declines according to current trends. From BEF-LT: *"Our case study would have a hard time standing out in a future like this. It would only last out if they would find a bigger consumer market for high value products."*	As in BAU	As above but rather the second development in which this type of farming is supported. From BEF-LT: *"Though I don't see this scenario very realistic in Lithuania, I think it that our case study would probably favor from this scenario, as local food production is key in it."*	Increases due to national support for such systems. From BEF-LT: *"Our case study would very much thrive in such a scenario if the farmers would be able to greatly cooperate with each other and produce the amounts of food that are necessary for the market."*
ROMANIA (WWF) Permanent crops and grazing **Key dilemma:** How to ***increase the economic viability*** of small-scale farming system while ***preserving the cultural landscape and biodiversity***?	Similar to the Latvian and Lithuanian cases.	Similar to the Latvian and Lithuanian cases.	Similar to the Latvian and Lithuanian cases.	Similar to the Latvian and Lithuanian cases.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

	Business-as-usual	Agro-ecology for exports	Localisation for protection	Local agro-ecological food systems
SPAIN (GAN) Re-design farms in the Basque county and Navarra **Key dilemma:** How to ***reduce the fragility of agro-ecological farms*** (already in the redesign phase) while maintaining the social, economic and environmental sustainability?	This production will remain a niche. From GAN: *"The case study will continue to be an island of people who are very aware and very convinced of the way they are doing, and they will be able to a certain extent promote their values at a local level, but they will have no influence yet to reach regional national governments."*	As in BAU or even a reduction. From GAN: "*This differentiation will at points be very difficult and harmful for the case study producers, because they will have to compete with large companies that have a great capacity to carry out eco-marketing and greenwashing campaigns. There is a real risk of part of the consumers not being able to distinguish products coming from the bio-industry presented in this scenario (especially if the companies are locally based and well known by consumers), from products coming from the case study farmers.* *The case study will not be directly affected by import-export trades (since it's a locally based organization), unless the price or organic products varies due to the increase of global organic production."*	Decreased as governments would rather invest in conventional production, or maintained as a niche*. From GAN: "If the government closes the boarder to imports, the case study would benefit from it since the demand of locally produced food would increase. Local consumption would establish as a normal habit, and that would be considered very positive. However, the case study implements cross-border activities and exchanges of goods. They try to work in a regional framework but crossing an international border between Spain and France, in which case trade barriers would then affect them. The case study would probably also benefit from public measures that promote short commercialization channels."	Increased level of re-design farms. From GAN: "*The case study farmers would benefit enormously from an increase in financial support from the government, a reduction of costs for organic farming systems by lowering the price differentiation between conventional and organic products, and an increase in demand."*
SWEDEN (SLU) Diversification of ruminant farms **Key dilemma:** To ***diversify animal production units towards more crops for direct human consumption*** in order to reduce the climate impact of food production, improve outcomes for biodiversity and other sustainability aspects	Specialisation as today or according to current trends.	As in BAU.	As in BAU.	Ruminant farms diversify – less human edible food in ruminant diets -> more human edible foods produced and dairy yields decrease somewhat.
SWITZERLAND (FIBL) Milk and cattle, Lucern central lakes **Key dilemma:** How would a ***site-and soil-specific agriculture*** in the Lucerne Central Lakes region look like? How can emissions from agriculture be reduced?	Production stays as today.	Increase of export oriented production + introduction of weak agro-ecological practises for those.	As in BAU or further specialisation.	Reduction of cattle number to "fit the land".
UNITED KINGDOM (UA & HUT) Mixed cropping and cropping in north-east Scotland **Key dilemma:** Producing public goods whilst maintaining viable production of private goods, and securing economic and social sustainability at a farm level.	TBD	TBD	TBD	TBD

* Contradicts the view on this from the GAN team. However, the local, agro-ecological is covered in the last scenario.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

6. NEXT STEPS

Below the next steps in the scenario development process is lined out:

- Updated storylines and proposed case study integration will be sent to stakeholders and project partners for input – April 2020
- Updated storylines, proposed case study integration and initial results to be discussed with stakeholders and project partners at the next project meeting in May 2020
- Deliverable 4.2 Report on participatory scenario development of AEFS finalised June 2020
- Modelling of the options spaces and case study innovations and economic aspects – ongoing until September/October 2020
- Joint documentation of scenarios including storylines and modelling outputs – October 2020 – D4.3 Report on territorial impacts and lessons learnt of the diffusion of AEFS under scenarios finalised

7. REFERENCES

Audsley, E., Pearn, K. R., Simota, C., Cojocaru, G., Koutsidou, E., Rounsevell, M. D. A., . . . Alexandrov, V. (2006). What can scenario modelling tell us about future European scale agricultural land use, and what not? *Environmental Science & Policy, 9*(2), 148-162. doi:https://doi.org/10.1016/j.envsci.2005.11.008

Börjeson, L., Höjer, M., Dreborg, K.-H., Ekvall, T., & Finnveden, G. (2006). Scenario types and techniques: Towards a user's guide. *Futures, 38*(7), 723-739. doi:http://dx.doi.org/10.1016/j.futures.2005.12.002

Erb, K.-H., Lauk, C., Kastner, T., Mayer, A., Theurl, M. C., & Haberl, H. (2016). Exploring the biophysical option space for feeding the world without deforestation. *Nature Communications, 7*(1), 11382. doi:10.1038/ncomms11382

Karlsson, J., Röös, E., & Pira, K. (2017). *Future Nordic Diets - exploring ways to sustainably feeding the Nordics*. Retrieved from

Kummu, M., Kinnunen, P., Lehikoinen, E., Porkka, M., Queiroz, C., Röös, E., . . . Weil, C. (2020). Interplay of trade and food system resilience: Gains on supply diversity over time at the cost of trade independency. *Global Food Security, 24*, 100360. doi:https://doi.org/10.1016/j.gfs.2020.100360

Muller, A., Schader, C., El-Hage Scialabba, N., Brüggemann, J., Isensee, A., Erb, K.-H., . . . Niggli, U. (2017). Strategies for feeding the world more sustainably with organic agriculture. *Nature Communications, 8*(1), 1290. doi:10.1038/s41467-017-01410-w

O'Neill, B. C., Kriegler, E., Ebi, K. L., Kemp-Benedict, E., Riahi, K., Rothman, D. S., . . . Solecki, W. (2017). The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. *Global Environmental Change, 42*, 169-180. doi:https://doi.org/10.1016/j.gloenvcha.2015.01.004

Riahi, K., van Vuuren, D. P., Kriegler, E., Edmonds, J., O'Neill, B. C., Fujimori, S., . . . Tavoni, M. (2017). The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. *Global Environmental Change, 42*, 153-168. doi:https://doi.org/10.1016/j.gloenvcha.2016.05.009

Scarlat, N., Dallemand, J.-F., & Fahl, F. (2018). Biogas: Developments and perspectives in Europe. *Renewable Energy, 129*, 457-472. doi:https://doi.org/10.1016/j.renene.2018.03.006

Stürck, J., Levers, C., van der Zanden, E. H., Schulp, C. J. E., Verkerk, P. J., Kuemmerle, T., . . . Verburg, P. (2018). Simulating and delineating future land change trajectories across Europe. *Regional Environmental Change, 18*(3), 733-749. doi:10.1007/s10113-015-0876-0

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

Therond, O., Duru, M., Roger-Estrade, J., & Richard, G. (2017). A new analytical framework of farming system and agriculture model diversities. A review. *Agronomy for Sustainable Development, 37*(3), 21. doi:10.1007/s13593-017-0429-7

Wiebe, K., Zurek, M., Lord, S., Brzezina, N., Gabrielyan, G., Libertini, J., . . . Westhoek, H. (2018). Scenario Development and Foresight Analysis: Exploring Options to Inform Choices. *Annual Review of Environment and Resources, 43*(1), 545-570. doi:10.1146/annurev-environ-102017-030109

Wolf, J., Kanellopoulos, A., Kros, J., Webber, H., Zhao, G., Britz, W., . . . de Vries, W. (2015). Combined analysis of climate, technological and price changes on future arable farming systems in Europe. *Agricultural Systems, 140*, 56-73. doi:https://doi.org/10.1016/j.agsy.2015.08.010

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.