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ORIGINAL ARTICLE

Shared socioeconomic pathways for climate change research in Finland: co-developing extended SSP narratives for agriculture

Heikki S. Lehtonen[1] · Jyrki Aakkula[1] · Stefan Fronzek[2] · Janne Helin[1] · Mikael Hildén[2] · Suvi Huttunen[3] · Minna Kaljonen[4] · Jyrki Niemi[1] · Taru Palosuo[1] · Nina Pirttioja[2] · Pasi Rikkonen[5] · Vilja Varho[1] · Timothy R. Carter[2]

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Abstract

Shared socioeconomic pathways (SSPs), developed at global scale, comprise narrative descriptions and quantifications of future world developments that are intended for climate change scenario analysis. However, their extension to national and regional scales can be challenging. Here, we present SSP narratives co-developed with stakeholders for the agriculture and food sector in Finland. These are derived from intensive discussions at a workshop attended by approximately 39 participants offering a range of sectoral perspectives. Using general background descriptions of the SSPs for Europe, facilitated discussions were held in parallel for each of four SSPs reflecting very different contexts for the development of the sector up to 2050 and beyond. Discussions focused on five themes from the perspectives of consumers, producers and policy-makers, included a joint final session and allowed for post-workshop feedback. Results reflect careful sector-based, national-level interpretations of the global SSPs from which we have constructed consensus narratives. Our results also show important critical remarks and minority viewpoints. Interesting features of the Finnish narratives compared to the global SSP narratives include greater emphasis on environmental quality; significant land abandonment in SSPs with reduced livestock production and increased plant-based diets; continued need for some farm subsidies across all SSPs and opportunities for diversifying domestic production under scenarios of restricted trade. Our results can contribute to the development of more detailed national long-term scenarios for food and agriculture that are both relevant for local stakeholders and researchers as well as being consistent with global scenarios being applied internationally.

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✉ Heikki S. Lehtonen
heikki.lehtonen@luke.fi

Jyrki Aakkula
jyrki.aakkula@luke.fi

Stefan Fronzek
stefan.fronzek@syke.fi

Janne Helin
janne.helin@luke.fi

Mikael Hildén
mikael.hilden@syke.fi

Suvi Huttunen
suvi.m.huttunen@jyu.fi

Minna Kaljonen
minna.kaljonen@syke.fi

Jyrki Niemi
jyrki.niemi@luke.fi

Taru Palosuo
taru.palosuo@luke.fi

Nina Pirttioja
nina.pirttioja@syke.fi

Pasi Rikkonen
pasi.rikkonen@luke.fi

Vilja Varho
vilja.varho@luke.fi

Timothy R. Carter
tim.carter@syke.fi

[1] Natural Resources Institute Finland (Luke), Latokartanonkaari 9, FI-00790 Helsinki, Finland

[2] Climate Change Programme, Finnish Environment Institute (SYKE), Helsinki, Finland

[3] University of Jyväskylä, Jyväskylä, Finland

[4] Environmental Policy Centre, Finnish Environment Institute (SYKE), Helsinki, Finland

[5] Natural Resources Institute Finland (Luke), Mikkeli, Finland

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Introduction

Future anthropogenic climate change is an issue permeated with uncertainties in all regions of the world. In the absence of confident predictions of future developments, scenarios have emerged as a useful tool for exploring possible outcomes. The impacts of climate change on ecosystems, economic sectors and society in general are of particular significance in high latitude regions such as Finland, where changes in climate are projected to be greater than the global average (Ruosteenoja et al. 2016). However, the magnitude of these impacts can be strongly conditioned by the extent to which exposure and vulnerability to climate change are influenced by changing global, regional and even local socioeconomic conditions (e.g. Harrison et al. 2019).

In Finland, scenarios have been widely applied by researchers and policy-makers since the 1990s to investigate implications of climate change. Whilst climate and related environmental scenarios have been accorded close scrutiny (e.g. Carter et al. 1996, 2004; Jylhä et al. 2004, 2009; Ruosteenoja et al. 2016), the socioeconomic context in which future climate will change has received much less attention in Finland. Some indications of alternative future economic, demographic and technological trends in Finland have been explored in earlier studies (Kaivo-oja et al. 2004; Carter et al. 2005) based on global scenarios developed for the Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios (SRES–IPCC 2000). Aspects of the latter scenarios were adopted in Finland's first climate change adaptation strategy (MMM 2005).

A new global scenarios framework for climate change analysis was introduced by Moss et al. (2010) to replace the SRES scenarios. This addresses a wider set of research questions than SRES with more emphasis on regional aspects of climate change impacts and explicit attention paid to challenges presented by mitigation and adaptation. Unlike SRES, these scenarios were not developed by the IPCC but by the international research community at large.[1] The scenario framework, which was recently reviewed and evaluated by O'Neill et al. (2020), is designed around projections of global forcing of the climate (representative concentration pathways—RCPs), which have been developed in parallel with projections of social and economic development (shared socioeconomic pathways—SSPs). In this paper, we focus on SSP development, but it is worth noting that when used in climate change impact and adaptation assessment, it is conventional to combine SSPs with RCP-based projections of future climate to construct integrated scenarios.

SSPs were developed at global scale, and comprise narrative descriptions of future world developments and their associated quantification by integrated assessment models (IAMs), commonly at a spatial resolution ranging from large world regions to national (Riahi et al. 2017). They are reference pathways that assume no climate change or climate impacts, and no new climate policies. There are five SSP narratives (storylines) that offer sharply contrasting visions of future society and the inferred challenges posed to climate change mitigation and adaptation (O'Neill et al. 2014, 2017). The positioning and labelling of the SSPs with respect to challenges for mitigation and adaptation is shown in Fig. 1 as originally reported (a) and as Finnish language equivalents (b) used with stakeholders in this study (see the "Step 1: Context setting" section). The SSP narratives are summarised in Supplementary Material (Section S1).

It was recognised that regional and local-scale impact and adaptation studies would need additional information that is not contained in the original global SSPs, so a distinction was introduced between *basic* SSPs and *extended* SSPs (O'Neill et al. 2014). It was argued that, aside from the global narratives, basic SSPs should include some representation of a set of nine basic elements: demographics, economic development, welfare, environmental and ecological factors, resources, institutions and governance, technological development, broader societal factors such as lifestyle and attitudes and policies. While IAMs may offer some quantitative indicators for these, for certain variables or at resolutions for which information is not available, it may be necessary to turn to other models or methods, individual studies or expert assessments. Through such extensions, a richer and more relevant characterisation of SSPs would be possible. This argument is borne out by the growing number of regional and local SSP extensions now emerging around the world (O'Neill et al. 2020).[2]

Some of the socioeconomic and environmental factors regarded as important for assessing adaptation needs in Finland have been classified into nine categories in Finland's Climate Change Adaptation Plan 2022 (MMM 2014), which match closely the nine elements described for the basic SSPs listed above. There have already been some early efforts to interpret SSPs for different sectors (including agriculture) in Finland, primarily in the context of research projects that focus on climate change impacts and adaptation.

[1] A helpful source of information about the SSPs is the web site of the International Committee On New Integrated Climate change assessment Scenarios (ICONICS): www.iconics-ssp.org, which is the ad hoc committee overseeing their development.

[2] Literature database at: https://www.ciesin.columbia.edu/data/ssp-literature-database-v1-2014-2019/

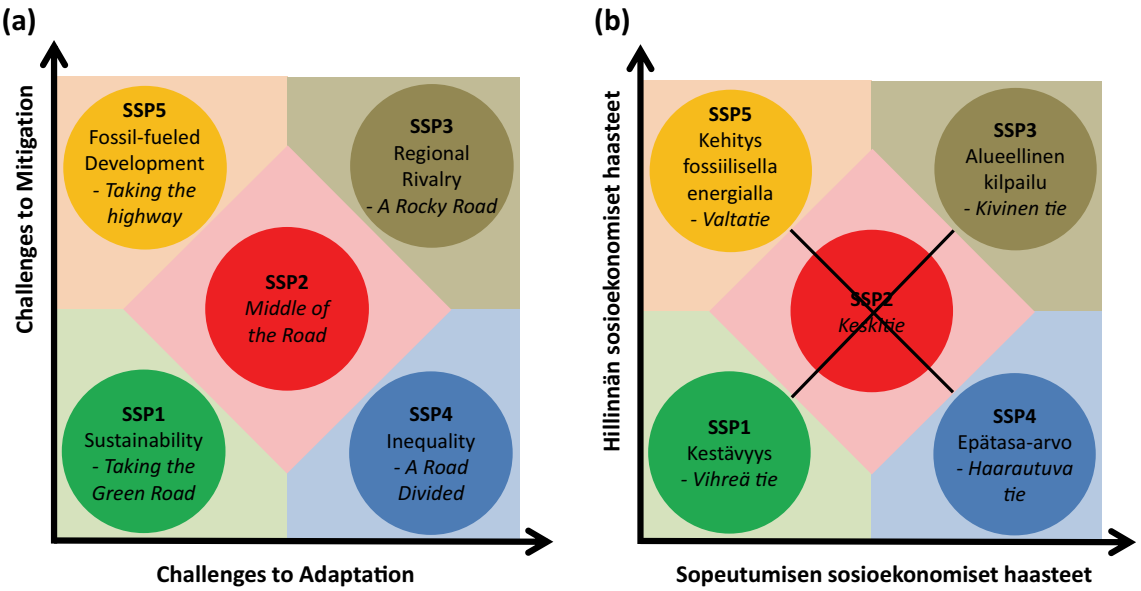

Fig. 1 The five shared socioeconomic pathways (SSPs) characterising challenges to mitigation and adaptation (**a**) and their Finnish language equivalents (**b**). Note that SSP2 was not adopted in the present study. Sources: based on O'Neill et al. (2014) and Frame et al. (2018)

Some studies consider SSPs in combination with RCP-based climate projections. The following examples are noteworthy:

1. Extended SSPs were developed around narratives for SSPs1, 3, 4 and 5 in a series of four workshops focusing on the Barents Sea region (Nilsson et al. 2017).
2. Baltic Sea narratives that describe regional drivers of three major pressures for regional ecology: (i) water-borne nutrient loads and atmospheric emissions; (ii) commercial fishing and (iii) shipping. All five SSPs were considered, but not RCP-SSP combinations, and detailed sector or country level developments in SSPs were not reported (Zandersen et al. 2019).
3. Four RCP-SSP combinations were selected (RCP8.5-SSP5, RCP8.5-SSP3, RCP4.5-SSP1 and RCP4.5-SSP4) and applied within and across multiple sectors and at different scales from Europe-wide to local (Kok et al. 2019).
4. Scenarios of population, GDP and trade liberalization based on SSPs1–3 were applied in a study of cereal and oilseed production in Finland (Biewald et al. 2015).

The objective of this study is to develop sector-specific national SSP narrative extensions for the agriculture and food sector in Finland up to 2050 and beyond. Judged in the context of global agricultural markets and the European Union's Common Agricultural Policy (CAP), Finnish agriculture is characterised by relatively low crop yields, high production costs and dependence on agricultural subsidies to maintain production motivation and farm income (Lehtonen and Niemi 2018). Various stakeholders reliant on supply chains for food could benefit from analyses of how global drivers may affect food and agriculture in the long run.

Some specific reasons for constructing national SSP narratives include:

- To explore alternative socioeconomic futures for key agricultural variables
- To provide input assumptions for climate impact models (e.g. technology, management or regulation assumptions for simulating agronomic, economic and integrated responses to key drivers of change)
- To initiate reasoning, analysis and comparison of how international developments might affect sectoral aspects at national level, such as markets, technology and regulation; to offer future context for climate change adaptation and mitigation decisions
- To increase the relevance of SSP-based scenarios for policy development, processes and assessment, emphasising policy needs, key uncertainties and barriers
- To form a basis for developing quantified indicators; and
- To complement projections of future climate

We present the method and results of a participatory exercise to develop socioeconomic narratives for the agricultural sector in Finland that are extensions of global SSPs. Participatory methods are increasingly emphasised for ensuring scenario relevance (Riddell et al. 2018).

Method

The process to co-develop SSP narratives for the agricultural and food sector in Finland comprised six steps centred around a stakeholder workshop held in May 2018 (Fig. 2). These

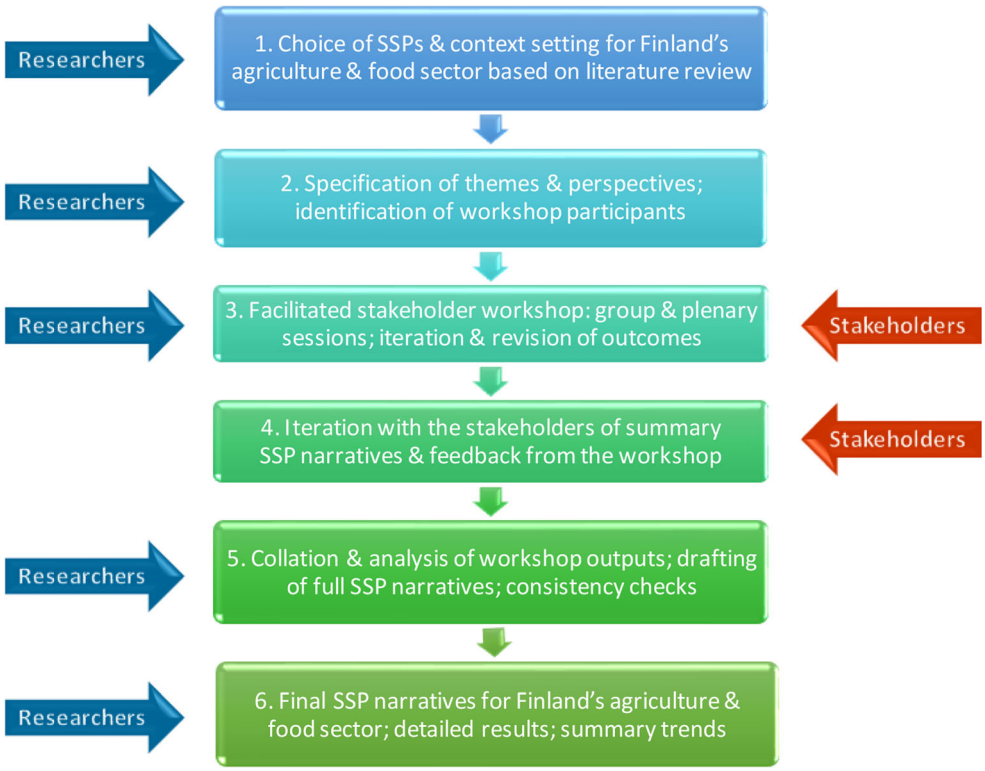

Fig. 2 Steps in the co-development of SSP narratives for Finland's agriculture and food sector with the timing of researcher and stakeholder inputs also indicated

steps are described in more detail below. Steps 1–2 and 5–6 were undertaken by the research group in this study. Stakeholders provided key input during the workshop (step 3) and were invited to offer feedback regarding the workshop organisation, themes and perspectives and to comment on the agreed narratives after the workshop (step 4). We adopted an interactive approach to co-development of the narratives (see also Mitter et al. 2019). On practical grounds, we opted for a single workshop that still offered several opportunities for iteration during and following the event. This was due in part to time and resource constraints, which precluded additional workshops, but also due to feasibility, as many of the participants were senior representatives from public and private sector organisations whose availability for repeated workshops would have presented a formidable challenge.

The basic concept was to organise the workshop around key themes judged by the research team to be important for understanding the exposure and vulnerability of the agri-food sector in Finland to changing climate, and for these themes to be addressed from three very different viewpoints in society (see below). These criteria then helped us to identify the types of stakeholder representation required. We wanted to attract knowledgeable and insightful stakeholders, often working in demanding executive or managerial positions, with experience and competence to interpret the potential implications of very different societal futures for their specialist area of expertise. Note that stakeholders were also offered an opportunity to critique these criteria during and after the workshop.

The process included consistency checking—comparing Finnish agri-food narratives to the global SSP narratives—during and after the workshop. This was undertaken by facilitators in guiding group session discussions and when writing the summary SSP narratives, as well as by other researchers classifying the individual comments and refining the final narratives.

Step 1: Context setting

A literature review was undertaken to compile background narrative and quantitative information of relevance for describing the global and European context in which the Finnish agricultural and food sector might operate in different SSP worlds. In the global framework (O'Neill et al. 2017), SSPs are positioned with respect to socio-economic challenges for mitigation and adaptation (Fig. 1). It is important to emphasise that they aim to depict alternative societal trends that "…result in making mitigation of, or adaptation to, climate change harder or easier, without explicitly considering climate change itself" (ibid. p. 170). Hence, SSPs are designed to be combined "orthogonally" with projections of future climate represented by RCPs, but do not themselves account either for climate change or its impacts. Instead, they cover many important socio-economic and sustainability drivers and issues that are relevant for agriculture, such as those related to consumer behaviour and sustainability awareness, directions of technology development, international cooperation and

trade. Brief excerpts of these global narratives were extracted for introducing the SSPs (Section S1.2, SM). Projections held in the global SSP database at the International Institute for Applied Systems Analysis (IIASA)[3] were extracted for Finnish population and GDP (Fig. S1.1, SM).

It was decided to focus on the four SSPs positioned at the corners of Fig. 1, omitting SSP2, which is an intermediate case. Aside from the logistical advantage of reducing the number of pathways to four, SSP2 was regarded as being less likely to offer insightful departures from recent and on-going trends (see also Mitter et al. 2020). It also removed any temptation for future users of the narratives to perceive this middle case as a more likely or more robust selection than the other four. A further practical reason was that SSP2 is omitted from two previous studies used here to provide sectoral and regional context (see below).

The primary source of background information on agriculture in Europe under the SSPs was the H2020 SURE-Farm project (Mathijs et al. 2018), which itself drew on some elements of the IMPRESSIONS multi-sectoral SSP narratives for Europe (Kok et al. 2019). The SURE-Farm scenarios focus on the agriculture sector and aim to describe the future context in which EU farming systems may develop, including environmental, economic and social issues. Consumer trends receive special attention. Technology includes many relevant developments in the long run, for instance, crop and animal breeding, crop protection, precision farming and efficiency at the whole farm level (see Tables S2.1–S2.4, SM). Scenarios were designed for analysing strategic decisions enhancing long-term resilience through adaptation or transformation at the level of the farming system. The SURE-Farm scenarios were developed by researchers, drawing on previous scenario exercises, on a detailed analysis of consumer trends, and on an expert solicitation procedure for checking consistency between scenario elements. The same four SSPs were addressed as in this study. Trends for several core elements identified in the SURE-Farm scenarios were adopted as context for the Finnish narratives.

Finally, adding a visual dimension to the SSP descriptions, each SSP world was represented using images related to consumer perspectives on diet, e.g. more or less meat and plant-based food stuffs shown in a typical lunch serving for each SSP (see Tables S2.1–2.4, SM). It was judged likely that these might offer an effective communication tool—easily identifiable and readily comparable to stakeholders' own personal preferences.

As a summary, core SSP ingredients were combined into single-sided, A2-sized posters (Tables S2.1–S2.4, SM). These were intended and emphasised to be merely indicative—a means to introduce the SSPs without pre-judging how the stakeholders might interpret them for the Finnish food system.

[3] https://tntcat.iiasa.ac.at/SspDb/

Step 2: Themes, perspectives and stakeholder identification

In preparation for a stakeholder workshop intended to characterise elements of SSPs that might be of importance for the agricultural sector, it was necessary to identify some core themes that could be used to structure the discussions. It was decided to organise the discussions around five *themes*, each potentially having a strong influence on ongoing and future trends in agriculture that would operate alongside changing climate. These were (A) diet, (B) food industry, (C) agriculture and horticulture, (D) technology and (E) environment.

Clearly, different stakeholders were likely to have varied viewpoints concerning each of the five themes. Rather than relying on the uncertain premise that such a diversity of stakeholder expertise and interest would deliver a representative range of perspectives, it was thought important to assist this process. As such, the five themes were each addressed from three different pre-specified *perspectives*: (1) consumers, (2) producers and (3) policy-making.

For example, a *consumers' perspective* on future trends in diet might include a shift from meat eating to vegetarianism, but how and to what extent? A *producers' perspective* could describe how and where healthy and good quality products would be produced to serve the type of diet already discussed under the SSP. A *policy-making perspective* on a dietary shift away from meat may require policy measures (national or EU) to be adjusted, e.g. nutrition recommendations, food safety regulation and farm support. Regardless of their professional expertise, stakeholders were invited to adopt all three roles when discussing each of the themes. There was equal time allocated for addressing each theme and perspective, the 15 permutations being regarded as an ambitious but tractable target for participants to cover in the time available, guided by facilitators with the aid of examples provided in posters in each SSP room (see Supplementary material).

Examples of topics of potential interest at the intersections between the three perspectives and the thematic areas are illustrated in Table 1, which was constructed to assist workshop facilitators in stimulating discussion. In essence, the workshop sought to re-populate a blank version of Table 1 for each SSP with alternative future descriptions of the Finnish agriculture and food sector.

Stakeholders were identified from among the following target groups: farmers (represented by 6 participants), agricultural extension (2), food industry (5), input suppliers (3), agricultural administration (6), research (6) and NGOs such as environmental organisations (2). The aim was to engage some of the major players in Finland's agricultural and food sector, who could represent all the essential elements of the food chain. It was considered important to invite senior representatives of significant agri-food organisations, since the food industry and retail sectors are quite concentrated in Finland. On

Table 1 Illustrations of consumers', producers' and policy making perspectives in relation to the five themes

	Consumers	Producers	Policy
A. Diet	Cultural, health, lifestyle & ethical preferences	Types of food product; sourcing of inputs; food processing; new product development	Health policy; food quality regulation; monitoring of public opinion; investment in R&D
B. Food Industry	Market research & marketing; packaging; prices; retail outlets	Supply chains; production units (size) and ownership; contracts; competition; quality requirements	Food quality regulations; import tariffs; regulation of multi-nationals
C. Agriculture & horticulture	Direct sales to consumers; fruit picking; farm noise, traffic, odours	Product diversity; supply contracts; costs for labour, machinery, inputs, buildings; labour availability	Public subsidies and incentives; insurance; production quotas; regional development
D. Technology	Awareness of new products and their availability; food marketing & delivery; ethics (e.g. GM crops)	Plant/animal breeding; animal health; crop protection; crop yields, new product development, precision farming,	R&D investment; patents; ethics (e.g. cloning, GM)
E. Environment	Carbon footprint, landscape preservation, species conservation	Use of fertilizers and herbicides; land management for erosion, biodiversity, & C-sequestration	Interventions for climate change mitigation & adaptation, air & water pollution, biodiversity, cultural heritage

the other hand, while a few representatives of smaller firms were also present, there were some omissions (e.g. processors of minor crops, were not invited). Inclusion of a fully representative sample would have increased the number of workshop participants beyond the resources available as well as potentially undermining effective interchange and discussion, especially in the plenary sessions.

We were fortunate in being able to draw on a diverse network of well qualified contact persons supplied by members of the research team. Targeted selection from these, combined with the requirement to attend only a single, stand-alone workshop, probably contributed to the strong uptake by many influential participants. Alongside the facilitators there were 39 participants in all. Facilitators were approached from among a set of expert participants with experience both of moderating group discussions as well as working in the agricultural sector or on environmental issues related to agriculture. Each of the four facilitators was allocated one of the SSPs, and then moderated two group sessions for that SSP.

Step 3: Facilitated stakeholder workshop

The workshop began with an opening session to welcome all participants, describe the context of the workshop and its main objectives and introduce the main ideas and logic of the global and European SSP narratives. The meaning and consequences of SSPs 1, 3, 4 and 5 for the Finnish agricultural and food sector were then discussed in two 90-min group discussions. Participants were allocated so that stakeholders covering different parts of the food chain as well as policy and environmental perspectives were represented in each group in as balanced a way as possible, i.e. there were representatives from all parts of the value chain and policy in each group. There were four groups, each of seven or eight participants. Each participant attended two different SSP sessions with group membership chosen in advance to differ as much as possible between the first and second sessions.

Groups met in separate "SSP world rooms", where moderators first presented the background global and European narrative for the relevant SSP, using the summary poster described under step 1. Participants were then given some time to think about how the global and European developments in each SSP might be realised in Finland under each of the five themes and from three different perspectives (cf. Table 1). Individuals wrote their initial thoughts on small sticky notes provided to them. Next, guided systematically through each combination of themes and perspectives, participants were invited by facilitators to communicate their views concerning developments they judged to be important. They discussed these with the group whilst attaching their (usually multiple) sticky notes onto a large, wall-mounted blank version of Table 1 (15 empty cells). Since two groups discussed each SSP, and to ensure independence of interpretation, outcomes of the first group were not shown to participants of the second before the latter had articulated their initial views and thoughts. After that, the outcomes of group 1 were also shown, compared and discussed. Note-takers recorded the discussions in each session. Facilitators guided the discussion and ensured that the global SSP narrative was accurately considered. They then prepared a short summary of the outcomes across the two groups they had moderated for a given SSP and presented this verbally to all participants in a final concluding session, where there was an opportunity to comment and ask questions.

Step 4: Co-development of summary SSP narratives

Based on the various contributions compiled during the workshop, facilitators edited a summary SSP narrative describing how future developments in the five thematic areas were considered to evolve in Finland in their respective SSP world. One week after the workshop, the four SSP summaries were sent to all participants by email with a request for any final comments.

Before leaving the workshop, most participants had completed a feedback questionnaire on the workshop as a whole, which included an open field for any general comments. These responses were used to judge the usefulness of the event, its strengths and weaknesses and suggestions for improving the process, content and effectiveness of future workshops.

Steps 5 and 6: Analysis of workshop outputs and drafting of full SSP narratives

Summary narratives and all individual comments provided in written form by the participants in the workshop formed the basis for a more detailed analysis of the outcomes and fuller description of the narratives. The written material given by anonymised participants in each SSP session was compiled from collected sticky notes and the views expressed were analysed. We distinguished between views that were directly comparable or equivalent to the global narratives, those that were consistent but complementary when interpreting the global narrative in the national context, or opposing views that challenged either the global narrative or the complementary material consistent with that narrative. In particular, these latter views provided important novel information and insights into the meaning and unique features of each SSP narrative that were not present in the original global or EU narratives.

Final SSP narratives were organised according to the thematic structure of the group discussions and were drafted to achieve approximately equivalent target lengths. The same thematic structure was also used for preparing two other outputs: tables of the detailed written material, classified using the criteria described above, and a table summarising trends in some selected indicators under each SSP.

Results

All responses are presented in Supplementary material (Tables S3.1–S3.4), organised according to the structure of the sessions as reflected in Table 1 (above). Of the feedback received on the draft summary narratives and workshop as a whole, most was positive, though a few participants expressed disappointment at the lack of advance distribution of materials included in the introductory workshop presentations. In the four sections below, we have combined insights on the five themes obtained from Tables S3.1–S3.4 with the summary outcomes reported by SSP facilitators into concise narratives for each SSP. The international context for each SSP narrative given below is based on the global (O'Neill et al. 2017) and European SURE-Farm (Mathijs et al. 2018) narratives.

SSP1: Sustainability—Taking the green road

International context The world and Europe shift gradually, but pervasively, towards a more sustainable path, emphasising more inclusive development that respects perceived environmental boundaries. Land use is strongly regulated through concerted actions at all levels to resolve environmental trade-offs. Crop yields increase quickly in low- and middle-income regions, leading to rapid convergence with high income countries. Healthy diets prevail with low animal-calorie shares and minimal waste. In an open, globalised economy, food is traded internationally. Local production and consumption are largely based on ecological principles, and trade of food and feed is liberalised. Nevertheless, trade volumes and sea traffic decrease to account for increasing sea traffic costs and to reduce greenhouse gas emissions and marine pollution. High environmental standards are required from all trading partners.

Diet The proportion of plant protein in diets is significant and there is a focus on domestic plant protein production. Consumers value sustainable domestic production and reduced greenhouse gas emissions and nutrient leaching to watercourses, which provide motivation for decreasing consumption of livestock products. However, while the diversity of food production and diet increases, dietary segregation also continues, since not all consumers are happy with a plant-based diet. Hence, while meat consumption drops significantly, it falls only to about half of today's level. Few policy measures other than taxation are necessary to promote healthy food consumption, as the majority of consumers do so based on their preferences, though there is still a significant minority that resists change.

Food industry A wide range of food products are produced in Finland. The availability of processed plant-based alternatives rises and there is strong competition in food markets. Processing of food is targeted towards both global markets and domestic consumption of locally sourced food. Self-sufficiency in food products decreases due to reduced livestock production, and because not all plant-based substitutes are produced domestically. Raw materials are processed domestically due to an abundance of water and renewable energy. Bucking the international trend food trade remains buoyant, driven by the need to offset an otherwise significant downscaling of agriculture.

Agriculture and horticulture Farm size increases and family farms develop towards entrepreneurial farming companies. Agricultural producers are rewarded for delivering environmental benefits based on environmental values. Farmers are proud of their environmental credentials, with legislation allowing for diversity in local sustainable practices, producers are more appreciated and the acceptability of Finnish production is strengthened. Direct farm payments are replaced by agri-environmental and less favoured area payments, but only in part, with the overall level of farm payments decreasing. Some forms of livestock production are maintained, at least in less favoured areas, for biodiversity and cultural heritage purposes. Recognising this, some livestock subsidies are retained to maintain production while at the same time contributing to national food security.

Technology Production becomes more efficient through technological innovations in organic farming, biotechnology, automation and robotics. There are competence and learning challenges, such as the production of insect and plant proteins, vertical cultivation, biotechnology and risk management to counter new diseases and pests. Utilization of new technology is supported by training of agricultural producers. Imported energy is expensive, so there is a profitability incentive for self-sufficiency in energy.

Environment In areas of productive farmland, ecosystems prosper and are a source of recreation and well-being for citizens. On the other hand, since a large proportion of farmland is no longer required for livestock feed production, the need for farmland decreases. Sustainable intensification is at the core of agricultural production and in order to ensure resource efficiency smaller fields can become afforested. Productive fields are expensive and food production is valued. Construction on fields is regulated.

SSP3: Rocky road—Regional rivalry

International context Globally, a resurgent nationalism, concerns about competitiveness and security and regional conflicts push countries to focus increasingly on domestic or, at most, regional issues. There is a sharp decline of international cooperation, including cooperation within the European Union (EU), with increased food tariffs and food prices. The EU is a very weak player at global scale and has little effect on national policies. Land use change is only weakly regulated. Trends of increasing crop yield level off over time, due to little investment. Unhealthy diets with high animal shares and high waste become widespread. A regionalised world leads to reduced trade flows. Population decreases due to declining birth rates and reduced immigration.

Diet Protectionist policies prevail at the expense of the product range. Both the volume and diversity of imported food products decrease. Consumers find less choice and are confronted with high food prices and an increasing number of domestic products, not all of which are good substitutes for the imported ones. However, the basic nutrition needs of the population can be fulfilled, with a heavy emphasis on meat and dairy products. Policies are implemented to protect consumer interests and to guarantee food security.

Food industry A tariff-based and self-sufficiency focused agricultural policy strengthens the position of Finnish primary producers and the food industry in the food value chain. Cooperatives producing food for domestic consumers are successful. Declining population and demand and the protected domestic market reduce incentives for the industry to invest in or to compete with the existing product range. On the other hand, more costly imports and exports create an incentive to develop new domestic products to provide variety for consumers.

Agriculture and horticulture Increased prices of agricultural inputs drive farms towards domestic sources of fodder and energy. Profitability of long-term investments decreases due to decreasing domestic population and decreased access to capital. However, the position of farmers in the food chain is strong due to reduced imports. Horticultural production increases and crop production diversifies while imports decrease. The livestock sector remains strong. Adaptation to climate change is considered possible and likely in Finland, with high producer prices, domestic technology development and efficient use of domestic inputs increasing the adaptive capacity of farmers. Interactions between producers and the food industry are important for the marketing of food products. Agricultural policy is production-focused, at the expense of environmental degradation. Regional and environmental subsidies decrease and payments overall show a moderate decrease.

Technology Though there is an overall decrease in the rate of technological change, in line with global and European trends, technological developments are nonetheless encouraged to counter declining trade. Domestic technology development has a stronger role than today, substituting for imported inputs and techniques.

Environment Though the reduction of greenhouse gas emissions is accorded low priority, local adverse environmental effects remain in focus. Some current policy measures are kept in place to decrease nutrient leaching from agriculture to watercourses, but at a reduced level, and paid entirely from the national budget.

SSP4: Inequality—A road divided

International context There is a strong division between people living at higher and lower development levels, both between countries and between regions and communities within

countries. Purchases are based on wealth: an elite class eats high quality food; the large majority eats cheaper and poorer quality bulk products. There are opportunities for producers to respond to specific demands for luxury items by the elite class from a large number of small enterprises and networks. Economy is effective and globally connected and benefits the elite but not the poor and vulnerable populations.

Diet Policy-makers try to keep people satisfied by helping to ensure low prices of bulk commodities, whereas the elite class follows personal diets. Consumers use global brands. There are some policy measures promoting relatively healthy food diets, for the sake of societal stability and to counteract growing obesity, but this proves challenging for the majority of the population whose incomes are insufficient to purchase high-quality food. Unhealthy diets have significant adverse effects on public health and the national economy. The focus shifts from nutrition to control of food safety, through processing by heating, radiation and acid treatments.

Food industry Purchasers of agricultural commodities have a strong role in food chains and they decide on the production methods in agriculture. The industry is mostly owned by international investors who rely on market forces to drive farm production. Bulk food for the masses is prepared using mostly imported commodities. Farmers specialise in the production of ingredients for luxury foods. While Finland is not competitive in producing low-priced food, some special products are exported to elite classes in other countries.

Agriculture and horticulture Few crops are sufficiently high yielding in Finland that producers could produce at a price level demanded by the food industry, so there is specialization to products demanded by elites who can afford the high prices. Small farms specialise in direct sales to consumers, utilising technology to cope with the logistics of private orders. Large international companies occupy a major role in agricultural production for the masses, affecting policy as owners of Finnish firms.

Technology Large farms use advanced technology. This supports automation and robotics, requiring little labour and leading to unemployment in rural areas. Crop cultivars must be climate-robust, with special cultivars developed for high valued products. Various IT applications are used to promote healthy lifestyles, but diets are increasingly market driven.

Environment With reduced interest in environmental issues, especially in urban centres, environmental protection is not a political priority. Global issues like climate change are not discussed widely; only local ones raise interest, such as safeguarding the quality of watercourses and restrictions on land use. Environmental control of large productive farms is strict but there is little control on small farms, so with increasing misconduct, the role of reactive policies of control and sanctions increases. A large part of the country becomes depopulated wilderness, with some "no-go" areas populated by rebellious groups. Large areas of farmland are withdrawn from production. The elite classes are able to spend their free time in selected well-kept and secure environments.

SSP5: Fossil-fuelled development—Taking the highway

International context Trade in global markets is open and brisk. Fossil energy is relatively cheap. There is rapid development of technology and societal capacity as well as agricultural productivity. The vast majority of people eat low-cost food produced in various parts of the world. While the supply and demand of cheap imported bulk products increase, local food concepts allow for differentiation among food products. Food preferences are diverse, with personalised solutions and products. Food prices are low. Producers try to adapt through specialisation, increased scale or production efficiency. Multinational companies dominate food markets, though some local firms remain. International standards regulate food safety, but there is no national control and no food tariffs.

Diet Consumers come to trust imports and products of new technology, but local production is not favoured and hence limited. This situation does not support food security, though some consumer groups recognize the importance of well-being and healthy diets. It is difficult to make dietary recommendations to support health policy because of the fragmentation of preferences, so there is little influence on actual diets.

Food industry There is contract-based production by domestic firms for multi-national enterprises. These enterprises demand standard quality and quantities, which implies high levels of fertilisation and chemical crop protection. Policy supports the growth of domestic firms to become large global operators. On the other hand, some smaller domestic companies are also supported, to the extent allowable under international rules. A number of special domestic products succeed in the export market, whilst organic and local foods are regarded as luxury products. Little attention is paid to animal welfare and ethics in the mainstream—but there is also a place in the market for ethical production.

Agriculture and horticulture The production specialization of large farms results in a narrow range of domestic food products, though a small group of producers produce organic products or luxury items with on-farm processing. There are some exports of livestock products from Finland, and there is occasional high demand for Finnish commodities when extreme weather reduces yields in major production areas elsewhere.

Crop production shifts towards marginal products and the quantity of national crop production decreases. Since productivity growth is fast, agriculture becomes increasingly orientated towards the global market, while the role of EU subsidies declines. However, where allowable, domestic production is maintained using investment support. Consequently, the food sector is based on highly productive and specialised farms depending strongly on chemical fertilizers and pesticides.

Technology Different types of data are collected at all phases of production. With advanced enterprise resource planning, the development of primary production and industry are closely linked, and strongly steered by the refining industry's needs. Technology enables effective control over production and, together with international standards, maintains food safety. Automation reduces jobs and improves productivity.

Environment Climate warming progresses, introducing new opportunities for adapted food production in Finland, with northward expansion of farmland area due to a growing global demand for food. There is no public funding for ecosystem services, but some agri-environmental payments are used to eliminate negative local environmental effects. The responsibility of individuals and companies is emphasised while societal regulation is reduced. Policies on greenhouse gases are largely ignored in favour of trade policy and promotion of Finnish food industry exports, but at the same time there are strict environmental standards for water protection, since there is a common desire to keep the environment in better condition than in other countries. On the other hand, since overall agricultural policy (including decreased EU subsidies) favours food imports, this has the effect of outsourcing the negative environmental impacts of agriculture.

Minority views

In some cases, individual participants in a group challenged the majority view. For example, while it was largely agreed that a high proportion of consumers would prefer shifting to plant-based diets under SSP1, some individuals emphasised that there is likely to be significant resistance to change among certain groups, leading to increased diet segregation. The attainment of SSP1 objectives was also thought by some participants to require strong taxes on meat, controlled production and environmental measures. This is somewhat contrary to the global narrative, where consumer preferences are the major drivers.

Majority views on the global SSP3 narrative were also challenged by some participants from the perspective of energy production. If Finland needs to be largely self-sufficient in energy under SSP3, this is a considerable challenge that would also affect rural areas, farms and hence the food sector, but in ways that were poorly specified in the global or European narratives. Such questions, connected to cooperation and trade with neighbouring countries, require more consideration when constructing national-level scenarios for food and agriculture.

While most participants considered dietary recommendations and policy measures for promoting healthy diets necessary and likely under SSP4, some disagreed. They believed that such policy measures were incompatible with an increasing division between rich and poor. SSP5, the fossil energy growth narrative, provoked some contrasting views. For instance, in spite of rapid technological change, environmental protection was widely considered to be neglected. Here, some participants expressed a view that actual environmental outcomes depended largely on the effectiveness of technological solutions: efficient use of resources in SSP5 can also be considered good for environment.

Summarising the national food sector narratives

In order to provide a quick glance of the selected developments implied by the SSP narratives for the Finnish agriculture and food sector out to the mid-twenty-first century and beyond, Table 2 offers an interpretation by the author team of the four narratives: how the agri-food sector develops differently from the 2018 situation. Of course, judgements on individual entries may be subjective and other indicators might have been selected instead of these, but the aim here is to point the way towards possible quantification of the national narratives, should there be interest in doing so in future studies.

Discussion

The outcomes of the SSP workshop show that a diverse group of participants were able to grasp the main global SSP narratives rather well, reasoning out point by point what specific effects and adaptations or choices might be realised in Finland.

Aligning the narratives with multiple perspectives

Some current or past tendencies and trends of Finland's food sector show up repeatedly in stakeholders' responses. Numerous participants suggested that even under SSPs 3, 4 and 5, with the significant societal challenges for climate change adaptation and/or mitigation they implied, Finland would still try to achieve some level of environmental sustainability, at least higher than in most other countries. This indicates optimism that sustainability concerns would remain a high priority in Finland which would be hard to dislodge by other objectives.

An argument was put forward in several comments that farm subsidies of some kind would continue to be paid in the future for Finnish farms under all SSPs. Under SSP1,

Table 2 Summary of selected developments in the Finnish agriculture and food sector out to 2050 and beyond, organised by themes (see Table 1) with respect to the 2018 situation. Relative scores are subjective judgements by the authors based on the four SSP narratives described in the 'Results' section: L = low; M = medium; H = high. Arrows show direction of change from 2018. A-E is Agri-Environmental; GHG is greenhouse gas

	2018 situation[a]	SSP1: Taking the green road	SSP3: A rocky road	SSP4: A road divided	SSP5: Taking the highway
A. Diet					
Meat and dairy-based	M	↘	↗	↗	→
Plant-based	M	↗	↘	→	→
Health concerns	M	↗	→	↘	→
Sustainability concerns	M	↗	↘	↘	↘
B. Food industry					
Trade liberalisation	M	↗	↘	↗	↗
Foreign ownership	L	→	→	↗	↗
Market power	L	→	↗	↗	→
Export orientation	L	→	↘	↗	↗
C. Agriculture and horticulture					
Role of large farms	M	→	→	↗	↗
Role of small farms	M	→	→	↘	↘
Output prices	M	→	↗	→	↘
Input prices	M	→	↗	→	↘
Coupled subsidies[b]	H	↘	→	↘	↘
Decoupled subsidies[c]	H	↘	↘	↘	↘
Effectiveness of A-E policy	M	↗	↘	→	→
D. Technology					
Productivity[d]	M	↗	↘	↗	↗
IT utilisation	L	↗	→	↗	↗
New products and methods	M	↗	↗	↘	↗
E. Environment					
Agricultural GHG emissions	H	↘	→	↘	→
Water pollution	H	↘	→	→	↘
Biodiversity	M	↗	↘	↘	↘

[a] Judgements by the authors based on status of the Finnish agri-food sector in 2018 (Niemi and Väre 2019)

[b] Agricultural support payments coupled to production

[c] Agricultural support payments paid per ha irrespective of (i.e. decoupled from) production

[d] Productivity in crop and livestock production; relatively low crop yields but medium livestock yields in 2018

support is primarily in the form of agri-environmental and regional payments to encourage plant-based, ecological agriculture for domestic and foreign markets. Under SSP5 and SSP4, agricultural payments are decreased, but some are required to maintain the viability of a domestic sector forced to compete with low-priced imported bulk foods and experiencing reduced consumer demand for domestic foods. Under SSP3, subsidies are reduced but support for investments in production diversification and technology development is needed to increase domestic production to meet self-sufficiency requirements. The need for farm subsidies despite higher prices suggests that the participants do not believe productivity and competitiveness of Finnish agriculture would develop to a sufficient extent to allow farm subsidies to be fully abolished. This view can best be understood in the historical context of high production costs in Finland that have persistently exceeded market prices (Lehtonen and Niemi 2018). Since consumers are also hit by higher prices and reduced imports and product variety in SSP3, this prospect would imply a major welfare loss.

Comparison to other studies

There is a growing literature on attempts to develop regional SSP extensions for the agricultural sector. Methodologically, these range from exercises that were highly participatory to those conducted exclusively by researchers. Towards the participatory end of the spectrum, there are studies in which

stakeholders initially defined their own independent set of alternative development pathways, progressing from qualitative to quantitative specifications in a series of steps before only later attempting to map these onto SSPs. Examples for the agricultural sector include four regional scenarios for West Africa out to 2050 (Palazzo et al. 2017), and four scenarios for Southeast Asia quantified for use in economic and land-use modelling (Mason-D'Croz et al. 2016). However, in neither case is it readily apparent how compatible the final scenarios really are with their global SSP counterparts. This ambiguity is also noted by Kok et al. (2019), who comment on the lack of pre-existing guidelines for deciding whether similarities are sufficient to justify pairing scenarios with global SSPs. Standardised procedures for the scenario co-development processes could be designed but would necessarily represent a trade-off with the freedom necessary to engage stakeholders in a creative and deliberative scenario definition process (Hagemann et al. 2020).

At the other end of the spectrum, there are national or regional level SSP extensions undertaken largely or entirely by researchers, with little or no participation by stakeholders. For instance, researchers in one study quantified national food and agriculture-specific SSP-based scenarios for China through a combination of their own interpretation of the global SSPs and economic modelling (Wang et al. 2017). Similar examples include Dong et al. (2018) and Duku et al. (2018). Such approaches are understandable for the practical goal of fulfilling the quantitative input requirements of models. However, while they may produce outcomes highly consistent with global SSP narratives, knowledgeable stakeholders might still challenge crucial details of the resulting national or regional level SSP extensions. The involvement of stakeholders is generally needed to ensure the validity and credibility of the extended SSPs, particularly if they are to be applied for decision-making (Allan et al. 2018).

Stakeholder engagement is also integral to the development of Representative Agricultural Pathways (RAPs), which are interpretations of global-level SSPs prepared in the Agricultural Model Intercomparison and Improvement Project (AgMIP) for application in regions around the world (Valdivia et al. 2015; Rosenzweig et al. 2017). A 12-step protocol is employed for developing RAPs, with research teams working to draft narratives up to step 10. Stakeholder feedback is invited through a workshop at step 11 after which the RAPs are finalised at step 12. Practices of stakeholder engagement vary across studies, depending on the type of research, knowledge of the research team and capacities of the stakeholders (Antle et al. 2017; Valdivia et al. 2015). The protocol does not seem to prioritise stakeholders' input or demand a high level of consistency with the global SSPs; rather the RAPs are intended to provide an indication of the range of future conditions in a region for informing decision making through agricultural climate change impact and adaptation analysis (Rosenzweig et al. 2017).

There are few studies offering direct comparison to our results for Finland, which are specific to a small open economy at northern latitudes with harsh climatic conditions for agriculture. In this more localised context, there are few recent studies aiming to interpret global SSP narratives for the agriculture and food sector that explicitly analyse agriculture in Finland or in other Nordic countries and are methodologically positioned close to our approach. However, one that is close to our study in terms of method and regional context is Zandersen et al. (2019). They developed five narratives for future development in the Baltic Sea region consistent with the global SSPs, focusing on agriculture, wastewater treatment, fisheries, shipping and atmospheric deposition, which all represent major pressures on the coastal waters. They used a world cafe type workshop as the main means for deriving interpretations of global SSP narratives at regional scales, though with less detail for the agricultural sector than in this study. Nonetheless, the overall trends for agriculture in their narratives for the entire Baltic Sea region in general are very similar to those in this study, concerning interpretations for diet, technology and agricultural policy (Zandersen et al. 2019). Nonetheless, there are also differences in some detailed results. For example, under SSP5, Zandersen et al. (2019) indicate increasing agricultural production and reduced N and P use efficiency across the larger region, whereas this study suggests decreasing production and increasing nutrient use efficiency in Finland, implying reduced water pollution, an opposite outcome from the larger-scale study.

Mitter et al. (2020) applied a stakeholder-assisted protocol developed earlier (Mitter et al. 2019) to create five European-scale SSP storylines for developments in food and agriculture, summarising this using a table of trends for key variables similar to Table 2 in this study. In their study, storyline development was assisted by 105 stakeholders and experts from different parts of Europe (Mitter et al. 2020). However, the list of affiliations of the experts reveals that advocacy organisations, such as national farmer organisations as well as non-profit organisations dominated the group of stakeholders. There were few commercial firms represented, in contrast to the strong role these played in our study. Nevertheless, the findings of Mitter et al. (2020) show similarities with ours under different SSPs, though with some important exceptions relating to national level context. For example, their results suggest increasing direct farm payments in Europe under SSP3 while our study concluded, with strong stakeholder agreement, that direct payments will most likely decrease in Finland. This is because with a weak EU under SSP3, these would likely be replaced by other farm subsidies, such as national payments (which are more significant in Finland than in most other EU countries—Lehtonen and Niemi 2018) or by support for domestic technology development.

There are some features of the protocol suggested by Mitter et al. (2019) that the present study clearly follows, including wide stakeholder participation, researcher-driven facilitation of workshops, utilisation of the outcomes for consistent narratives and consistency checks and quality control. However, their protocol also specifies iterative consultations, which can be demanding for a large and diverse group of busy stakeholders working in senior managerial positions. Instead, we relied on intensive and replicated (parallel) workshop discussions, as well as stakeholders' oral and email feedback on the draft SSP-specific narratives, to ensure both their plausibility and consistency with the global SSP narratives. While discussion was lively and comments were presented on the summary narratives in the workshop, we received few comments by email after the workshop. This suggests that iterative consultations (Mitter et al. 2019) may not always be viable in practice, at least in the case of a large and diverse group of stakeholders, often in influential managerial positions. Instead, the importance of well-managed group discussions becomes decisive so that all participants should have a chance of expressing their views in written and oral form. The abundance of material collected in the workshop across all themes and issues (see supplementary materials) suggests that in this case, the proceedings were highly productive. Note also that more iteration is not ruled out in follow-up studies to refine the narratives presented here.

Local narratives can be highly sensitive both to the local context in which agriculture is practiced and to interpretations of some underlying assumptions. This can be illustrated with reference to the SSP1 narrative. It was largely agreed that the pathway towards sustainable agriculture in Finland would imply a significant reduction in all livestock production consistent with increasingly plant-based food diets and enhanced technological development at farm level. With more than 70% of farmland currently used for feed production, often with low crop yields, the reduced demand for feed crops along with higher crop yields would indeed suggest a substantially lower demand for farmland. This seemingly contradicts reasoning in an earlier European-wide project (Papadimitriou et al. 2019), where sustainability goals imply a need for environmentally friendly methods, and lower intensity production. In that study, livestock for meat declines but dairy production increases in Europe. In order to meet consumer demand whilst also reducing imports, production areas would expand in Europe, requiring additional land for arable and low-intensity grassland for dairy production. Hence, technological advances would not be sufficient to compensate for the requirement to expand the agricultural area, reasoning that seems plausible in a context where crop yields and fertilisation levels are already high and would decrease under SSP1. In contrast, under these assumptions, the demand for farmland could develop in an opposite direction in Finland than considered in some other EU countries, mainly due to the assumption that livestock production would decrease significantly in Finland in the SSP1 narrative. The significant reduction of cultivated farmland area in SSP1, also because of low productivity and competitiveness of plant-based protein crops (e.g. beans and other legumes), implies an unfavourable outlook for agriculture in less productive rural regions since much farmland would not be used in SSP1.

Overall, the similarity of many key outcomes between our study and the studies of Zandersen et al. (2019) and Mitter et al. (2020), which use a comparable participatory approach, offer grounds for confidence that our results are salient as well as being consistent with the global SSPs. Our assessment of plausibility is also founded on our analysis of the detailed stakeholder interpretations of the SSPs, and subsequent consistency checking against the global narratives.

Study limitations

Inevitably, there are certain limitations of the study that merit close attention and might offer scope for improvement in future analyses. First, a focus on the most important agricultural products and influential companies in value chains, and the concomitant under-representation of small- and medium-sized companies, and of lower and more marginal value chains (e.g. special crops of regional and local importance) clearly weakened the overall representativeness of all interest groups. However, given the large market shares of those interests represented, the outcomes still probably reflect dominant trends, though viewpoints from smaller concerns in different regions might have altered some outcomes. Including a more representative set of interests would have required a much larger workshop, exceeding the resources of this study.

A second potential weakness concerns the limited iteration with stakeholders. Participants had a chance to influence the consensus SSP narratives in the group sessions and final session of the workshop, as well as through feedback on summary narratives and in general following the workshop. However, few comments were received after the workshop, most concerning small details of the narratives. It is possible that significant modification of the results might have been triggered by additional face-to-face consultation, but the paucity of feedback on the narratives combined with relatively positive comments on the workshop organisation as a whole suggests general satisfaction and trust in the SSP narrative outcomes rather than any aversion or reluctance to provide further input.

A third drawback, pointed out by some individual workshop participants, concerned a perception that developments in the energy sector, and their likely impacts on agriculture under different SSPs, had been insufficiently addressed. The treatment was considered insufficient already in the introductory material based on published sources on SSPs in the context of agriculture. It refers to the role of agriculture both as a

user of different energy and different energy intensive inputs (e.g. fertilisers) and as a potential producer of energy. This is a highly valid critique, and it argues for urgent additional analysis of the connection between agriculture and energy in northern Europe, with its potential effects on the price of fertilisers and many other inputs as well as on rural land use.

A fourth limitation, unavoidable in exercises of this kind, concerns the reproducibility and hence robustness of the outcomes obtained. Even if a comparable workshop were to be organised again with the same participants, some differences in outcomes would inevitably result, given that the agricultural and food sector as well as its global operating environment are under constant change. However, there is reason to be confident that outcomes would still be similar, given the dominance of the most influential players in the sector. We have not tested whether two similar exercises conducted using samples of participants with other backgrounds would yield results that are either consistent with those obtained in this study or with each other.

Added value of this study

Overall, this study has generated relatively detailed SSP narratives for the Finnish food and agriculture sector that are designed to be consistent with background global and EU-level SSPs. It is the first national-scale, sector-based study of its kind to be conducted in Finland. The co-development process involved researchers and knowledgeable stakeholders with influence in key sectoral value chains. The configuration of moderated group sessions in the workshop was carefully designed to ensure diversity of stakeholder expertise across small groups. These groups interpreted the background SSP narratives across five themes and three perspectives as they could apply to Finnish agriculture. This novel structuring of the discussion was then carried forward into the analysis and summary of outcomes, which are presented in Tables S3.1–3.4 of the supplement. The tables show the anonymised contributions of the stakeholders, a variety of views that may be overlooked in the summarised extended SSP narratives prepared by researchers. Validation and consistency checks are necessary, but they may also "round off" important insights and uncertain issues. Both detailed and summary results are documented and include important minority views and critiques. Hence, decision makers and researchers in different organisations can now draw on these results as a point of comparison for considering how the agriculture and food sector might develop and change under future scenarios. Consistency with global scenarios is of particular importance for a country like Finland, as the study makes explicit how the world around us and various driving forces might shape the future of agriculture and food in a small country with very high and often immediate dependencies with the rest of the world. Such storylines also point to alternative capacities that could exist in the future for designing policies for coping with climate change, for example, in the context of the revised Finnish Climate Change Act and of the EU's new adaptation strategy as part of the European Green Deal.

Conclusions

Global SSP narratives portray future states of the world in terms of the main social, economic and technological drivers of development. Here, we have reported a stakeholder-assisted approach for interpreting the global narratives in a European and national context. In this way, we have derived four narrative descriptions of developments in the agriculture and food sector that aim both to be valid and consistent under the different SSP worlds and to be potentially applicable for climate change analysis in Finland. Our results include important critical remarks and minority views of the stakeholders, in addition to validated and consistent consensus narratives.

Some key findings in these narratives for Finland that offer a contrast to global and European narratives published elsewhere include:

- A greater emphasis on environmental quality than in most other regions of the world across all SSPs.
- In SSPs with significant shifts from meat and dairy to plant-based foods, farmland area could decrease markedly, with major implications for rural land use. However, a significant minority is likely to continue with livestock-based diets.
- Some agricultural subsidies, though reduced, would be needed under all SSPs to maintain production in Finland.
- Overall economic development and consumer choice would be jeopardised, possibly significantly, in SSPs with barriers to trade and high domestic food prices. Nevertheless, with additional efforts and resources, there are still opportunities, for domestic solutions in agriculture that diversify and increase production and successfully adapt to climate change.
- There are clear variations of trends in key elements of the agricultural system that emerge from analysing stakeholder perspectives, both within and across the SSPs (Table 2).

Stakeholder co-development of SSP extensions for Finland can offer validity to national and sectoral interpretations and reveal important uncertainties or deficiencies. Some opportunities for further elaboration include:

- Adopting and disseminating a set of national SSP extensions for the agricultural sector consistent with global SSPs could be beneficial for facilitating international comparison, both for research and policy.

- Quantifying the narratives for key indicators could facilitate their application in model-based scenario analysis. Iterative rounds of cross-checking the internal coherence of scenarios would be required for this.
- Constructing socio-economic scenarios for Finland's agricultural sector that extend beyond conventional planning time horizons could offer a valuable longer-term perspective for planning and policy making at national and regional levels (e.g. for land use, climate change adaptation and mitigation, sustainable development and food security).
- The approach we have outlined for extending SSPs in the agriculture sector, showing the contributions of the stakeholders, can be readily transferred to other sectors or systems.

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