Catalyzing Transformative Change:
Identifying Leverage Points for a Sustainable EU Agriculture

Master's thesis Governance of Sustainability Transformations

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Catalysing transformative change: identifying leverage points for a sustainable EU agriculture

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Abstract

As the world's leading importer and exporter of agri-food products, the European Union (EU) plays a key role in transforming global food production and diets sustainably. Addressing the urgent need for change in the EU's food system requires informing EU food governance approaches on leverage points, which are pivotal areas capable of inducing system-wide effects. This thesis identifies leverage points that can improve the sustainability of the EU’s agriculture, indicating where interventions should be prioritized at this first stage of the EU food system to catalyse transformative change. Through a literature review, factors contributing to the growth or decline of evolving trends in EU agriculture were identified and mapped. These trend maps were validated through semi-structured interviews. Utilizing social network analysis on the evolving trend maps, I identified factors which are the biggest influencers of these trends. This analysis was complemented by qualitative content analysis of semi-structured interviews, validating the maps and allowing experts to pinpoint leverage points. The findings offer a list of 12 factors ranging from different dimensions that could potentially serve as leverage points. These leverage points cannot be approached as ingredients of a recipe to cook sustainable EU agriculture. Instead, interventions at these leverage points should be in the light of adaptive governance, which is well suited to managing the complexity and unpredictability of EU agriculture. Subsequent research should delve deeper into identifying key actors who can intervene in these points and assess which are the most suitable levers to influence them to bring about sustainability.

Keywords: EU agriculture, leverage points, systems thinking, sustainability, transformative change and adaptive governance

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1 Introduction

1.1 The need to catalyze transformative change in EU agriculture

With a growing global population, the question that follows is: how can we satisfy the global food demand? This question not only pertains to food access, but also relates to environmental and health concerns associated with food production and consumption. In terms of health, about one-third of the global population suffers from malnutrition spanning from undernourishment to obesity. Regarding the environment, food systems account for one-fourth of anthropogenic greenhouse gas emissions and 70% of freshwater withdrawal worldwide (Lindgren et al., 2018).

Due to the prevalent malnutrition and adverse environmental impact of current food systems, organizations such as the EAT-Lancet Commission and IPES-Food are calling for transformations in food production and people's diets (IPES Food, 2021; Parodi et al., 2018; Willett et al., 2019). The European Union (EU) recognizes the environmental and health impacts of the current food systems and highlights the importance of satisfying the global food demand without jeopardizing the planet's and people's health (European Council & Council of the European Union, 2023c). As the biggest importer and exporter of agri-food products worldwide, the European Union (EU) has a pivotal role to play in transforming food production and people's diets to sustainably feed the growing global population (European Environment Agency., 2022).

The EU's commitment to transforming the food system is reflected in the Farm to Fork (F2F) strategy which aims to create a fair, healthy and environmentally friendly food system. The EU expects that the F2F strategy will reshape the EU's food system into one that ensures and promotes access to healthy diets while safeguarding planetary health (European Commission, 2020c). Despite the hope that this strategy may bring, some scholars (Alberdi et al., 2020; Duncan et al., 2020; Schebesta & Candel, 2020) have expressed concerns about the strategy's success in achieving its aim. They argue that the F2F strategy fails to address root causes of environmental and health challenges faced by the food system.

The urgent need for transformative change of EU's food system comes with the challenge of developing effective governance approaches to bring about such transformation. Governing the food system is already challenging due to the complexity of this system, involving synergies, trade-offs, multiple stakeholders, conflicting views, etc (Den Boer et al., 2021). Traditional policy responses, such as technological improvements, have shown limited effectiveness in addressing the challenges of the food system (European Environment Agency, 2021), as they primarily focus on adjusting the current system rather than challenging its foundations (Slater et al., 2022). Therefore, governance approaches in the EU should advance towards transformative change, embracing the complexity of the EU food system and challenging the unsustainable and unhealthy foundations of this system.

Exploring the concept of leverage points can offer guidance on how to catalyse this transformative change. This concept emerged in the field of systems thinking, which views the world as composed of highly interconnected systems. Unlike narrow thinking, systems thinking aims to solve problems by analysing the systems they are part of, rather than addressing them in isolation. Leverage points indicate where a small change yields a big impact on the entire and interconnected system (D. H. Meadows, 2008). By identifying leverage points in EU's food system, interventions can be strategically implemented in these places to promote system-wide changes that promote sustainability and health (Riechers et al., 2022).

The EU food system comprises a complex network of diverse and interconnected national and local food systems. The focus on the EU level is key because regulation, trade and financial resources of the EU food system, including agriculture, are decided and coordinated at this level (European Environment Agency., 2022). The EU food system encompasses activities and stakeholders spanning from food production to consumption. Agriculture stands out due to its high environmental impact and the pivotal role played by farmers, who are the backbone of EU self-sufficiency but also face huge challenges (European Commission, n.dc; European Environment Agency, 2023b). For these reasons, the scope of this master thesis is on EU agriculture as it plays a fundamental role in the broader context of the EU food system.

When considering optimal areas to ignite change, Birney (2021) suggests directing attention to areas where things are in motion, indicating energy for change. Following this recommendation, this research focuses primarily on identifying leverage points within the evolving trends of the EU agriculture. Trends are the evolution of clusters of important variables (Brons, A., personal communication, August 10th, 2023). These trends have been developing over the years, signalling the presence of energy to catalyse transformative change.

Besides the societal impact that this research brings by providing a list of candidates of leverage points, it has two main contributions to academia. First, this research contributes to the existing body of knowledge on leverage points in the food system (Dorninger et al., 2020; Malhi et al., 2009) by applying the concept of leverage points specifically to evolving trends within EU agriculture. To my knowledge, no research has yet been conducted on this topic. Second, an innovative aspect of this research is the combined approach of system maps and semi-structured interviews to identify leverage points and validate the results.

My master thesis contributes to task 2.2 of the PLAN'EAT Project, which is one of the projects funded under the Horizon Europe initiative to support research and innovation in the food system. The overarching goal of PLAN'EAT is to transform EU food system and food environments into ones that are healthy and sustainable (PLAN'EAT project, n.d.). Task 2.2 is dedicated to analyzing the underlying drivers that affect both overarching and specific trends across the four stages of the EU food supply: (1) food production, encompassing agriculture and aquaculture, (2) storage and distribution, (3) processing and packaging and (4) retail and markets. Building upon these insights, leverage points that can support a sustainability transformation are identified (Brons, A., personal communication, August 10th, 2023) Contributing to this task entails aligning the decisions and methodological approach with the task's description.

1.2 Research objective

This master thesis aims to identify leverage points that can improve the sustainability of EU's agriculture, indicating where interventions should be prioritized to bring about transformative change.

Please refer to Section 2.4 to understand how and why this thesis embeds health into sustainability.

1.3 Research questions

To attain the previous research objective, my MSc thesis will answer the following research question:

RQ1: Based on the evolving EU agricultural trends, what are the leverage points that can drive transformative change towards sustainability in EU agriculture?

1.1 What are the factors contributing to the growth and decline of the evolving EU agricultural trends?
1.2 Based on the factors contributing to the growth and decline of the evolving EU agricultural trends, which ones are leverage points?
1.3 What are the leverage points that experts identify within or outside the evolving EU agricultural trends?

1.4 Methodological approach

To answer these research questions, this study employed an exploratory research design with a mixed methods approach. The primary data collection methods included a literature review and semi-structured interviews. The literature review aimed to identify the first and second-order factors influencing the development of evolving EU agricultural trends. The findings from the literature review were visualized in subsystems maps. These maps were then validated and enhanced through the insights gained from the interviews. Data from the interviews was analysed using content analysis, a qualitative technique. Additionally, the validated subsystems maps were subjected to analysis using degree distribution measurements from Social Network Analysis, a quantitative technique. These two analyses were performed to identify leverage points.

1.5 Outline of the master thesis

This master's thesis is organized into 10 chapters. After this chapter, Chapter 2 offers definitions of key concepts and background information on the current sustainability status of EU agriculture. In Chapter 3, the conceptual framework explains systems thinking, leverage points, social network analysis, transformative change, and adaptive governance, as they are central to this research. Chapter 4 outlines the research methodology. Chapter 5 details the five evolving EU agricultural trends and factors influencing their development, addressing research question 1.1. Chapter 6 presents the identified leverage points based on the degree distribution measurements of the elements in the subsystem maps and the content analysis from the expert semi-structured interviews, addressing research questions 1.2 and

1.3. Chapter 7 discusses the results in the light of the conceptual framework and previous research. Chapter 8 concludes this thesis and provides recommendations. Additionally, there are the references and the appendix with supplementary research material.

2 Defining important concepts and background information

This thesis employs key concepts crucial for understanding the research; thus, these concepts are defined in this chapter. Additionally, to provide context about the current state of EU agriculture, this chapter concludes with the sustainability issues of EU agriculture.

2.1 EU agriculture and the Common Agricultural Policy

According to Oxford's Dictionary of Environment and Conservation, agriculture is defined as: "The practice of cultivating the soil, growing crops, or raising livestock for human use, including the production of food, feed, fibre, fuel, or other useful product" (Chris Park, 2007). Based on this definition, this research defines EU agriculture as crop and livestock production that occurs in EU member states. This definition excludes fisheries and aquaculture because of time constraints to include these activities in the scope of the research.

Agriculture, which covers about 40% of EU land, is a highly important economic sector, albeit with a large environmental footprint (European Environment Agency, 2020a). The EU is one of the leading producers and exporters of agricultural goods worldwide (European Union, n.db). However, as it is practiced today, it has a large environmental impact. Besides multiple detrimental consequences such as soil pollution and biodiversity loss, agriculture emits 11% of the total greenhouse gases of the EU and 54% of the total methane[1] emissions of the EU (European Environment Agency, 2023a). Section 2.4 presents more information about the environmental impact and sustainability issues of EU agriculture.

Agricultural policy at the EU level has a long history of over 60 years and is at the heart of the EU (Rossi, 2022). In 1957, the Treaty on the Functioning of the European Union (TFEU) established agriculture as a shared competence between the EU and the member states. Article 38 of the TFEU mandated the implementation of a common agricultural policy which was launched in 1962 (European Union, 2012). This agricultural policy is known as the CAP (Common Agricultural Policy) which is the main funding source of EU agricultural activities, corresponding roughly to one-third of the EU's total budget (Bradley & Pagnon, 2023).

Throughout the years, the CAP's objectives have changed and adjusted to society's needs. Article 39 of the TFEU stated the objectives of the CAP, which were mainly focused on increasing agricultural productivity and ensuring food supply at reasonable prices (European Union, 2012). This occurred in the context of a post-war Europe characterized by food shortages and low food production (European Council & Council of the European Union, 2023b). The newest CAP reform entered into force in 2023 and will last until 2027. This CAP has established ten key objectives which relate to environmental, social and economic aspects. While the first CAP did not include environmental goals (European Union, 2012), the newest one does, responding to the issues such as climate change and biodiversity loss (European Commission, n.da).

[1] Methane (CH_4) is a greenhouse gas with a higher warming potential than carbon dioxide (CO_2), which means that traps more heat while it is in the atmosphere (International Energy Agency, 2021)

The Common Agricultural Policy (CAP) stands as a key policy instrument facilitating the transition towards sustainable food systems, as envisioned by the F2F Strategy. It serves to encourage and support the sustainability efforts of European farmers, aiding them in combating climate change and safeguarding the environment. The recent reform to the CAP has integrated various sustainability measures, including eco-schemes, which offer new funding for farmers who voluntarily adopt climate- and environment-friendly practices and additional requirements for beneficiaries of the CAP's direct payments to comply with the so-called "Good Agricultural and Environmental Conditions" (GAECs) (European Commission, 2020b, 2023).

2.2 Farm to Fork Strategy

The EU has the ambition to become the first climate-neutral continent by 2050. The EU Green Deal comprises a set of policy initiatives to guide this transition towards neutrality (European Council & Council of the European Union, 2023a). One of these policy initiatives is the Farm to Fork Strategy (F2F Strategy), aimed at making the EU food system more sustainable, healthy, and fair. It responds to the need to address the sustainability challenges of the EU food system and recognizes the importance of having healthy people and a healthy planet (European Commission, 2020a).

The Farm to Fork Strategy was launched in May 2020, following the onset of the COVID-19 pandemic (European Commission, n.da). During this time, the food system encountered various challenges, including labour shortages due to movement restrictions, delays in food and agricultural input deliveries, and the closure of specific trade channels. These disruptions led to significant economic losses for farmers (Montanari et al., 2021). As a result of these consequences and the EU's commitment to carbon neutrality, the importance of establishing a robust and resilient food system became evident, emphasizing the need to transition towards sustainability.

Specific to agriculture, the Farm to Fork Strategy set four main targets by 2030:

1. Reduce both the use of pesticides and the nutrient losses to the environment by 50 %
2. Increase organic farming to 25 % of the EU's agricultural land.
3. Reduce by 20% fertilizer use.
4. Reduce by 50% the sales of antimicrobials for farmed animals and in aquaculture by 2030(European Commission, 2020a).

The F2F strategy has the potential to steer the EU food system towards sustainability, as pointed out by Schebesta & Candel (2020). However, the authors also emphasize that whether this potential would be fully exploited depends on its implementation. The strategy primarily serves as an agenda-setting function, and successful implementation will demonstrate how envisioned objectives and actions are translated into legislation (Schebesta & Candel, 2020).

Schebesta & Candel (2020) highlight four key challenges that the F2F Strategy needs to overcome for effective implementation.

Firstly, resolving the ambiguity of food sustainability, as the strategy does not provide a clear definition. This lack of clarity allows for multiple and contrasting interpretations by actors within the EU food system (Schebesta & Candel, 2020) .

Secondly, addressing the discrepancy between policy objectives and proposed actions. Some actions are deemed insufficient to achieve the stated objectives, while certain objectives lack corresponding action points (Cuadros-Casanova et al., 2023; Schebesta & Candel, 2020).

Thirdly, navigating the vulnerable institutional embedding within the EU. Tensions may arise between the various directorate generals of the European Commission due to differing priorities for the food system. Additionally, conflicts may occur also with the European Parliament stemming from divergent political viewpoints. Such discord over mandates and policy ideas can hinder inter- and intra-institutional cooperation necessary for a coherent and effective policy mix (Schebesta & Candel, 2020).

Lastly, ensuring coordination between the EU and member states. While the EU sets overarching objectives, state governments may not share the same level of commitment to the strategy, and how the strategy is implemented can vary between member states. Collaboration between the EU and member states is essential to prevent diluting the ambition of the strategy and achieve its objectives at the EU level (Schebesta & Candel, 2020).

2.3 Defining sustainability in the context of EU agriculture

Like transformative change, sustainability is a concept that has gained attention when addressing social and environmental issues. However, it often entails multiple and sometimes conflicting definitions (Sgarbi & Nadeu, 2023). So, what does it mean to talk about sustainability in the context of EU agriculture? Based on Sgarbi & Nadeu's (2023)definition of a sustainable food system, this research defines sustainable EU agriculture as the cultivation of a "safe, nutritious and healthy food of low environmental impact for all current and future EU citizens in a manner that itself also protects and restores the natural environment and its ecosystem services, is robust and resilient, economically dynamic, just and fair, and socially acceptable and inclusive. It does so without compromising the availability of nutritious and healthy food for people living outside the EU, nor impairing their natural environment (p. 21)".

This definition is quite extensive, covering multiple aspects that the following paragraphs will unpack. Sustainability, considered as a normative concept (Schmieg et al., 2018), delineates how a system should be and specifies the necessary actions to achieve it. Therefore, discussing the sustainability of EU agriculture naturally prompts questions about what is produced and how it is produced, aiming to assess whether the system aligns with its ideal state and, if not, what changes are needed.

Incorporating sustainability into EU agriculture involves aligning produce, farming methods, stakeholders, and outcomes with social, economic, and environmental sustainability dimensions. These three dimensions entail the following:

- Environmental sustainability: this dimension calls for agriculture with minimal environmental impact. Besides reducing its negative impact, it should also increase its positive impact by preserving and restoring the natural environment and advocating for practices that safeguard the ecosystems' capacity to sustain future food production. Additionally, it encompasses building resilience to environmental stressors such as extreme weather events.
- Social sustainability: the focus is on providing nutritious, safe, and healthy food which is socially acceptable and inclusive. It also ensures farmers´ safety (e.g., avoiding harmful substances or risky activities), and recognizes intergenerational responsibility to ensure food security for future generations.
- Economic sustainability: This dimension ensures that farming serves as a source of employment within rural communities, providing fair incomes for farmers and supporting financially viable livelihoods. Additionally, it aims to maintain food affordability for consumers, ensuring that sustainably produced food products remain economically accessible.

By addressing these three dimensions, EU agriculture can move towards a more sustainable future, benefiting both present and future generations while preserving the environment and promoting people´s well-being and economic prosperity.

Note that the definition of sustainability encompasses health and embeds it within the social dimension of sustainability. This research aims to integrate the concept of health into sustainability, as a combined approach in both areas is necessary. Consequently, starting from this section, whenever this document references sustainability, it inherently includes the health aspect. The following section elaborates on the connection between health and sustainability.

2.3.1 Health embedded in a sustainable EU agriculture

Experts have underscored the link between sustainability and health in diets, particularly on the consumption side of the food system, but this connection has not been sufficiently addressed on the supply side.(FAO & WHO, 2019; Kopainsky et al., 2020; Meybeck & Gitz, 2017; Willett et al., 2019). The focus has been mostly on reducing the consumption of animal products, which not only decreases the environmental footprint of agriculture but also promotes health. Increasing the consumption of plant-based products, such as legumes, improves not only people's health, but also that of agricultural ecosystems due to their benefits (e.g., nitrogen fixation and protection against soil erosion) (Willett et al., 2019). However, there is limited information available regarding the connection between health and sustainability in agriculture (Hawkesworth et al., 2010), indicating the importance of integrating health into the sustainability perspective of the supply side of food production.

Agriculture serves as a crucial source of nutritious food and medicinal plants, forming the foundations of healthy diets (FAO, 2023). The contribution of agriculture to people's heath can be analyzed from two perspectives: 1) what food is produced? and 2) how food is produced. These two perspectives are explained in the following paragraphs.

From the standpoint of what food is produced, agriculture should supply the necessary food to maintain healthy diets, offering a range of nutritious and safe products suitable for meeting the population's dietary requirements. The connection between health and agriculture relates to the physical factors influencing what is available for consumers to purchase.

Considering that the composition of global food supplies has become more homogenous in recent decades, revolving mostly around 12 crops (Hunter, n.d; Lachat et al., 2018), increasing farm biodiversity can be a pathway to support healthy diets for three reasons (Jones, 2018). Firstly, diversified farms can enhance the diversity of food products, consequently improving the nutrient adequacy of diets among smallholder farming households that cultivate crops for their consumption(Jones, 2018; Ricciardi et al., 2024). This aspect is particularly relevant among farmers who produce a limited variety of crops. Secondly, expanding the diversity of crops cultivated to include local and nutrient-rich varieties facilitates the access to nutritious food as they are adapted to local conditions and produced in proximity (Hunter et al., 2018). Thirdly, diverse farms can contribute to more varied food markets and reintroduction of underutilized crops[2], thereby expanding access to healthy and diverse foods, and fostering a positive impact on overall dietary choices and nutritional intake (Jones, 2018).

When considering how this perspective specifically relates to EU agriculture, it is important to recognize that EU agriculture has a comparatively weaker impact, as opposed to agriculture in low-income countries, on determining what is accessible to consumers. This can be attributed to two main reasons. Firstly, despite structural differences in farms among EU member states, most farms in Europe are commercial farms, which means that their primary goal is to generate income from their produce. They supplement their diet with both their produce and items purchased from food markets and retailers(McEldowney, 2019; Rossi, 2022). Secondly, the open EU market fosters a constant exchange of agricultural goods, allowing consumers to access food produced locally or overseas (Directorate-General for Agriculture and Rural Development, 2023b).

From the standpoint of how food is produced, it's crucial to prioritize both food safety and public health. Farmers should be vigilant in avoiding the spread of zoonoses or harmful bacteria that could endanger people's well-being. High-density animal farming systems can facilitate the emergence of new zoonotic diseases and increase the likelihood of serious contamination incidents. Moreover, the extensive use of agrochemicals in agriculture raises concerns regarding the potential health effects of prolonged exposure to low doses of chemicals, including those that may disrupt the endocrine system (European Public Health Alliance, 2022).

[2] Underutilized crops refer to domesticated or wild species adapted to local environments. They were traditionally cultivated, but throughout the years they were increasingly neglected by farmers and researchers as other crop become more commercial and monocultures with yielding varieties became widespread. Underutilized crops have remarkable nutritional and environmental benefits as they are a good source of micro and macro nutrients and more resilient to climate change (Li et al., 2020).

2.4 Current sustainability status of EU agriculture

The current agricultural practices in the EU predominantly prioritize economic aspects of sustainability. There's a strong emphasis on achieving short-term economic gains and growth while ensuring high levels of food safety. However, for agriculture to truly become sustainable, a fundamental shift is needed. This shift involves moving away from a narrow focus on productivity ("productivist view") towards a more holistic approach. This holistic perspective should encompass not only economic considerations but also the social and environmental dimensions of sustainability (European Environment Agency, 2023b) .

From an **economic perspective**, agriculture operates under the pressures of global competition, which often prioritizes maximizing production at the lowest cost, with little regard for social or environmental aspects. This emphasis on short-term productivity and profitability has led to a focus on efficiency-driven approaches aimed at boosting farm output (European Environment Agency, 2023b).

While these strategies have contributed to a notable increase in average farm income—rising by approximately 22% between 2007 and 2018 (Directorate-General for Agriculture and Rural Development, 2021a)—one must question who benefits the most from this growth. Are farmers truly receiving fair compensation for their efforts? EU farmers aren't reaping the greatest benefits from the food system. On average, their income lags behind that of other sectors of the economy. However, this income disparity can vary based on factors such as farming type, location, and farm size. While the Common Agricultural Policy (CAP) plays a significant role in supporting farmers' income through subsidies and direct payments, it still falls short compared to the average income of other EU economic sectors (Directorate-General for Agriculture and Rural Development, 2021a; Mondelaers et al., 2021).

From a **social perspective**, the EU agriculture has effectively prevented food shortages (European Council & Council of the European Union, 2024). However, it falls short in addressing broader societal challenges. These include the risk of food insecurity for future generations, gender inequalities, unfair working conditions of seasonal migrant works and lack of access to healthy eating for everyone.

The CAP and F2F strategy focus solely on the needs of current generations (European Commission, 2020a, 2023), disregarding how future generations will meet their needs and ensure food security. This disregard of intergenerational responsibility amplifies threats of food insecurity, particularly for upcoming generations. Environmental and geopolitical challenges like climate change and economic sanctions further exacerbate these risks, diminishing the EU's ability to provide sufficient, affordable, and adequate food for all its citizens (Fears, 2020).

Women face significant disadvantages in the farming sector, evident in the overall decline in their participation across member states. Despite this variation, statistics show that approximately 29% of farms in the EU are managed by women, who typically operate smaller farms compared to their male counterparts. Compounding this issue is the aging population of farmers, alongside a lack of interest among younger generations, especially women, in pursuing farming as a livelihood and career. The CAP recognizes the pressing need to address these challenges and allocates funds to support women entering the farming sector, aiming to narrow the expected widening gender gap in the future (Directorate-General for Agriculture and Rural Development, 2021b; European Institute for Gender Equality, 2017).

The working conditions for farm workers in the EU are far from ideal. EU farms heavily rely on non-national farm workers, often hiring seasonal migrant workers who face poor working and living conditions. Although both migrant workers and EU nationals are legally protected under EU law to ensure minimum working conditions, seasonal migrant workers are often exposed to harsh conditions and can be victims of gang-master practices or even modern forms of slavery (Augère-Granier, 2021).

While EU agriculture upholds high standards of food security in farming practices, it does not adequately address the issue of access to healthy food for low-income consumers. Regulations and monitoring processes effectively manage potential health risks, such as zoonoses, antimicrobial resistance, and pesticide residue. However, in terms of what consumers can access to have a healthy diets, affordability of healthy food products remains an obstacle.Penne & Goedemé,(2021) found out that the price of nutritious products continues to pose a significant obstacle for at least 10% of low-income consumers in 16 EU member states, thereby hindering their ability to adopt and maintain a healthy diet.

From an **environmental perspective**, agriculture contributes to the loss of biodiversity, climate change, and the depletion of natural resources using pesticides and over-fertilization. While these impacts are pronounced in farmland across the EU, they are also observed outside of the EU. For example, consider the environmental impact of feed produced outside the EU for feeding EU cattle. (Stummerer & Hablesreiter, 2023).

Agriculture heavily relies on factors like soil characteristics, weather patterns, and biodiversity, making it one of the socio-economic sectors most vulnerable to climate change. Extreme weather events, such as heatwaves and flooding, result in yield losses, livestock deaths, landslides, and soil erosion. Faced with these challenges, farmers not only struggle to maintain current practices but also find it challenging to invest in and experiment with new ones due to the associated risks. Farmers have expressed concerns about the difficulty in preserving soil quality, a challenge exacerbated by climate change (European Environment Agency, 2023b).

Soil health and biodiversity are crucial for sustaining agricultural production. However, despite their significance, the EU experiences an alarming average soil loss of 2.5 tonnes per hectare annually—a rate far exceeding the average annual soil formation rate of approximately 1.4 tonnes per hectare. This issue is particularly acute in arid regions of Europe, where soaring temperatures have transformed the soil into a dust-like substance. Consequently, its capacity to retain water diminishes and increases the risks of soil erosion, flooding, and nutrient runoff (Agovino et al., 2019; European Environment Agency, 2023b).

Despite the multiple issues mentioned above, agriculture also holds a unique potential to drive sustainability transformations in the EU food system. Covering about half of the EU's land, it can serve as a steward of the natural environment and people's well-being (European Environment Agency, 2023b). Sustainable agricultural practices can mitigate climate change by reducing greenhouse gas emissions, storing carbon, and enhancing biodiversity and ecosystem resilience (FAO, 2021). Additionally, agriculture can support rural communities and farmers by taking care of its landscape and livelihoods, ensuring good working conditions for farmers and fair payment. Furthermore, agriculture can contribute to people's health by providing safe and nutritious food over the long term (European Environment Agency, 2023b).

3 Conceptual framework

My master thesis draws on four conceptual fields to understand the sustainability transformation of EU's agriculture: systems thinking, leverage points. social network analysis, transformative change and adaptative governance. These concepts are explained in the following sections, including an overview of previous research on similar topics and applying the concept of leverage points.

3.1 Systems thinking to understand EU's agriculture

Systems thinking offers a lens to view the world. From this perspective, everything is interconnected as part of the entire system. A detailed explanation about systems will follow in upcoming paragraphs after introducing systems thinking. Instead of seeing aspects of society as isolated, they are parts of a system. Besides looking at the components of the system, this perspective also gives attention to the relationship between the parts which creates feedback loops (Sanneh, 2017).

Woodhill & Millican (2023) have summarized in the following statements what systems thinking entails:

- "Looking at situations from a holistic perspective (seeing the whole system).
- Understanding the key relationships shaping how a system behaves.
- Accepting the uncertainty and complexity of systems, and working in adaptive, flexible, and learning-oriented ways.
- Recognising that different people and different groups have legitimately different perspectives and see 'the system' differently (p. 8)."

Systems thinking has been used by scholars (Finegood, 2020; Knight et al., 2019; Lönngren & Svanström, 2016; Sunitiyoso et al., 2020) to understand wicked problems and thereafter devise solutions for them. Systems thinking is a suitable approach to understand complex societal problems such as unsustainable food production and unhealthy eating habits. This approach can unravel the underlying causes of these problems to address them, instead of focusing solely on the effects of these issues, which will ultimately not resolve them (D. H. Meadows, 2008; Seibert, 2018). Since the part of my research objective is to bring about transformative change to EU's agriculture, the systems thinking is a key conceptual lens because it embraces the complexity of this system and can indicate places where change must occur to have an impact in the entire system.

A prerequisite for understanding systems thinking is to first grasp the concept of a system. A system is a network of interrelated elements that are organized to fulfill a purpose. From the preceding definition, one can observe that a system comprises three key components: elements, interconnections, and a function or purpose[3] (D. H. Meadows, 2008). A system

[3] A distinction exists in the appropriate usage of the terms "function" and "purpose." "Function" is employed when referring to non-human systems, whereas "purpose" is used for human systems. However, many systems include human and non-human elements, such as the food system. Therefore, a clear-cut distinction does not always apply (D. H. Meadows, 2008). If the system includes human elements, I use the term "purpose".

can serve multiple purposes as long as they are shared among the system's interconnected elements (Jackson, 2003). Note that a system is not a physical object or aggregation of objects without a function and interlinkages. Instead, it is a way of thinking that helps make sense of the world (Seibert, 2018).

To better understand the concept of a system, consider agriculture as an example. The elements of this system are the various actors, including suppliers, farmers, and buyers, along with different activities such as sowing and selling agricultural inputs. These elements are interconnected because what buyers demand often determines what farmers cultivate. While a system's purpose is not always explicit, it can be inferred by observing its behaviour rather than relying on rhetoric or stated goals (D. H. Meadows, 2008). For instance, if buyers claim their goal is to reduce the food miles of their purchases but frequently opt for the cheapest products available regardless of the country of origin, then their true purpose may be to save money.

When discussing a system, it is crucial to define its boundaries. This is important because a system can contain subsystems while also being a subsystem of a larger system, which is the supersystem (See Figure 1) One can examine a system at different scales: local, national, regional, or international levels. Herein lies the importance of defining the system's boundaries (Seibert, 2018).

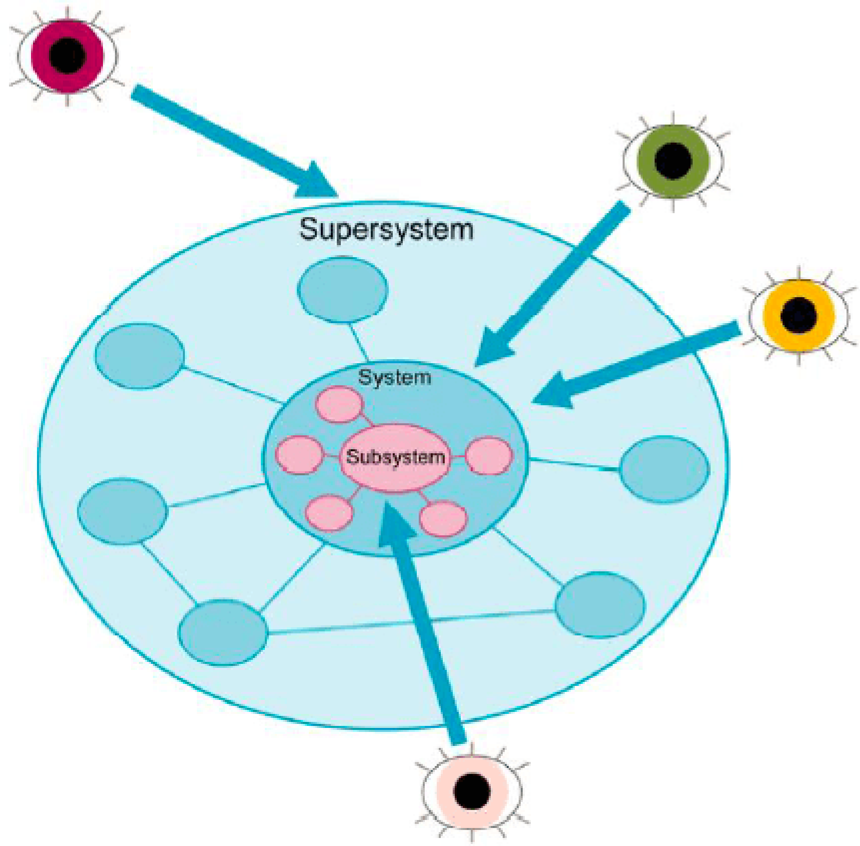

Figure 1 Illustration of how systems are embedded and interrelated to one another. A system has other systems around it, and they are integrated vertically in a hierarchy. The main system one is studying is called the system. Parts of this system are called subsystems, and the larger system that includes our main system is called the supersystem. The eyes represent multiple points of view on the system and how differently they can establish the boundaries of the system. source: M. R. Emes et al., 2012

In this research, adopting a systems thinking approach involves taking a comprehensive view of EU agriculture, akin to a 'helicopter view'. This perspective enables the identification of the components and interconnections within this system and its connections to other systems. EU agriculture is the primary focus of this research, hence the system of study. Specifically, this thesis delves into evolving EU agricultural trends (a subsystem of the EU agriculture system), which are simultaneously influenced by broader supersystems.

Systems are constantly adapting to changes which influence their behaviour. All three components of a system are essential and should not be overlooked. However, when it comes to changes, how and which components are influenced determines the impact on the entire system. Generally, if the changes concern the elements of a system, the effect on the overall system is minor, as long as the purposes or interlinkages remain unchanged. On the other hand, changes in the purposes or interlinkages have a bigger impact on the system (D. H. Meadows, 2008).

Building on the example of agriculture, if the farmers within the system are replaced by other people while the interlinkages or purposes remain intact, the system will undergo slight changes. However, if these new farmers introduce new interlinkages and purpose (e.g., adopting regenerative farming practices) then new elements, linkages, and purposes will emerge. This could include the introduction of cover crops, the establishment of contracts with suppliers of no-tilling equipment and the purpose of maintaining and enhancing ecosystems functions.

Systems can be conceptualized from two perspectives, depending on their aims. From a positivist perspective, systems are mapped to closely resemble reality, and based on this knowledge, one can identify suitable points for intervention. From a normative perspective, systems are designed to serve the accomplishment of certain objectives. Since this research aims to identify the leverage points in the system, I use a positivist perspective to conceptualize the agriculture system at the EU level (Von Braun et al., 2021)

Since systems are inherently complex, they are difficult to predict and control. When it comes to sustainability transformations, D. H. Meadows (2008) suggests 'dancing with the system'. Systems are dynamic and affected by multiple connections and feedbacks loops, which makes it impossible to know exactly how the system will look like and control every single outcome and activities within the system. Therefore, Meadow's invitation is to explore and learn from the system of interest before designing any intervention. For this reason, the first research question explores the factors influencing the development of the EU's agricultural trends before identifying leverage points within or outside these trends.

3.2 Application of Social Network Analysis to systems

Social Network Analysis (SNA) is a field of methods and theories rooted in both mathematics and sociology. At its core lies the concept of a social network, comprising a collection of actors interconnected through various relationships (Butts, 2008). These actors can range from individuals to larger entities such as groups, teams, political parties, or organizations. Rather than existing in isolation, these actors are part of a broader network, influencing and being influenced by others within the system (Yang et al., 2017).

A parallel can be drawn between social networks and systems. The actors in social networks are the elements of the system, and the connections between actors are the interlinkages between elements in a system. Both perspectives understand reality as made up of interconnected elements and use graphical representations to visualize and analyze it. Due to the similarities between systems and social networks, this conceptual framework draws on degree distribution measurements from SNA to analyse the system maps created for research question 1.1 and answer research question 1.2 (Please refer to Chapter 4 for information on the methodology).

Degree distribution measurements indicate the importance and role of an actor within a network (Hanneman & Riddle, n.d). In networks where the interlinkages are directed, meaning they point in one direction, two-degree distribution measurements can be calculated: in-degree and out-degree. The in-degree describes the number of incoming connections, while the out-degree describes the number of outgoing connections (Kiekens et al., 2022). An actor with a high in-degree is considered prominent, as other actors seek to make connections with them. Conversely, actors with a high out-degree are influential, as they can impact a large number of actors within the network (Hanneman & Riddle, n.d).

3.3 Transformative change

Although transformative change, also known as transformation, has been portrayed as the remedy for societal and environmental problems (O'Brien, 2012), it has simultaneously become a buzzword, leaving its meaning unclear. The lack of consensus on its definition is evident among numerous scholars and practitioners (Lidskog & Sundqvist, 2022; Linnér & Wibeck, 2019; Nelson et al., 2007; Pelling & Manuel-Navarrete, 2011; Pörtner et al., 2021; Termeer et al., 2017) .

To bring clarity on how this thesis understands transformative change, I use the definition from Patterson et al. (2017):"fundamental changes in structural, functional, relational, and cognitive aspects of socio-technical-ecological systems that lead to new patterns of interactions and outcomes (p.2)".

There are four key aspects to this definition. Firstly, it describes a form of change that transcends mere adaptation, involving the rearrangement of existing or new elements within a system in fundamentally novel ways. Secondly, it encompasses not only technological changes but also changes in social and ecological systems. This may include shifts in meanings, norms and values, as well as the reconfiguration of power structures and patterns of interaction (O'Brien, 2012). Thirdly, transformation often challenges the status quo, threatening those who benefit from current systems and structures. Fourthly, the call for transformative change implies that previous efforts have been insufficient and inefficient; "More of the same" is not a relevant cure (Lidskog & Sundqvist, 2022).

3.4 Leverage points for sustainable EU agriculture

Leverage points are a key concept in systems thinking, as they inform where to catalyze transformative changes within systems. These points function as strategic entryways for intervention, directing efforts towards areas where the most substantial impact can be achieved. By targeting these leverage points, the potential for inducing system-wide change is amplified (Leventon et al., 2021).

The origin of the leverage points concept can be traced back to Meadows in 1999 (Meadows, 1999). This concept arises as response to the following question: "how do we change the structure of the systems to produce more of what we want and less of that which is undesirable? (D. H. Meadows, 2008, p. 145)" Systems have sensitive places that, when altered, can change the systems' behavior. These sensitive places are leverage points (Fischer & Riechers, 2019).

Meadows provides a hierarchy of twelve leverage points, which were later grouped into four realms: material, processes, design, and intent. As depicted in Figure 2, these four realms exert different impacts on the system and lie on a spectrum explaining the reason for change in terms of causality or teleology. While causality explains the change based on cause-and-effect relationships, teleology does so based on the purpose it serves instead of the cause by which it arises (Fischer & Riechers, 2019).

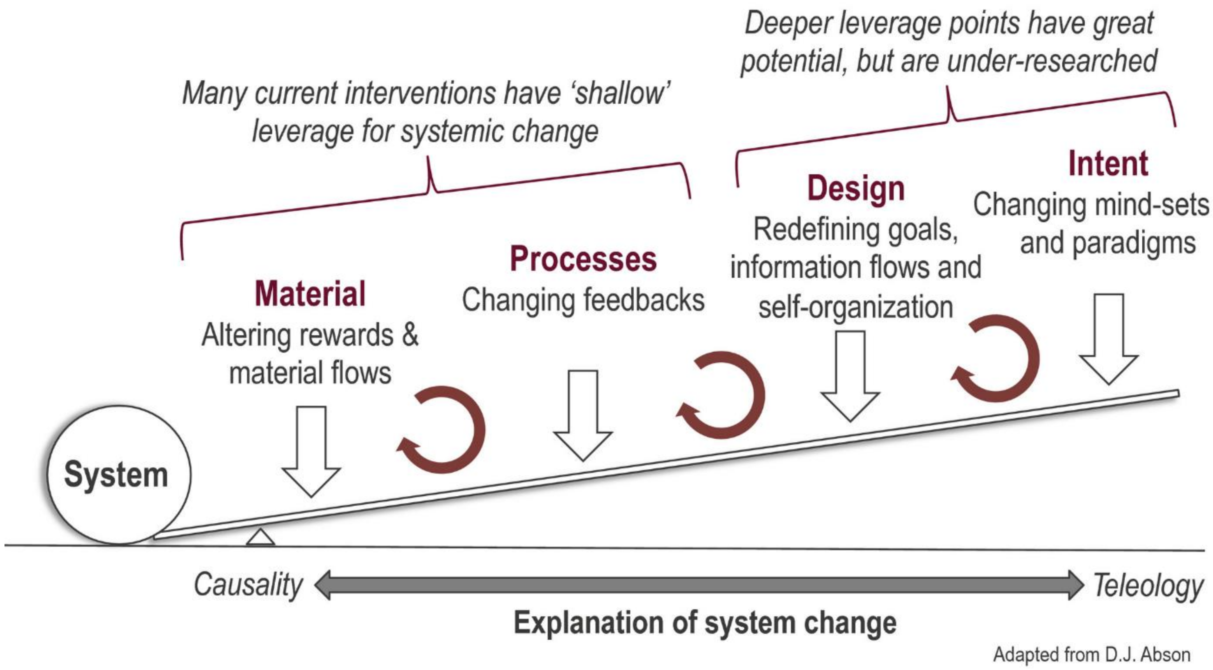

Figure 2 Illustration of the types of leverage points and their capacity to change the entire system. The round arrows indicate that these leverage points may interact with one another. Source: Fischer & Riechers, 2019

Not all leverage points have the same impact on the system. Depending on the system's components and properties affected by these leverage points, the impact on the system varies. Since the objective of this research is to identify leverage points, not to classify them in these four realms, I draw on a general distinction between shallow and deep leverage points. This distinction is done to discuss the impact of the leverage points identified in this research for the sustainability transformation of EU agriculture. Shallow leverage points, as the name suggests, have little influence on the system as they target superficial attributes of the system, such as material flows. In contrast, deep leverage points have a significant impact on the system as they affect the foundations of the system, such as mindsets and goals (D. Meadows, 1999).

As leverage points are embedded in a system, they influence one another as they are interconnected (see round arrows in Figure 2). Interventions at one leverage point ripple out to influence others. For instance, interventions at the system´s intent might substitute certain parameters with. However, substitution of parameters can also constrain or facilitate changes in the system's intent. (Fischer & Riechers, 2019; Jiren et al., 2021).

To drive sustainability transformations, Fischer & Riechers (2019) recommend integrating interventions at leverage points addressing causal and teleological explanations to maximize their impact. Solely focusing on causality misses the possibility of altering the system's purpose, which, as mentioned before, has potential to bring about system-wide change.

However, shifting the attention only to teleology lacks the concrete steps to translate the new system's purpose into action (Fischer & Riechers, 2019).

By strategically engaging with leverage points, it becomes possible to navigate the complexities of altering larger systems. Consequently, interventions at a small scale, such as EU agriculture, can influence broader systems, including the European and global food system. Leventon et al. (2021) asserted that transforming smaller-scale systems is a prerequisite for driving substantive changes in interconnected systems.

3.5 Existing literature on leverage points of the food system

This section serves a dual purpose. Firstly, it aims to present literature related to the thesis' research topic to enhance awareness of existing research and knowledge. To my knowledge, there is currently no literature addressing the leverage points specific to improving the sustainability of EU agriculture, underscoring the importance of undertaking this research. The selected articles employ the leverage points concept to address challenges or enhance the food system on local, European, and global scales. Secondly, this section aims to reflect on their results to highlight the importance of distinguishing between leverage points and levers.

To tackle antimicrobial resistance (AMR) within the EU food system, Lambraki et al. (2022) used a participatory approach for identifying leverage points. Using the insights gained from multi-stakeholder discussions, they created causal loop diagrams to pinpoint leverage points. The study identified three shallow and eleven deep leverage points for AMR interventions, following Meadows' framework. The only point related to agriculture was non-antimicrobial disease prevention and infection control in plant agriculture (Lambraki et al., 2022).

Following a similar methodology, Poelman et al. (2023) used a participatory approach to identify leverage points for healthy and sustainable local food environments. Using a causal loop diagram, the stakeholders identified several leverage points. These included the anti-lobby from food industry, food industry's willingness to change, Government/consumer priority on healthy food, food policy, e-commerce and platform economy, demand for healthy food and time to prepare/consume meals (Poelman et al., 2023).

With a broad scope on achieving global sustainability, Chan et al. (2020) employed an expert deliberation process to identify leverage points. Based on a literature review, they identified eight leverage points: (1) Visions of a good life, (2) Total consumption and waste, (3) Latent values of responsibility, (4) Inequalities, (5) Justice and inclusion in conservation, (6) Externalities from trade and other tele-coupling, (7) Responsible technology, innovation, and investment, and (8) Education and knowledge generation and sharing (Chan et al., 2020).

After reviewing the findings of Priefer et al. (2016) and Malhi et al. (2009), it appears that the authors may have confused the concepts of leverage points and levers. Their list of leverage points seems to align more closely with levers, as it prescribes actions (e.g., taxes and fees on waste treatment), whereas leverage points describe places in the system that can lead to system-wide effects (Chan et al., 2020). This research highlights the importance of both researchers and participants distinguishing between these concepts when researching leverage points. For this reason, I strived to uphold this distinction clear throughout my master's thesis research.

3.6 Governing the transformation of EU agriculture

The difficulty in predicting and controlling systems highlights that the governance of the sustainability transformation of the EU food system cannot be approached as a mere recipe book, where complete control over every facet is expected, nor can the complete appearance of this transformation be confidently predicted. This is particularly important in today's world as society expects quick and simple fixes to current issues. Actors involved in the governance of this transformation should be open to learn, be flexible and be capable of changing the course of action if needed (Nyamekye et al., 2018).

The nexus between leverage points and governance is key to advancing towards transformative change. While governments and formal institutions often craft plans and set goals, these alone are rarely sufficient to realize system-wide changes. Even though a clear destination exists, it is unclear how to reach there (Bolton, 2022). Leverage points represent points of power, as referred by D. H. Meadows (2008), for governance as they inform how to achieve these goals by indicating where change needs to occur. Equipped with this information, policymakers can make use of toolboxes such as the one presented by Parsons & Barling, (2021) to steer transitions towards a desired state (Mandl, 2023). Parsons and Barling's toolbox provides a variety of interventions applicable at the different stages of the food chain (e.g., agriculture, distribution and eating), suitable to be executed by both public and private actors. These interventions are compiled in toolbox, strategically grouped to enhance support for a common goal and coherence among them (Parsons & Barling, 2021).

While governments play an important role in governance, they are not the sole actors. Termeer et al. (2016) define governance as "the interactions between public and/or private actors ultimately aimed at addressing collective issues" (p.12). These issues are often embedded in complex socio-ecological systems, posing challenges to conventional governance approaches which are rigid and focused on solving the symptoms rather than the underlying causes. Consequently, novel governance modes have emerged as a response to effectively tackle these challenges and address societal issues (Nyamekye et al., 2018).

Adaptative governance is one of these modes, which highlights the value of incorporating adaptive capacity, collaboration, scaling, knowledge and learning (Nyamekye et al., 2018). At the core of adaptive governance are flexibility and learning-based collaborations between public and private actors involved in various levels of the systems. This governance model is well-suited for managing the complexity and unpredictability of systems. Adaptive governance encourages to learn constantly from the system and integrate this information into the governance tools and activities. With this solid foundation for actors to make informed decisions, adaptive governance stimulates the collaboration and coordination of actors in different yet interconnected systems to achieve common goals (Schultz et al., 2015).

When governing the EU agriculture's transformation towards sustainability, it is valuable to use this adaptive approach as it aligns with the inherent characteristics of complex systems, increasing the capability of achieving common goals. The concept of adaptive governance is used in the discussion chapter to reflect on the implications of the results.

4 Methodology

4.1 Research design

This master's thesis adopted an exploratory research design. This type of research design is typically employed for research topics that have received limited or no prior investigation (York, 2020). As mentioned in Section 3.5, the identification of leverage points to improve the sustainability of the EU's agriculture has been minimally explored. Consequently, this research design is deemed fitting, facilitating a detailed exploration to expand the body of knowledge on this topic.

To address the main research question and sub-research questions in this exploratory study, I employed a sequential mixed-method approach (see Table 1 and Figure 3). This approach enables the researcher to choose the methods that are best suited to answer the research questions from within or across the qualitative and quantitative paradigms and complement the strengths of diverse methods (Kumar, 2018). The selection of this approach was made to capture a richer picture of the leverage points from diverse methods.

Table 1. *Classification of the research components according to the paradigm they belong to*

Data collection method	**Paradigm**	**Data analysis method**	**Paradigm**
Literature review	Qualitative	Network theory measurements	Quantitative
Semi-structured interviews	Qualitative	Content analysis	Qualitative

Figure 3 illustrates the process and type of data collection and analysis methods employed by this research. The data collection process was qualitative and involved a literature review and semi-structured interviews. The data analysis process encompassed both qualitative and quantitative methods, incorporating content analysis as a qualitative approach and network theory analysis as a quantitative methodology. A sequential design was employed in which the results from the literature review served as input for the semi-structured interviews. This approach was adopted to triangulate and complement the findings, aiming to identify aspects of correspondence and discrepancy between the two sets of results. The next sections provide more information on how these methods were conducted.

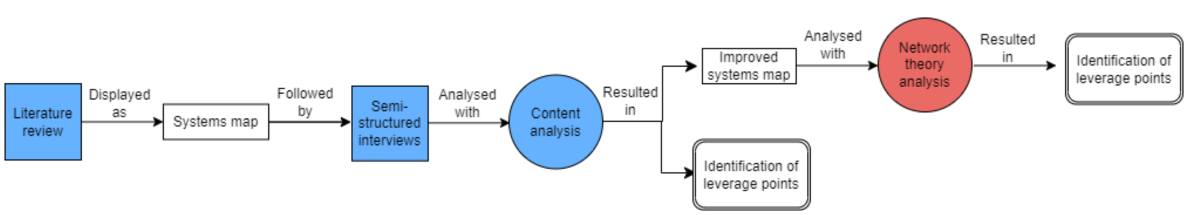

Figure 3 Flow chart of the research methodology highlighting the type of data collection and analysis methods. The figures in blue represent the qualitative paradigm. The figure in red represents the quantitative paradigm. The squares are the data

collection methods. The circles are the data analysis methods. The rectangles with double frames are the outcomes of the research. Source: author, 2024

4.2 Data collection

As mentioned above, the two data collection methods were a literature review and semi-structured interviews. The literature review aimed to identify factors influencing the development (contributing to the growth or decline) of evolving EU agricultural trends. The semi-structured interviews served the purpose of validating information gathered from the literature review and directly eliciting input from the interviewees to identify leverage points.

4.2.1 Literature review

To answer RQ 1.1 (*What are the factors contributing to the growth and decline of the evolving EU agricultural trends?*), I conducted a literature review. A literature review was suitable to answer these questions because one of its main purposes is to provide an overview of the knowledge on a specific topic (Snyder, 2019). I used grey literature and peer-reviewed articles to ensure that, if not all, most factors were captured during the search. The databases I used for retrieving literature were Scopus and Google Scholar. These databases were chosen because Scopus offers a wide selection of peer-reviewed articles, and Google Scholar provides a comprehensive collection of grey literature articles.

A Boolean search was performed for each evolving trend. The search string comprised [the name of the evolving trend in parentheses] AND (“driver” OR “obstacle” OR “factor”) AND (“EU” OR “Europe” OR “European Union”) AND (PUBYEAR > 2007 AND PUBYEAR < 2024). These search terms were determined based on the keywords from sub-research question 1.1. This literature search was conducted between September 6th, 2023, and November 3rd, 2023.

From the documents retrieved, I excluded those published more than 15 years ago, in line with the timeframe used in the literature search conducted by PLAN’EAT researchers to identify the main evolving trends in the EU food supply. In addition to the publication year criterion, other filters included relevance to the European Union or at least one of its member states, and the requirement that the factor influenced the trend of interest based on a relationship of causation, correlation, or theory-based association. The literature used in Working Package 2 of the PLAN’EAT project was also examined to filter relevant documents for this literature review, considering the above-mentioned criteria.

Only first and second-order factors were included in the literature review. First-order factors are those that directly influence the development of the trend. Second-order factors are those that directly influence the first-order factors. With the PLAN’EAT research team, we limited the degree of influence to this level due to time constraints, focusing on capturing the most important and relevant factors of each evolving trend.

After selecting the relevant documents from the literature search, a snowballing process was followed inspired by Geissdoerfer et al. (2017). The references of the sampled papers were reviewed to identify titles of papers that could be relevant to answering this sub-research question. This process involved checking whether these titles referred to the evolving trends in the European Union and were published no later than 15 years ago. Iterations of this process were conducted until no relevant documents were found (see Figure 4 for more information).

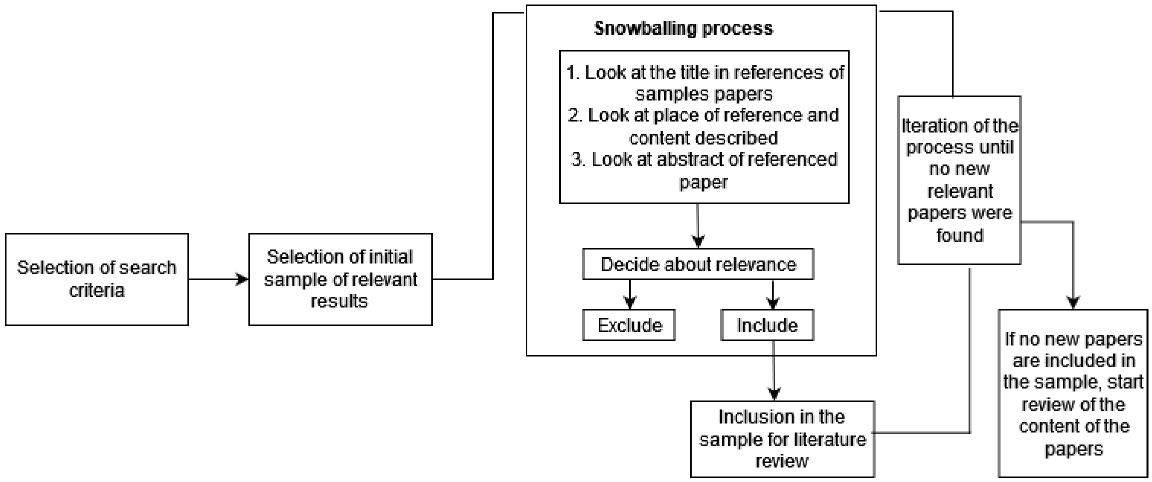

Figure 4 Flow chart of the process of selecting the sample of documents to review. Inspired by Geissdoerfer et al., 2017.

Based on the content of the final sample of relevant documents, a Word document for each trend was created, containing two tables (Please refer to Appendix I for an example). One table listed the first-order factors, and the other listed second-order factors. The table included the following columns: 1) name of the trend 2) name of the factor 3) effect of the factor on the trend 4) The dimension to which the factor belongs to 5) source from which the information was taken. The effect was represented with a minus indicating decline and plus indicating growth. The dimensions were taken from the food system conceptual framework developed by the High-Level Panel of Experts on Food Security and Nutrition (HLPE) in 2017.

Using the tables for each evolving trend, these factors were mapped into a systems map. The KUMU software was employed to develop a map providing an overview of the trends and their influencing factors in the entire EU food supply, along with maps for each of the evolving trends in EU agriculture. The arrows indicated the direction and type of influence and colours indicated the dimension to which the facto belongs to. Note that these subsystem maps are embedded in the EU food supply map elaborated for the task 2.2 of the PLANT'EAT project.

A system map is a tool used in systems thinking to visually represent the components of a system and interrelationships. In doing so, it helps to unravel the complexity of the system and offers a simplified understanding. This tool was chosen because one of its functions is to enable the identification of intervention points to facilitate the transition towards a desired state (Madden & Ohlson, 2020).

4.2.2 Semi-structured interviews

The semi-structured interviews had a dual purpose. The first purpose was to validate the sub-maps for each evolving trend, the factors identified and the type of influence. The second purpose was to answer RQ 1.3 (*What are the leverage points that experts identify within or outside the evolving EU agricultural trends?*). I conducted nine semi-structured interviews. They were online via Microsoft Teams, as this platform automatically generates a transcript. The interviews were audio and video recorded with prior consent from the interviewees.

The interview was semi-structured, providing a balance between clear guidelines to address our research questions and the flexibility to explore additional relevant topics. Please refer to Annex I to read the interview guide. This approach aims to yield insightful responses and allow for in-depth discussions (Kumar, 2018). The interview questions were developed with a member of the PLAN'EAT project and were refined after a pilot test with a few social science students and researchers.

This research adopted Von Soest's (2023) definition of experts as "any person who has specialized information on or who has been involved in the political or social process of interest" (p.278). This broad definition encompasses a wide range of actors, including scholars, policymakers, practitioners.

Based on this definition, the criteria to select the interviewees were the following:

a) in-depth knowledge and/or experience with EU agriculture and the CAP

b) work in an NGO, Think Tank, academia, policy making or farming

c) speak English.

Of the nine people interviewed, one was from an NGO, two from policymaking, one from a farmers' organization and five researchers. The researchers come from different EU countries to account for the diversity of this region. The interviewees were found through contacts of the members of the PLAN'EAT project and through Google search using the criteria above. They were contacted via email to inform them about my master thesis and invited to participate in the interviews. The interviews lasted approximately one hour.

Given that expert judgment is inherently personal (Von Soest, 2023), the PLAN'EAT research team opted to conduct interviews with experts from various sectors to broaden the sample and incorporate diverse perspectives. The selection of interviewees took into account potential information gaps and biases, following the recommendations of Von Soest (2023). To ensure a balanced representation, the inclusion of both inside and outside experts was a crucial criterion. Inside experts, directly involved and active in the field, provided firsthand experience, while outside experts, detached from the subject matter, acquired their knowledge through research and interaction with these insiders (Von Soest, 2023). As part of this approach, an inside perspective was offered by a farmer and policymaker, while outside expertise was contributed by an NGO policy analyst and researchers.

The interview was structured into three sections (see Annex I for more information on the interview guide). The first section aimed to understand the interviewee's positionality on the topic. The second section focused on validating the system maps that were created. The questions in this section were centred around the factors and interactions depicted in each of the subsystem maps. Initially, the interviewees observed and were walked through the map created by the PLAN'EAT research team, illustrating the evolving trends of the entire food system. Subsequently, the maps for each of the evolving EU agricultural trends were presented, and the corresponding questions were posed. The interviewees received the maps in advance, giving them time to familiarize themselves with the content. The third section was designed for the interviewee to identify leverage points, whether depicted or not in the maps.

4.3 Data analysis

The two data analysis methods were qualitative content analysis and social network analysis. The first analysis aimed to validate the maps created based on the literature review and capture the leverage points identified by the experts. The distribution measurements from social network analysis aimed to identify the leverage points based on the maps for each evolving trend by calculating out-degree and in-degree values for each of the factors in the map.

4.3.1 Qualitative Content Analysis

The interview transcripts were reviewed to generate a two-page summary for each interview. Refer to Annex I for instructions on the summary. Essentially, the summary had to contain the modifications suggested to the maps by the experts and the leverage points they identified. When the transcript was unclear, I listened to the recording to verify the information. The process followed a deductive coding approach, as predefined interests were defined to analyse relevant passages in the transcripts (Sheppard, 2020). The coding was done manually.

I examined the aspects identified by the experts as potential leverage points, distinguishing between references to a 'leverage point' and a 'lever.' In certain instances, the experts described actions to be taken (lever) rather than identifying where one can influence the system for the most significant impact (leverage point). Only the identified leverage points were considered as results.

4.3.2 Social Network Analysis: out-degree minus in-degree

Social Network Analysis (SNA) offers valuable methodological tools, such as degree distribution measurements, for analysing graphic representations of networks. These tools are applicable to subsystem maps, facilitating the identification of leverage points (Williams & Hummelbrunner, 2011). To answer RQ 1.2 (*Based on the factors contributing to the growth and decline of the evolving EU agricultural trends, which ones are leverage points?*), degree distribution measurements were calculated for the subsystem maps of EU agricultural trends after being refined with insights from the interviews. These measurements pinpoint the best-placed actors to contribute towards a certain goal based on their interactions and position in the network (Buckingham et al., 2018). The factors' position and connections were used to identify which are the main influencers of these trends, serving as an indication of leverage points.

Inspired by the methodological approach of Kiekens et al., 2022 to identify leverage points in causal loop diagrams, I used the KUMU software to perform a SNA and calculate the in-degree and out-degree measurements of all the factors in the five subsystem maps. Please refer to the conceptual framework for an explanation about the similarities between social networks and systems, as well as the degree distribution measurements. The higher the in-degree, the more the factor is influenced by other factors in the system. On the other hand, the higher the out-degree, the greater influence this factor exerts on the rest of the system. Identifying factors with a high out-degree value and low in-degree value indicates a list of good candidates for leverage points in the system, as they impact several parts without being influenced by many others (Kiekens et al., 2022). For this reason, the in-degree value was subtracted from the out-degree value, and the factors with the highest result were identified as the leverage points.

4.4 Limitations

This section reflects on the two main limitations of the methodology. Please refer to Chapter 7 for a more comprehensive reflection on the research limitations and suggestions for future improvements.

Firstly, I was only able to access English sources and interview English speakers. The EU embraces multiple languages besides English, and I might be missing information from other scholars who do not publish in English. Therefore, certain perspectives might be under-represented.

Secondly, the systems maps offer a simplified representation of EU agriculture, which presents three shortcomings. First, although they capture overarching trends within the EU agriculture system, they fall short in encompassing its entirety. This choice stems from a strategic decision to prioritize areas with the highest potential for change – working with elements already in motion, aligning with Birney's (2021) criterion for intervention points. Second, the system's boundaries at the EU level may cause the maps to overlook specific factors unique to individual member states. Third, while the systems maps serve as a tool to identify leverage points, it mostly indicates leverage points based on causality instead of teleology, as the maps were created based on causal-effect and correlation relationships between the factors and the trends. Figure 3 illustrates that causality-based leverage points often fall within the spectrum of shallow interventions. To address this limitation, questions 8, 9 and 10 of the semi-structured interviews (see appendix I for interview guide) specifically inquire about leverage points to enhance insights and provide a more comprehensive list of leverage points.

5 Factors influencing the development of evolving EU agricultural trends

During the first part of task 2.2 the PLAN'EAT research team identified five main evolving trends in EU agriculture. The following sections will explain these five trends, setting the stage for a more detailed exploration of the factors influencing their development afterwards. This exploration of the factors provides an overview of the multifactorial and multi-dimensional nature of these trends but does not aim to delve into each individual factor and its relationships, as doing so would elongate this report without significantly contributing to the research objective of identifying leverage points.

5.1 Loss of agricultural farms

The first trend is agricultural land abandonment. According to Keenleyside & Tucker (2010), agricultural land abandonment is the "complete withdrawal of agricultural management such that natural succession processes are able to progress" (p.4). This trend is frequently observed in the decreasing number of extensively managed and small-scale farms. The impacts on biodiversity can either be positive or negative depending on the context (Keenleyside, C and Tucker, G M, 2010). Examples of positive outcomes include ecological restoration and forest regrowth (Ustaoglu & Collier, 2018), while negative outcomes may include increased wildfire risk and the loss of species adapted to agricultural environments (Leal Filho et al., 2017).

During the interviews, there was confusion about the interpretation of this trend. Several interviewees (ID 1, 2, 6, 7, 8) argued that abandonment does not happen to a large extent in Europe. Instead of using the term "abandonment," they suggested focusing on the loss of agricultural land due to its conversion for alternative purposes or the increasing number of small farms acquired by larger farms. After reviewing these suggestions, I decided to rename this trend as the loss of agricultural farms. This is a broader term that includes: a) land left unused, allowing natural succession processes to take over; b) agricultural land transformed for other purposes such as afforestation and urbanization, and b) reduction in the number of farms, particularly small-scale farms.

The extent of farmland abandonment in the EU remains unclear. While some authors (Estel et al., 2015; Renwick et al., 2013) mention it is widespread phenomenon, Eurostat acknowledges that while the number of farms has decreased between 2005 and 2020, the total agricultural land remained steady. Some of the difficulties in quantifying farmland abandonment in the EU result from the diverse definitions of land abandonment and the lack of data. However, it is known that the extent of abandonment varies temporally and spatially across the EU (Keenleyside & Tucker, 2010). For instance, Spain and Poland are the member states projected to have the greatest agricultural abandonment in the period 2015-2030.

Despite disagreements regarding the extent of farmland abandonment in the EU, it is evident that the number of farms has decreased over the years. Between 2003 and 2016, approximately five million farms disappeared, with the most significant decline observed in small farms (less than five hectares). Simultaneously, the number of large farms (more than

50 hectares) increased by 7%. This trend is anticipated to persist into the future, with a projected additional loss of 6.4 million farms by 2040. These values illustrate a pattern of farmland concentration over the years (Lecarte & Negre, 2020).

Agricultural farms are also lost because the land is used for other purposes, such as afforestation or built-up environments. Afforestation is the long-term conversion of non-forested land into forest. The forest land can be managed for timber production, nature conservation or as a climate mitigation strategy. Afforestation is an alternative to farmland. More than 10 million hectares of former cropland have been converted into forests with the support of EU subsidies (Wang et al., 2023). Additionally, with rapid urbanization, farms close to urban areas have been under pressure to be transformed for various purposes. This land is repurposed for built-up environments or non-productive rural activities such as recreation and horsekeeping (Grădinaru et al., 2015).

Box 1

How to understand EU agricultural trends maps.

As I am about to refer to the first subsystem map of a trend, I will first explain some features common among the subsystem maps of the five trends to facilitate their understanding. On the left side of the maps, you find the legends. The arrows with solid lines imply a positive influence, indicated by a plus sign (+). In systems language, this positive influence means that the factor contributes to the growth of the other. The arrows with dashed lines indicate a negative influence, noted by a negative sign (-), suggesting that the factor contributes to the decline of the other factor. Arrows with a red solid line indicate that the influence can be either positive or negative, meaning that the factor can contribute both to the growth and decline of the other factor. These red arrows have no sign. The direction of the arrows indicates which factor is influencing and which one is being influenced. The colour of the factors represents the dimension to which they belong. For instance, a blue factor belongs to the political, economic, and commercial dimension. Factors shaped like triangles are exogenous, meaning that they are not influenced by any other factor in the entire map of the EU food supply. The black diamonds correspond to a trend. The black circles in Figures 8, 11 and 12 represent overarching trends that influence agricultural trends but also other trends in other stages of the EU food supply. Factors with a larger size indicate those with a higher number of connections either incoming or outgoing. Factors encircled in black correspond to factors added based on the interviewees' insights.

Loss of agricultural farms

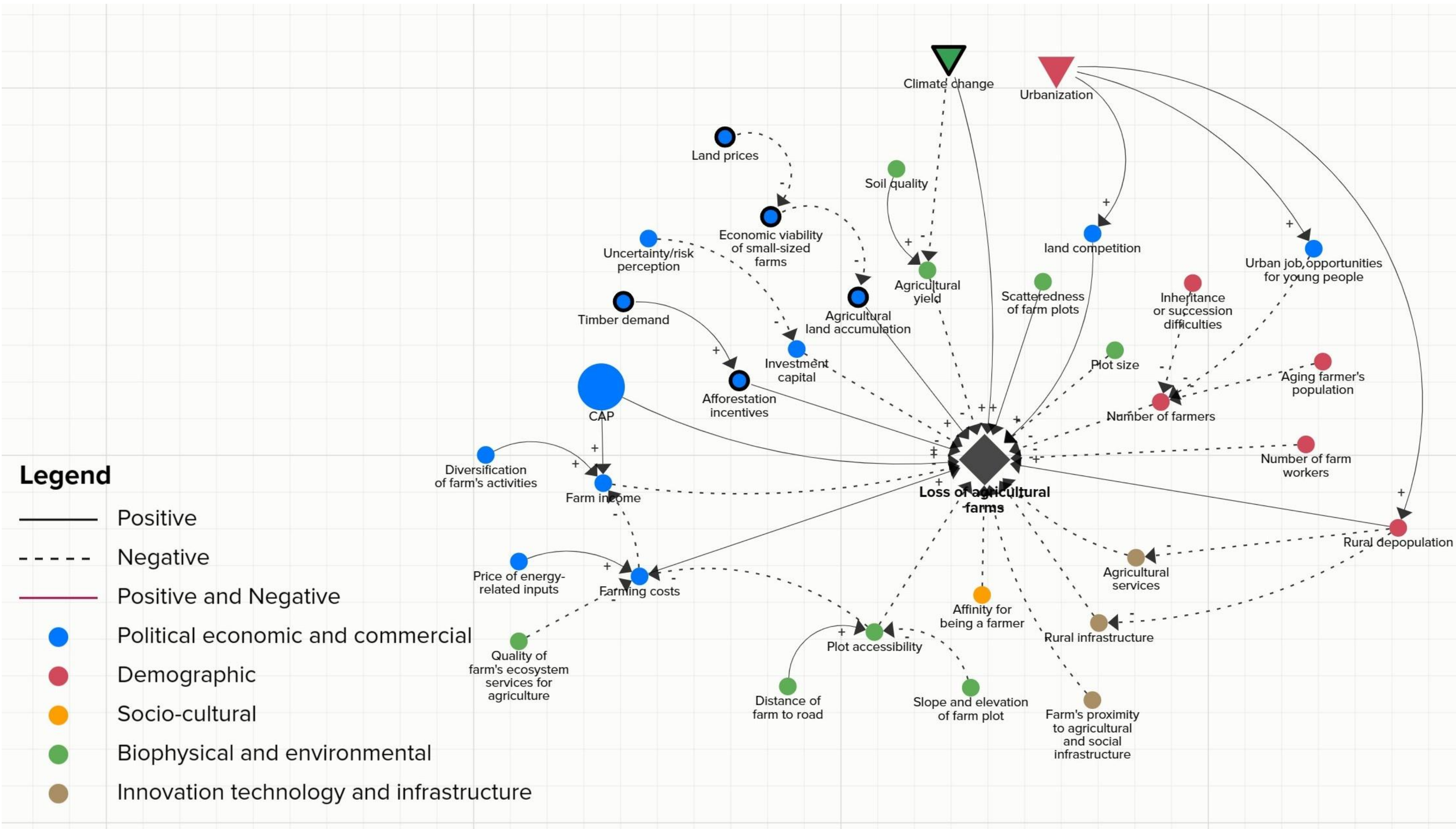

Figure 5 Subsystem map illustrating the factors influencing the of loss of agricultural farms and the relationships between them. Source: author, 2024

After exploring the features of the subsystem maps, I will explain the main aspects of the loss of agricultural farms map (see Figure 5). At first glance, it's evident that multiple factors influence it across five dimensions, with the socio-cultural dimension being the least dominant. This trend is influenced by two exogenous factors: climate change, categorized under the biophysical and environmental dimension, and urbanization, which falls within the demographic dimension.

Climate change directly impacts this trend by making farming more challenging because of the unsuitable conditions it creates for cultivation and raising livestock, such as water shortage and heat waves. These conditions result in lower agricultural yields (Fayet & Verburg, 2023). For instance, when cultivation costs are high and the crop yield is low, farmers are more likely to abandon the land (Gellrich & Zimmermann, 2007).

Urbanization influences this trend by impacting variables within the demographic dimension but also in the political, economic, and commercial dimension. For example, the growth and concentration of population in urban areas increase the demand for land used for other purposes than farming, such as recreation or residential development (Perpiña Castillo et al., 2018). Additionally, rural-to-urban migration reduces the rural population, resulting in fewer farmers and agricultural workers. With a larger portion of the population now residing in urban areas, economic growth and job opportunities become concentrated there, offering young people better prospects in urban environments compared to rural areas (Keenleyside & Tucker, 2010).

The factors in the innovation, technology, and infrastructure dimension indicate the importance of rural infrastructure and agricultural services. The more and better the infrastructure, the less incentive there is for farmers to cease farming (Pointereau et al., 2008). In addition to their presence, the proximity of this infrastructure to the farm is crucial. The farther away it is, the less accessible it becomes for farmers, increasing the likelihood of them discontinuing their activities (Terres et al., 2015).

In the biophysical and environmental dimension, several factors highlight how a farm's characteristics influence the loss of agricultural farms. For example, accessibility plays a crucial role, determined by the farm's distance from the nearest road and the feasibility of using machinery based on the plot's slope and elevation. Plots situated in mountainous areas often pose challenges for mechanization. Furthermore, farms comprised of multiple scattered plots present difficulties for farmers, as they must travel longer distances between them, impeding efficient care and management (Gellrich & Zimmermann, 2007; Pointereau et al., 2008).

Another significant aspect is the quality of ecosystem services within the farmland which impacts the costs of farming. Higher-quality services bring benefits to farmers, reducing costs that would otherwise arise from degraded ecosystems. For instance, soil with good water-holding capacity proves invaluable, particularly in summer, as it mitigates water shortages, reduces the need for irrigation, and minimizes the negative impact on crop yields. This underscores the dual benefit of environmental stewardship, where preserving the environment not only safeguards natural resources but also yields economic advantages for farmers (Keenleyside & Tucker, 2010)

Regarding the political, economic and commercial dimension, factors indicate that financial and policy considerations play a key role in the loss of agricultural farms. The increasing prices of energy-related inputs, notably influenced by the conflict in Ukraine (Caprile & Pichon, 2022), adds up to the economic challenges faced by farmers. These higher costs not only strain farmers but also lead to diminished income, intensifying their struggles to remain economically viable (Keenleyside & Tucker, 2010).The CAP recognizes that farms facing natural constraints, such as slope or elevation, experience lower income. Therefore, it provides payments specifically for these farms, known as Areas with Natural Constraints (ANC) payments. These payments aim to compensate for the difference in income and costs between land under constraints and non-constraint land (Directorate-General for Agriculture and Rural Development, 2023a). Additionally, diversifying activities can help mitigate financial risks by offering farmers multiple revenue streams and improving overall profitability (Terres et al., 2015).

Investing in farm improvements is a key factor in reducing the likelihood of losing agricultural farms. These investments can encourage farmers to continue their activities, leading to improved performance and benefits. However, farmers are often less inclined to invest when uncertainties are high or when they encounter significant investment risks (European Commission, 2018, 2023). Interviewee six mentioned that climate change further heightens their risk perception due to its negative influence on farming.

When it comes to farm loss caused by afforestation, economic incentives motivate farmers to convert their land into forests, with the demand for timber being a primary driving force for such conversions (Wang et al., 2023). Additionally, the decline in the number of agricultural farms is often linked to the high fixed costs that outweigh the revenue. According to Interviewee 2, the economic viability of small-sized farms is compromised as their costs exceed their revenue, with their produce unable to sufficiently compensate. High land prices, which farmers must pay for access, represent a significant financial burden.

5.2 Agricultural intensification

The second trend is agricultural intensification. Definitions of this concept vary greatly, with some of them being vague or imprecise (P. C. Struik & Kuyper, 2017). According to Eurostat (2023), intensification is “the process of increasing the use of capital and labour (e.g. fertilisers, pesticides, machinery) relative to land area, to increase agriculture production per hectare” (para. 1). This is the definition adopted to characterize this trend and identify the factors influencing its development.

In Europe, agricultural intensification has played a significant role in meeting the growing demand for food (European Environment Agency, 2023b). Although it is associated with high yields, this approach often comes at environmental costs. The effort to enhance farm productivity involves intensive land management and increased input usage. In the pursuit of efficiency and higher yields, agricultural landscapes are simplified, resulting in a loss of biodiversity and soil health (Altmayer, 2016) Unfortunately, short-term benefits appear to be prioritized over the long-term health of ecosystems (European Environment Agency, 2023b).

Agricultural intensification

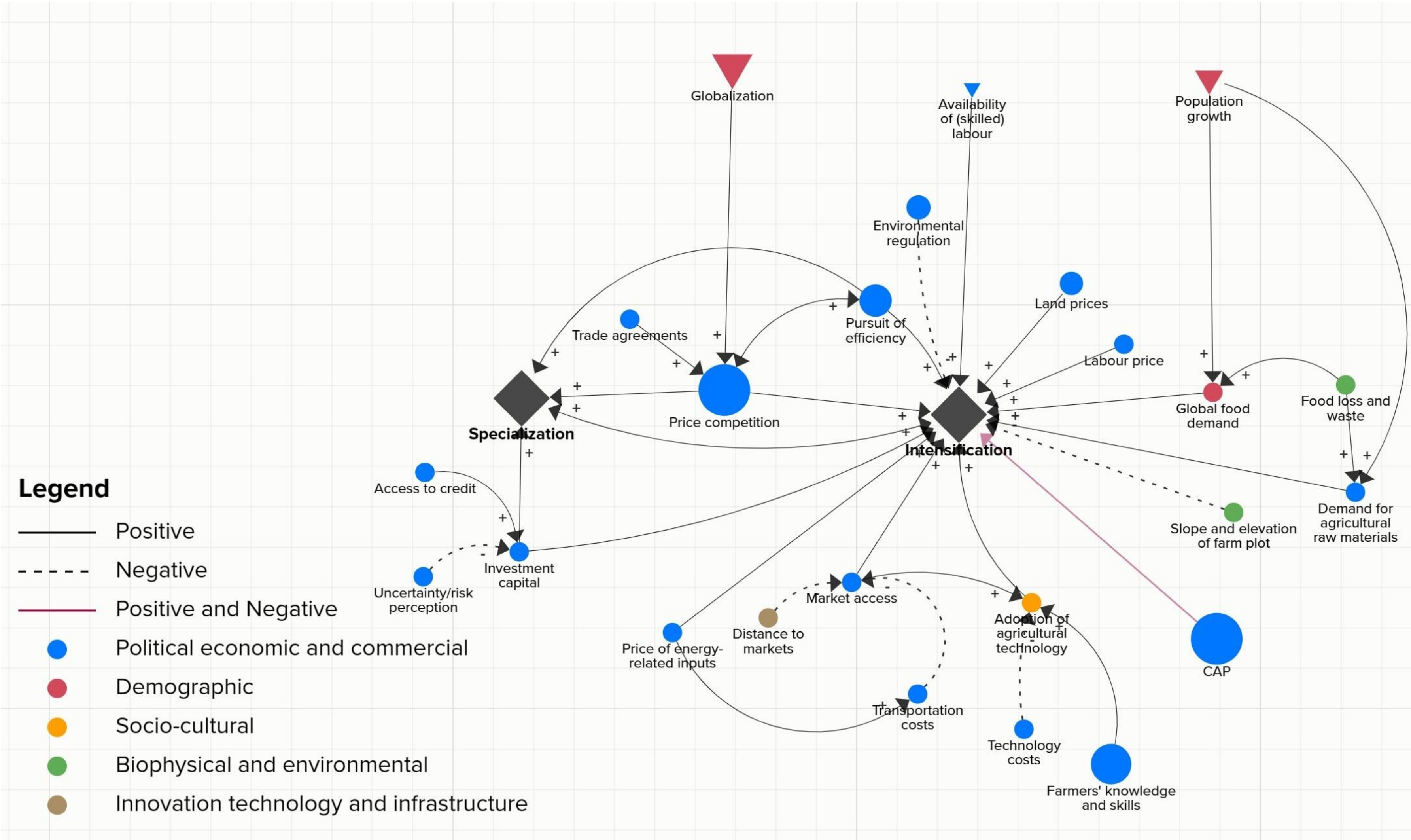

Figure 6 Subsystem map illustrating the factors and trend influencing agricultural intensification and the relationships between them. Source: author, 2024

Figure 6 illustrates the subsystem map of agricultural intensification, showcasing crucial factors and trends influencing the trend's development. Agricultural intensification is linked with specialization, as explained by Interviewee 7, who notes that farmers are pushed to specialize to maintain competitiveness. Most of these factors belong to the political, economic, and commercial dimension, underscoring their significance in driving agricultural intensification. On the other hand, the innovation, technology, and infrastructure dimension, along with the socio-cultural dimension, are less prominent.

Population growth acts as an exogenous factor, increasing global food demand and agricultural raw material (e.g., wood) demand. This demand prompts farmers to increase production to meet the rising demand (Schiefer et al., 2016; P. Struik et al., 2014). Additionally, food loss and waste contribute to increased food production requirements, exceeding actual needs (Helfenstein et al., 2020).

Price competition is a key factor, driving farmers to increase production to improve margins and competitiveness in a highly competitive market. Trade agreements opening the EU market to foreign products further heighten competition among farmers. Globalization fosters cross-border trade, expanding market options and fostering competition for lower prices (Clay et al., 2020). Moreover, higher input prices, including those for land, energy, and labour, incentivize intensification by prompting farmers to increase production to counterbalance these costs with higher revenues(Godde et al., 2018).

Efficiency in agriculture is closely tied to price competition. This is driven by a productivism mindset that focuses on maximizing revenue from agricultural products through economic efficiency. The push for lower prices encourages farmers to be efficient by seeking options to minimize costs and increase revenue. Simultaneously, this pursuit of efficiency also allows farmers to reduce prices and remain competitive in the market. However, this focus on efficiency can sometimes compromise animal welfare or human health. For example, increasing the number of animals in a confined space can raise the risk of spreading zoonotic diseases (Clay et al., 2020). Interviewee six raised thought-provoking questions: Is intensification economically viable in the long term? What about the environmental consequences of intensification, which could impact productivity and the revenue of intensive farms?

The Common Agricultural Policy (CAP) exerts both negative and positive influences on intensification. It is regarded as one of the main drivers of increasing agricultural productivity and thus intensification in the European Union (Emmerson et al., 2016; Lakner et al., 2019). As explained in Section 2.2, the CAP played a key role in driving intensification to meet the post-war food and fodder demands in Europe. Nonetheless, it is important to note that the CAP has undergone multiple reforms over the years. The latest CAP reform includes additional measures and incentives aimed at encouraging farmers to adopt environmental farming practices and reduce the use of chemical inputs, thus supporting the Farm to Fork strategy's targets. While the recent CAP aims to support low-input farming, there are still dependencies from its origin that incentivize to intensify (Oñate et al., 2023).

The decision of farmers to intensify their operations is influenced by several factors besides price competition and efficiency. Capital investment, often dependent on access to credit and perceived risks, is a key consideration (Godde et al., 2018). Additionally, political factors such as environmental regulation aiming to mitigate negative environmental impacts like water and soil pollution can limit intensification efforts (Morales et al., 2022). Also, transportation and technology costs pose significant barriers to intensification, as higher costs can restrict market access and hinder technology adoption. High price of energy inputs (e.g. fuel) increases the costs of transportation, posing more economic difficulties for farmers to transport their products to markets (Román, 2023). Lastly, the knowledge and skills of farmers are crucial in the adoption of technology, as they must understand its operation and potential effects on their operations (Godde et al., 2018).

5.3 Agricultural specialization

The third trend is agricultural specialization, defined as the process of concentrating resources such as labor, capital, and land to produce a limited range of products, focusing on those that the farm can most efficiently produce (Abson, 2019a; IPES-Food, 2016). The choice to produce only the most efficient products is aimed at leveraging comparative advantage and economies of scale to increase profitability. While this approach benefits farmers economically, it has ecological implications. Focusing on a few agricultural products simplifies the landscape, leading to a decline in the genetic diversity of crops and animals, as well as a decrease in wildlife (Abson, 2019b).

This trend is evident in the EU, where a minority of farms engage in mixed farming. In 2020, over half (58%) of all farms in the EU specialized in crops, while slightly less than a quarter (22%) specialized in livestock. The remaining and smaller percentage comprised mixed farms, representing 19% of all EU farms (Eurostat, 2023a) (see Figure 7).

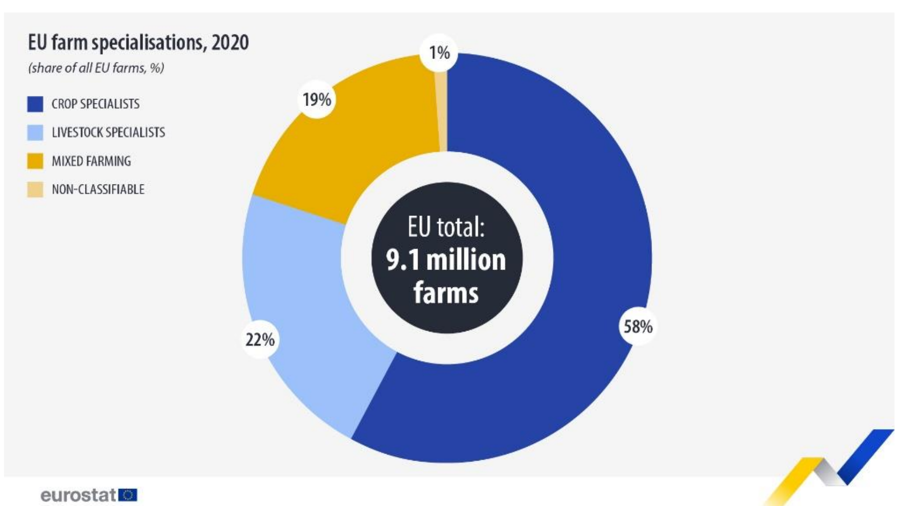

Figure 7 Percentage of specialized, mixed and non-classifiable farms in the EU in 2020. Source: Eurostat, 2023a

Agricultural specialization

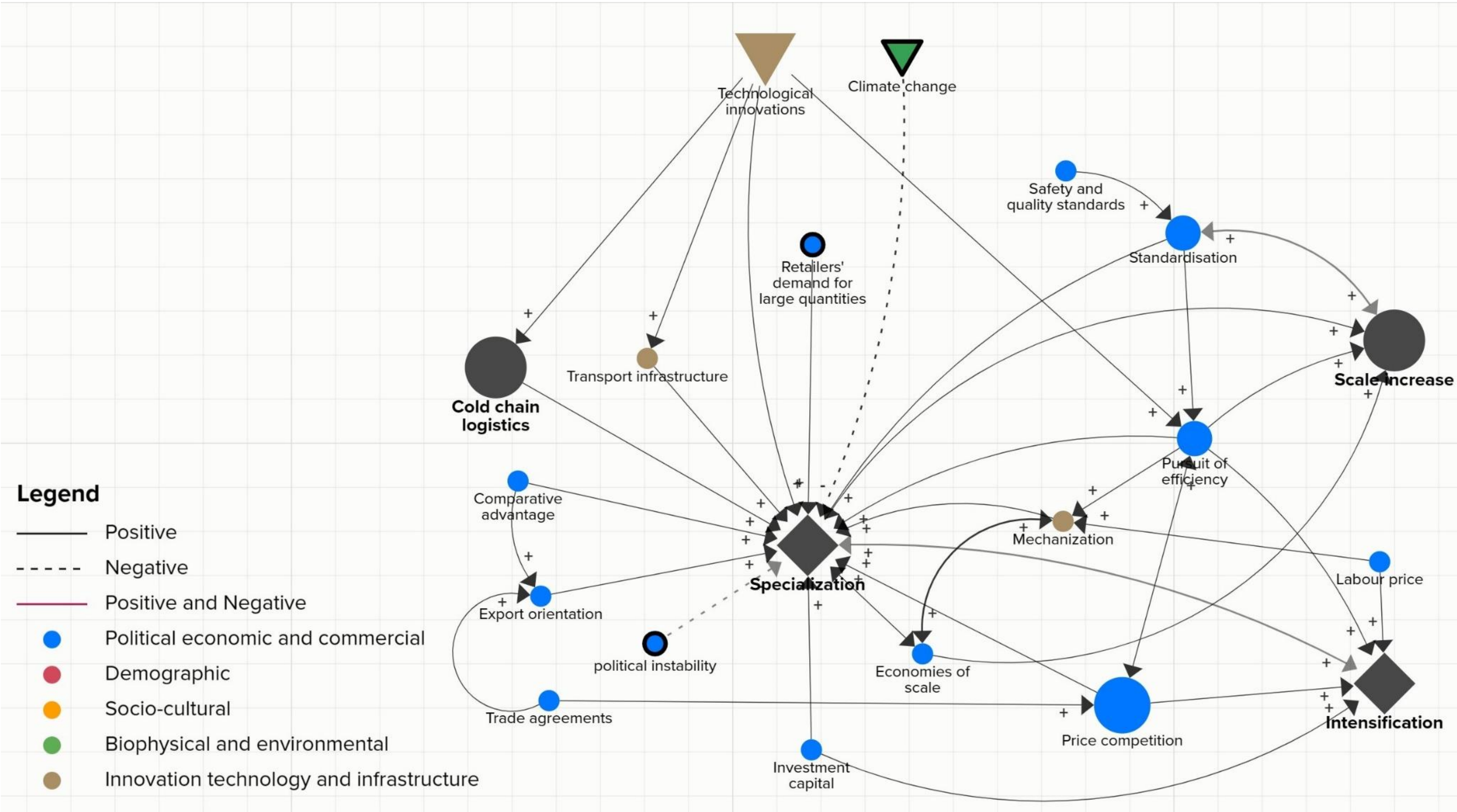

Figure 8 Subsystem map illustrating the factors and trends influencing agricultural specialization and the relationships between them. Source: author, 2024

Figure 8 depicts the subsystem map of agricultural specialization. Like agricultural intensification, it is mostly influenced by factors in the political, economic, and commercial dimensions. It is also interconnected with other trends, including scale increase (an overarching trend) and cold chain logistics (a storage and distribution trend). This indicates that not only factors are interacting with one another but also between trends. The socio-cultural dimension seems to play a minor role as there are no factors belonging to it. The biophysical dimension has only one factor, which is climate change. However, according to Interviewees 2 and 6, climate change is an important factor hindering farmers from specializing as they face higher risks due to climate change.

Regarding the political, economic, and commercial dimension, comparative advantage prompts farmers to specialize in producing goods in which they excel compared to others, fostering specialization and trade. Countries prioritize open markets to export foods they can produce advantageously and import goods in which they lack expertise (Abson, 2019b). Trade agreements play a crucial role in facilitating this exchange and promoting export-oriented agriculture (IPES-Food, 2016).

Interviewees 1 and 10 added retailers' demand for large quantities and political instability as important factors of this trend. They pointed out that modern retailers now require large quantities of food to meet their consistent demand for customers. To meet this demand and sell to retailers, farmers prefer to specialize in a single product to increase their quantity. According to interviewee six, this factor has a considerable influence on farmers because food retailers wield more bargaining power than them, leaving little room for negotiation. Political instability was mentioned as an obstacle as it brings uncertainty as to whether farmers will be able to obtain the inputs for their specialized production and be able to sell their produce.

Factors in the innovation, technological, and infrastructure dimension are the second most predominant in the subsystem map. Technological innovations facilitate developments in transport infrastructure, which, in turn, aids the distribution of farmers' produce to the national and international markets (Abson, 2019b; IPES-Food, 2016). Examples of a technological innovations which contribute to the transport overseas of food are cold storage technology and antibacterial packaging (Juneja, 2017; Mercier et al., 2019). Without it, farmers will have more difficulties exporting their produce in good conditions. Technological advancements also influence the pursuit of efficiency, enabling the optimization of resource use (Gaviglio et al., 2021).

Standardization and mechanization are additional factors contributing to the growth of this trend in the innovation, technological, and infrastructure dimension. The demand for compliance with safety and quality standards has led to a preference for standardized processes, which specialization can better fulfil (IPES-Food, 2016). Mechanization plays a crucial role in reducing the labour demand for large areas dedicated to specialized crops. The decision to mechanize is influenced by labour prices and economies of scale. Higher labour prices provide greater incentives for farmers to reduce their workforce and introduce machinery. Additionally, economies of scale support mechanization, as larger farms find it more practical to invest in machinery rather than relying solely on human labour. The economic returns from mechanization also increase as the scale of operations expands. (IPES-Food, 2016; Klasen et al., 2016).

5.4 (Sub)urban food production

The fourth trend is (sub)urban food production, also known as (peri-)urban food production. It encompasses the cultivation of crops, raw agricultural materials and animal husbandry in both urban and suburban areas (Santo et al., 2016). In urban areas, food production takes various farms ranging from household, school and community gardens to rooftop, vertical and indoor farms. In suburban areas, it typically involves a professional farmer hired by a community to produce their food (European Parliament et al., 2017). Note that the scale, intensity, and production output of (sub)urban food production vary depending on the specific type and focus of the practice (Piorr et al., 2018)

Contrary to what many people may think, (sub)urban food production is not a recent trend but rather a practice that has evolved over time. Historically, urban dwellers have resorted to producing their own food during periods of food shortages, economic crises, or war (European Parliament et al., 2017). Traditional allotment gardens trace back to the 19th century. With technological advancements and evolving societal demands, (sub)urban food production in Europe has transformed from being merely a means of self-supply during crises to a multifunctional land use that offers social, economic, ecological, and cultural benefits (Piorr et al., 2018).

Some forms of (sub)urban food production, such as vertical and indoor farming, are still in their infancy stage, and only recently have politics and academia begun to pay attention to these forms of production in suburban and urban contexts (Piorr et al., 2018). When interviewees were introduced to this trend, some (ID 7, 8 and 10) were even surprised that it was considered a mainstream trend in the EU, as they doubted its capacity to fully feed urban citizens. Currently, (sub)urban food production complements the food supply in cities. Much of its potential will be discovered in the future, particularly in addressing the question of whether it can sustain a hungry city. However, this trend is worth considering, as it has the potential to create environmental awareness, enhance social cohesion and (re)connect people to nature, as mentioned by interviewees 2, 3 and 5.

(Sub)urban food production

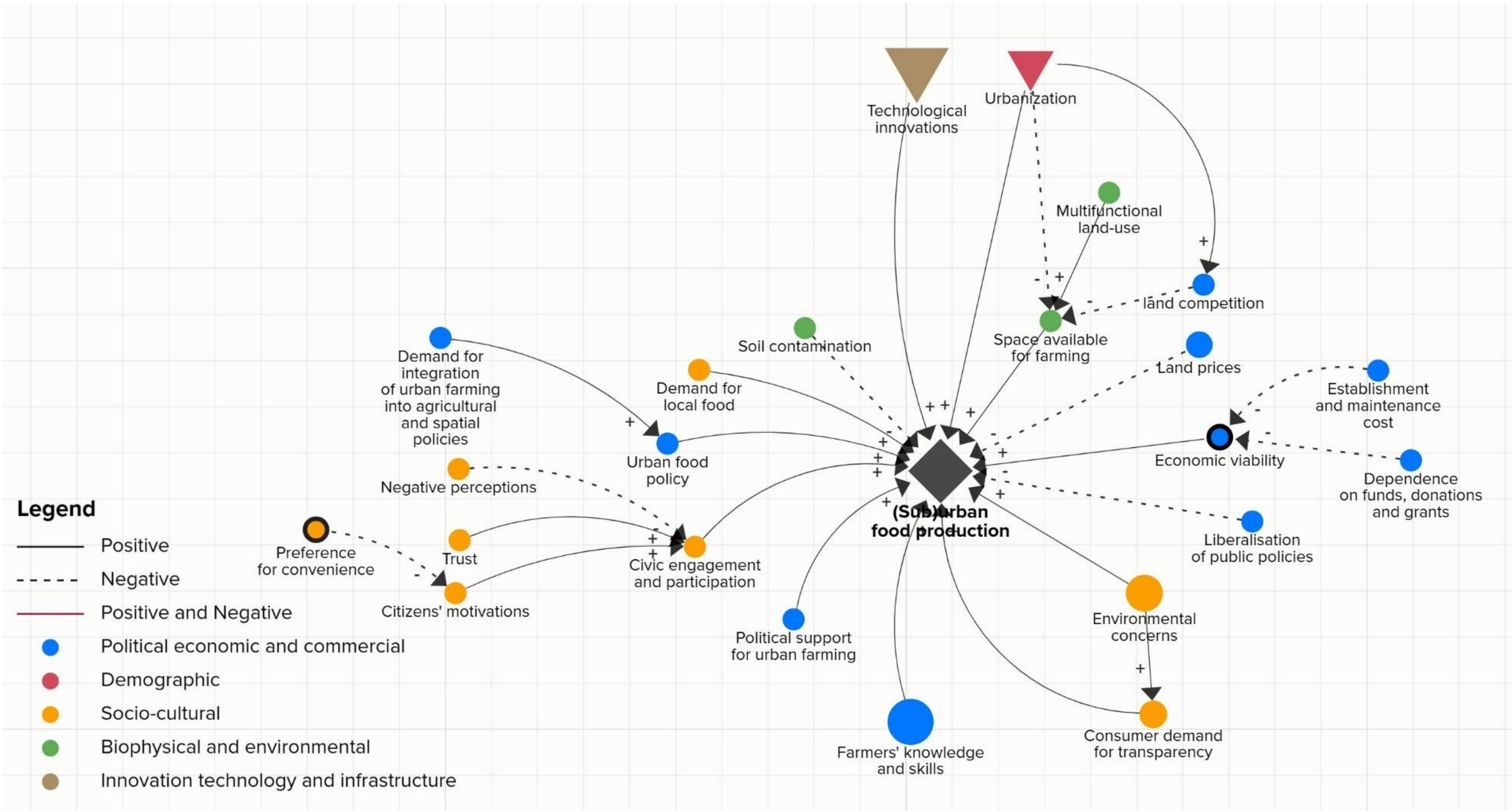

Figure 9 Subsystem map illustrating the factors influencing (sub)urban food production and the relationships between them. Source: author, 2024

As mentioned above and indicated by interviewees 1 and 3, (sub)urban food production embraces multiple forms of farming and gardening which also diversify the range of factors influencing this trend. The map above (see Figure 9) provides an overview of the most important factors affecting these diverse forms of farming that are encompassed by this trend. As evident from this figure, this trend is influenced by factors from all five dimensions without one dimension being influential. Technological innovation and urbanization are the exogenous factors influencing this trend.

Technological advancements provide the means to cultivate food in diverse ways, especially in indoor environments, thereby contributing to the growing demand for food in urban areas. Without technology, it would be unthinkable, for instance, to cultivate food indoors, a practice now made possible by LED grow lights and sensor technology (Noonan & Barreau, 2021; Paucek et al., 2020).

Urbanization influences occur in three distinct ways and affect different dimensions. Firstly, urban development exerts pressure on available land, reducing space for farming and impacting the environmental and biophysical dimension. Secondly, urban expansion leads to competing interests for land use, such as residential and recreational areas, which affects the political, economic, and commercial dimension. Lastly, as urban populations concentrate and grow, there is a greater demand for locally produced food to achieve city food self-sufficiency (Artmann & Sartison, 2018a; Olsson et al., 2016).

As mentioned above, the scarcity of space for farming is an environmental and biophysical factor constraining the growth of (sub)urban food production. One alternative to deal with the competition for land is multi-functional land use, which, as the name suggests, involves using land for more than one purpose. This approach can help reconcile competing interests while still allowing space for food production. An example of multi-functional land use is farm tourism, which combines food production and recreational activities (European Parliament et al., 2017). However, one environmental constraint to this trend related to space available and suitable for cultivating food is soil contamination. Soil may be contaminated with pollutants from industrial activities or wastewater (e.g., man-made chemicals and pathogens), impacting negatively people's health and creating distrust in food produced in urban areas (European Parliament et al., 2017; Noonan & Barreau, 2021).

Political factors exemplified by (sub)urban food policies and political support to (sub)urban food production initiatives contribute to the growth of this trend. The existence of urban food policies stems from the need to integrate urban food production across policy domains that affect it. Since agricultural policy centres on rural food production, it often neglects (sub)urban food production. Similarly, urban policies designed for urban areas frequently fail to address food production or integrate it effectively into urban planning (European Parliament et al., 2017; European Parliament Research Service, 2014). Regarding political support to sub(urban) food production initiatives, local governments can incentivize these initiatives by providing citizens with land and agricultural resources (Sartison & Artmann, 2020). However, Interviewee 3 criticized the support provided and the reasons behind it. Community gardening has gained popularity among city authorities because it allows them to demonstrate a commitment to community well-being and environmental care. They support these initiatives because they typically last about three years or less and can be easily abandoned, posing no significant obstacle to the government's development plans (Interviewee ID 3).

Political support can sometimes be insufficient or non-existent. The liberalization of public policies has a negative influence on this trend. Over the years, government protection and support for agricultural activities have decreased, exposing them to competition in an open market (OECD, 2023). This situation exposes farms to economic pressures, potentially leading to their conversion for alternative uses, such as horse farms and riding schools (Olsson et al., 2016).

Farmers' knowledge and skills related to (sub)urban food production are essential for farmers to thrive in (sub)urban areas. They have to engage in activities beyond producing food, such as advertising and selling their products. European Parliament et al. (2017) mentions that farmers lacking knowledge and skills related to entrepreneurship, marketing, and networking face difficulties engaging in (sub)urban food production initiatives. Thus, the importance to bridge their skills and knowledge gap. Interviewee six pointed out that this aspect of knowledge and skills is relevant not only to farmers but also to citizens who may engage in (sub)urban food production.

Interviewee one emphasized the need for (sub)urban food production initiatives to be economically viable to ensure their long-term existence. Most (sub)urban food production initiatives rely on public funds and donations to function. For some initiatives, food sales alone are insufficient to generate profit, so they rely on external financial support or volunteer work. Another factor influencing their viability is the cost of establishment and maintenance, as they may require significant capital investments to transform and maintain urban spaces suitable for agriculture (European Parliament et al., 2017).

Socio-cultural factors can positively and negatively influence this trend. Citizens' support for urban farming initiatives through their engagement, awareness, and demands can contribute to the growth of this trend (Artmann & Sartison, 2018a). Conversely, negative perceptions on (sub)urban food production (Artmann & Sartison, 2018a) or a preference for convenience, such as purchasing ready-made food, can discourage these initiatives (interviewee ID 10).

5.5 Alternative agricultural systems

The fifth trend is alternative agricultural systems for which there is no agreed-upon definition. Kremsa (2021) contrast it against conventional farming systems, yet this definition is equally ambiguous, diminishing clarity on the topic and creating a false dichotomy between alternative and conventional farming systems (Parks & Brekken, 2019; Sumberg & Giller, 2022). Drawing inspiration from Garibaldi et al. (2017), this research defines alternative farming systems as an umbrella term for farming methods focused on the environmental, social and economic dimensions of sustainability. The dimension which receives the most attention is environmental sustainability. Some examples are agroecology, organic farming and permaculture (Garibaldi et al., 2017).

The European Union's agriculture sector holds a crucial position in both ensuring food security and revitalizing the health of ecosystems. Acknowledged for its adverse effects on the environment and society, agriculture has faced increasing pressure to adopt practices aligned with sustainability principles. Consequently, there has been a growing focus on shifting towards both existing and novel farming methods that contribute to sustainable practices (European Environment Agency, 2023b).

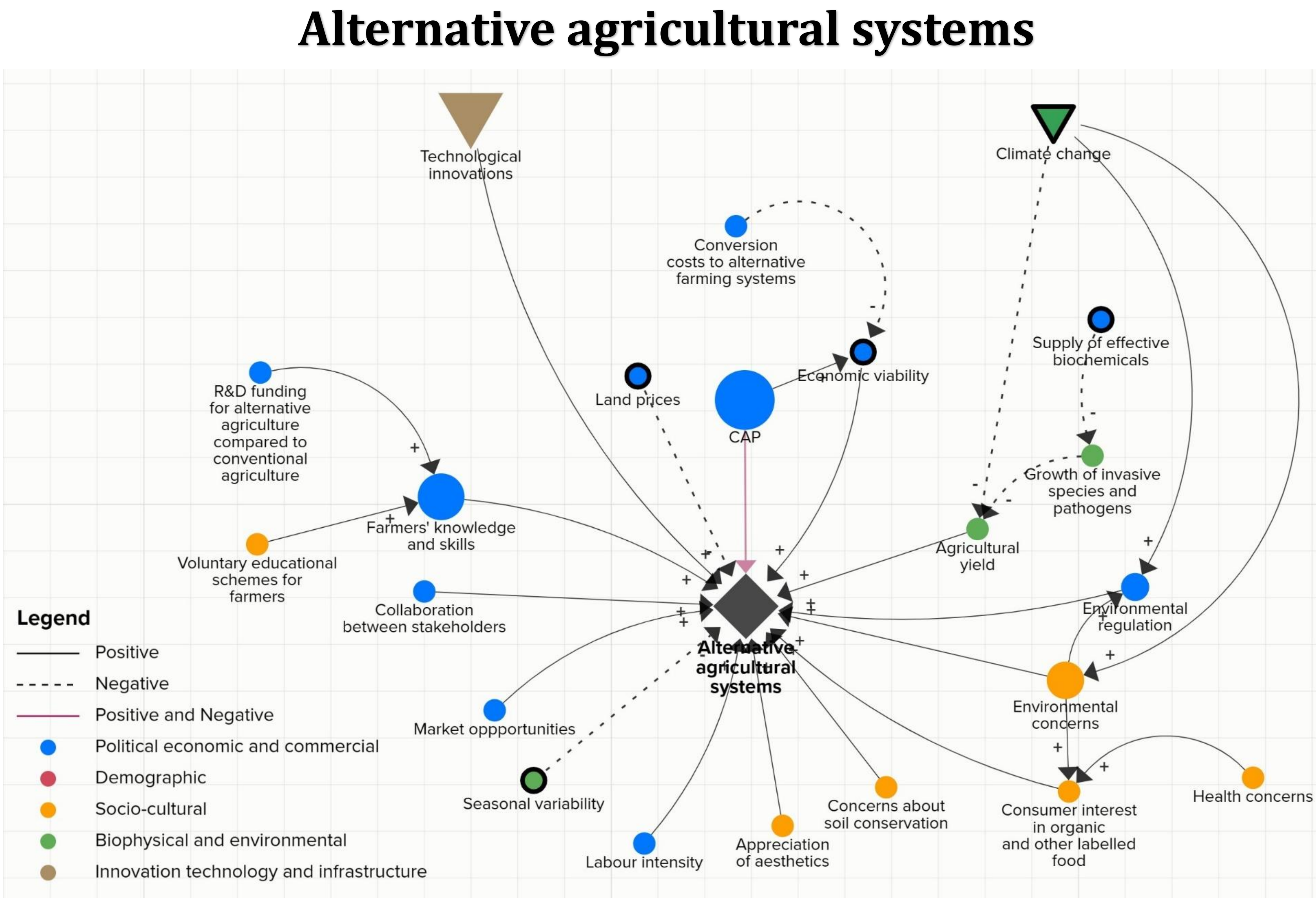

Figure 10 Figure 10 Subsystem map illustrating the factors influencing alternative agricultural systems and the relationships between them. Source: author, 2024

Figure 10 depicts the subsystem maps of alternative agricultural systems, containing the most important factors influencing the development of this trend. At first glance, it shows a diverse array of factors from the five dimensions, unlike agricultural intensification and specialization, which are predominantly driven by one dimension.

Factors in the socio-cultural dimension mostly contribute to the growth of alternative agricultural systems. Health and animal welfare concerns have increased consumer interest in organic and other labelled products. This consumer interest, in turn, increases the demand for products from alternative farming systems (Fiorilla et al., 2022; Papatsiros et al., 2020). Concerns about the soil quality and the importance of conserving it to produce food in the long term also motivate farmers to adopt farming practices that benefit the environment (Casagrande et al., 2016). Interviewee six suggested adding pursuit of resilience as a factor contributing to the growth of this trend. Having resilience as an objective counteracts the efficiency and profit maximization logic and focuses on the long-term and sustainability of the system agriculture. Additionally, voluntary education schemes emerging from society typically aim to rethink farming practices, embrace sustainability, and equip farmers with the knowledge and skills needed for the transition to sustainable agriculture (Dupré et al., 2020; Wezel et al., 2018).

In contrast to intensification, environmental regulation in this case drives alternative agricultural systems because they have a better impact on the environment and society. Climate change increases the likelihood of having more or stricter regulations as its negative consequences are experienced (Kakabouki et al., 2021).

The Common Agricultural Policy (CAP) exerts both positive and negative influences on this trend. On one hand, it encourages environmentally friendly farming methods, such as setting aside land for biodiversity and protecting peatlands and wetlands. The recent CAP reform introduced additional sources of income for farmers who adopt these practices, thus supporting the economic viability of these farming systems (Oñate et al., 2023). Interviewee 1 emphasized that for these systems to last a long time need to be economically viable. However, the conversion costs associated with transitioning to alternative farming systems can be excessively high for farmers to bear (e.g. organic certification costs) (Hijbeek et al., 2019; Reidsma et al., 2023). On the other hand, the CAP's focus on increasing food production and ensuring affordability tends to favor agricultural approaches that prioritize crop yield over alternative systems with a more holistic perspective, including the three dimensions of sustainability (Emmerson et al., 2016; Lakner et al., 2019).

Farmers' knowledge and skills are particularly important for success in these systems. Business and marketing skills (e.g., managing online sales, developing a sound business model) are necessary for farmers to sell their produce at good prices. Additionally, farming systems such as agroecology are knowledge-intensive and require understanding of their principles, how to boost productivity, and manage and enhance farm diversity (Dupré et al., 2020; Wezel et al., 2018). This factor is influenced by two other factors. One is research and development funding destined for alternative agricultural systems. The more funding allocated to these farming systems, the greater the opportunities for transferring and exchanging knowledge with farmers. Additionally, it allows for the development of projects aimed at bridging the knowledge and skills gap necessary for implementing these systems. (Wezel et al., 2018). The second is voluntary education schemes developed by institutions and farmers' organizations to support farmers with knowledge and skills who want to transition to alternative farming systems or who have already transitioned (Runhaar, 2021).

A couple of other factors in the political, economic, and commercial dimensions influence this trend. Most alternative farming systems are labour-intensive, contrasting with highly mechanized and high-input farming. The labour requirements of farming can discourage farmers from pursuing them. For instance, no-tillage, no pesticides, and the use of green manure are common practices in these systems. As some of them are additional activities and others imply manual labour, the labour requirements for farming increase.(Casagrande et al., 2016; Pissonnier et al., 2016) Another factor is land prices. Interviewee eleven added this factor, noting that high land prices hinder access to land.

Agricultural yield is an influential factor in the biophysical and environmental dimension. The higher the yield, the greater the incentive for farmers to opt for alternative farming systems. However, the growth of invasive species, which tends to be a bigger problem in these farming systems due to the absence of chemical inputs to treat pests or diseases, negatively impacts the yield (Casagrande et al., 2016). Interviewee eleven added that the supply of effective biochemicals is important to prevent weeds and pathogens in the field without negatively impacting the farm's ecosystems with harmful chemicals. Another biophysical and environmental factor decreasing the likelihood of farmers opting for alternative farming systems is seasonal variability, which does not ensure a constant supply of food year-round demanded by food retailers (Interviewee ID 8).

6 Leverage points within and outside the evolving trends of EU agriculture

After gaining an overview of the factors influencing the development of evolving EU agricultural trends, this chapter highlights those with the greatest potential to create system-wide effects when altered (See Table 2).

Table 2. Leverage points, specifying the data analysis method used and indicating whether they are included in the subsystem maps.

Leverage point	Identified through SNA	Identified through content analysis	Part of the subsystems maps?
Technological innovation	X	X	X
The CAP	X	X	X
Climate change	X		X
Urbanization	X		X
Land prices	X		X
Environmental concerns	X		X
Price of energy-related inputs	X		X
Concentration of power by food processors and retailers		X	
Farmers' educational exchange and advisory services		X	X
Geopolitics		X	
Research		X	
Current economic system		X	

As mentioned in Chapter 4, leverage points were identified in two ways. One was through the calculations of the degree distribution measurements of the factors in the subsystems maps. The candidates for leverage points have a high out-degree and a low in-degree. Table 3 presents the measurements for these potential leverage points. The second was through content analysis of expert interviews. I use interchangeably the terms interviewees and experts. The interview questions 8,9 and 10 (see Appendix I for more information) were formulated with the intention of prompting experts to identify leverage points.

Table 3. Degree distribution measurements of candidates of potential leverage points

Factor	**Out-degree**	**In-degree**	**Out-degree minus in-degree**
Technological innovation	7	0	7
The CAP	6	0	6
Climate change	5	0	5
Urbanization	5	0	5
Price of energy-related inputs	4	0	4
Environmental concerns	5	1	4
Land prices	4	0	4

Subsequent sections will delve into each leverage point listed in Table 2. While some leverage points have more extensive descriptions, this does not necessarily correlate with their degree of influence or importance. It simply indicates that in some instances, interviewees provided detailed explanations and even examples.

6.1 Technological innovation

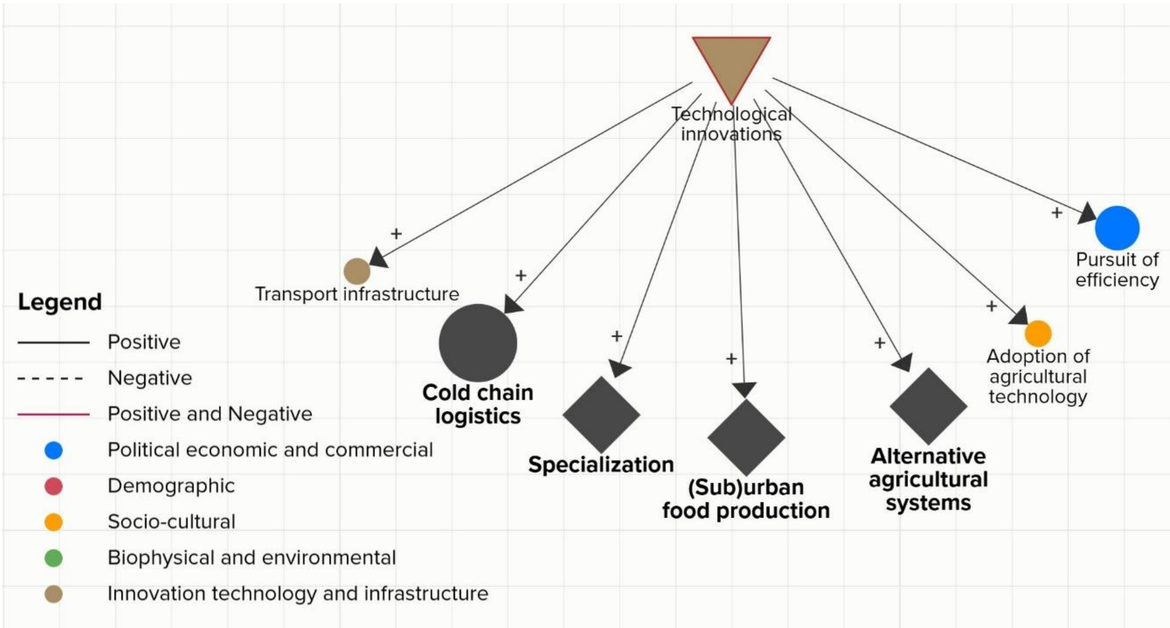

Figure 11 Factors and trends influenced by technological innovations. Source: author, 2024

Technological innovation stands out as the factor with the highest value of outgoing connections (out-degree value) and no incoming connections (in-degree value). It exerts influence over both trends and factors (see Figure 11), notably impacting three out of the five agricultural trends and one overarching trend. Its influence extends beyond the innovation, technology, and infrastructure dimension, encompassing sociocultural, political, economic, and commercial dimensions as well. This underscores the interconnectedness of technological aspects with social, political, and economic dimensions within a system.

As depicted in Figure 11, technological innovation significantly contributes to the growth of various trends and factors. Technological advancements contribute to improvements in transport infrastructure, facilitating the distribution of farmers' produce to national and international markets (Abson, 2019b; IPES-Food, 2016). Section 5.3 provides examples of such technologies, including cold storage technology and antibacterial packaging, which enable farmers to specialize in a few agricultural products and sell them in international markets use (Gaviglio et al., 2021). Cold storage technology, in particular, directly influences the logistics of the cold storage chain by ensuring physical availability (Han et al., 2021).

Additionally, technological advancements enable diverse methods of food cultivation, especially in indoor environments, meeting the increasing demand for food in urban areas. As discussed in Sections 5.4 and 5.5, technology plays a crucial role in making certain food production methods feasible in urban settings and reducing the environmental impact of farming, supporting alternative agricultural systems(Ditzler & Driessen, 2022; Noonan & Barreau, 2021; Paucek et al., 2020). Note that the adoption of agricultural technology is dependent among factors of the availability of this technology and the ongoing developments in the field (Gabriel & Gandorfer, 2023).

As mentioned in Section 5.2, the pursuit of efficiency aims to minimize costs and increase revenue. This drive for efficiency also enables farmers to lower prices and remain competitive in the market (Clay et al., 2020).

Moreover, technological innovation was also identified as a leverage point by interviewees 1 and 7. Interviewees 1 and 7 identified technological innovation as a leverage point. Interviewee 1 stated: “We need new technologies. More options we can offer farmers to move to a less intensive but productive system.” He regards innovation in farming practices and equipment as a powerful tool to facilitate the transition towards alternative farming systems without compromising productivity. Similarly, interviewee 7 referred to the key role of technology and innovation in transforming EU agriculture towards sustainability.

When leveraging technological innovation for sustainability transformations, it is crucial to approach it critically and consider its applications. Interviewee three pointed out “in science, in academia, everything that's labelled innovation or innovative is always considered to be somehow positive […] we somehow tend to overlook its negative effects and prioritize what we see as a positive thing.” When technological innovation is seen a quick fix to optimize the current situation, it may be reinforcing the current system instead of challenging its root causes that make it unsustainable. The invitation from this interviewee is to adopt a critical perspective and use technological innovation as a transformative strategy, redefining problems and paving new ways towards a new system.

6.2 The Common Agricultural Policy (CAP)

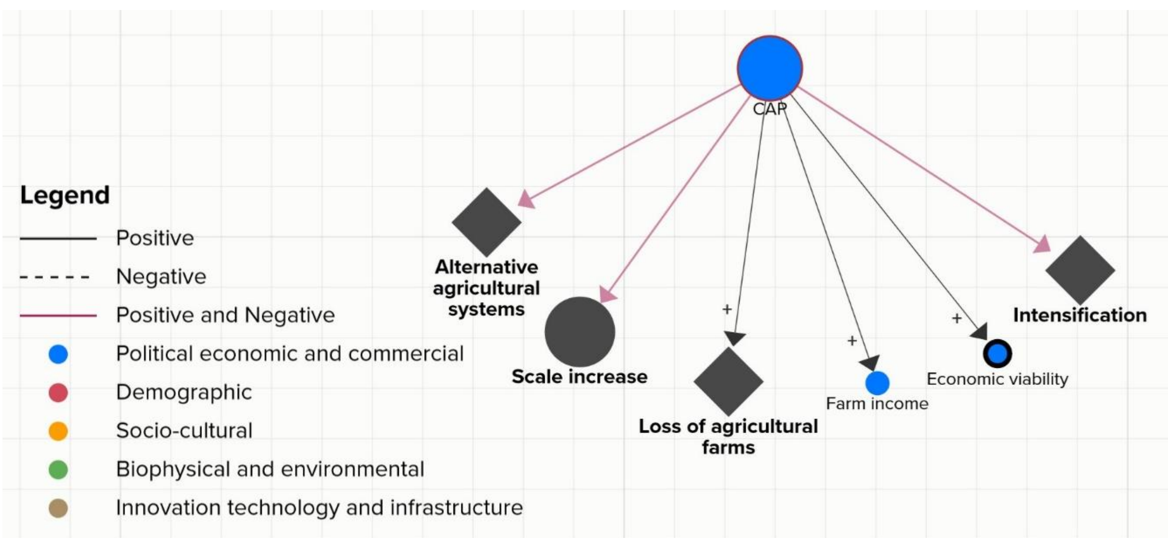

Figure 12 Factors and trends influenced by the Common Agricultural Policy (CAP). Source: author, 2024

The CAP has the second highest out-degree value. As seen in Figure 12, all connections are outgoing rather than incoming, indicating its significant influence. It affects both factors and trends, notably impacting three out of the five evolving trends of EU agriculture and one overarching trend. The factors it directly influences are farm income and economic viability. Please refer to Sections 5.1, 5.2 and 5.5 for information on how the CAP influences these factors and trends.

As technological innovation, the CAP was also identified by interviewees (ID 1,2,7,8, 9 and 10) as a leverage point. More than half of the interviewees identified it as such. They addressed various aspects concerning the Common Agricultural Policy (CAP) outlined in the following paragraphs.

The CAP has a long history of implementation and reforms, and while it has incorporated environmental aspects, it still generates a locked-in situation that prevents a swift transition towards sustainability (Interviewees ID 2, 10). According to interviewee 2, the CAP remains an ambivalent and inconsistent policy. Although new environmental measures, such as eco-schemes, were included in the CAP, past dependencies and needs still influence it. Regarding these past dependencies and needs, interviewee 10 remarked that the CAP objectives were established in the post-war period, requiring a boost in food production to prevent famines across Europe. Fortunately, current food production is sufficient, but the negative environmental outcomes have increased compared to post-war Europe, demanding an evaluation of present needs and the CAP's direction.

With respect to the current needs of farmers, interviewees 2 and 9 highlighted the support that farmers require, given the reduction in the CAP's budget and the competing uses of land. The CAP holds substantial influence over food production, as 72% of its budget constitutes a vital source of income for farmers, provided in the form of direct payments to sustain their activities and maintain profitability (Nègre, 2023). Interviewee 9 emphasizes that despite criticism of the CAP, we must consider the extent to which EU farmers rely on its budget and how they are affected by any reductions. Moreover, interviewee 9 underscores the importance of preserving farmland and prioritizing these areas for food production, given the current competition with other land uses and pressures from urbanization.

As part of the suggested changes to the CAP, a long-term perspective is recommended that aligns with farmers' activities and views instead of short-term perspective of measures that might change with every legislative period. "If a farmer invests today, they do that for 20 or 30 years. They want to pass down a farm to the next generation in a sustainable way, and we should think more in that direction than in a 5–6-year policy," explained interviewee 10. This example illustrates that farmers have a longer-term vision than legislation, and their investments also take time to yield benefits.

Furthermore, interviewees 1 and 10 emphasized on the importance of informing policymakers and farmers about the current situation in EU agriculture, as they are both the creators and recipients of policy. This information should be based on scientific evidence, allowing policymakers to make decisions grounded in recent findings (ID 10), rather than following ideologies. Farmers, as recipients of these policies, should also be informed to understand why policy needs to shift towards sustainability (ID 1). In addition to raising awareness and sharing knowledge, interviewee 1 suggested using incentives and sanctions as a complementary approach.

Regarding the transition towards sustainability, it was emphasized that despite the Farm to Fork strategy and reforms to the CAP aimed at making it greener, policies have not yet taken the necessary measures for this transition to fully occur (Interviewees D 2, 8 and 9).

Interviewee 2 referenced the concept of post-exceptionalism to emphasize that past dependencies still influence the CAP, indicating that a transition has yet to occur. Post-exceptionalism denotes a partial transformation in a policy domain while preserving its heritage, suggesting both continuity and change occurring simultaneously (Daugbjerg & Feindt, 2017). While EU policy and the CAP demonstrate an interest in achieving sustainable agriculture, the transition remains partial, and more changes are needed.

An example of a necessary change is the adoption and enforcement of the legislative framework for sustainable food systems, which is a flagship initiative of the Farm to Fork strategy. It has been seen as a tool to steer the EU food system towards sustainability. Although it was announced that this legislative framework was going to be adopted by the end of 2023, it has not been passed yet (Björkbom, 2023) and was not included in the tentative agenda of the EU Commission for 2024 (Katsarova, 2024).

6.3 Climate change

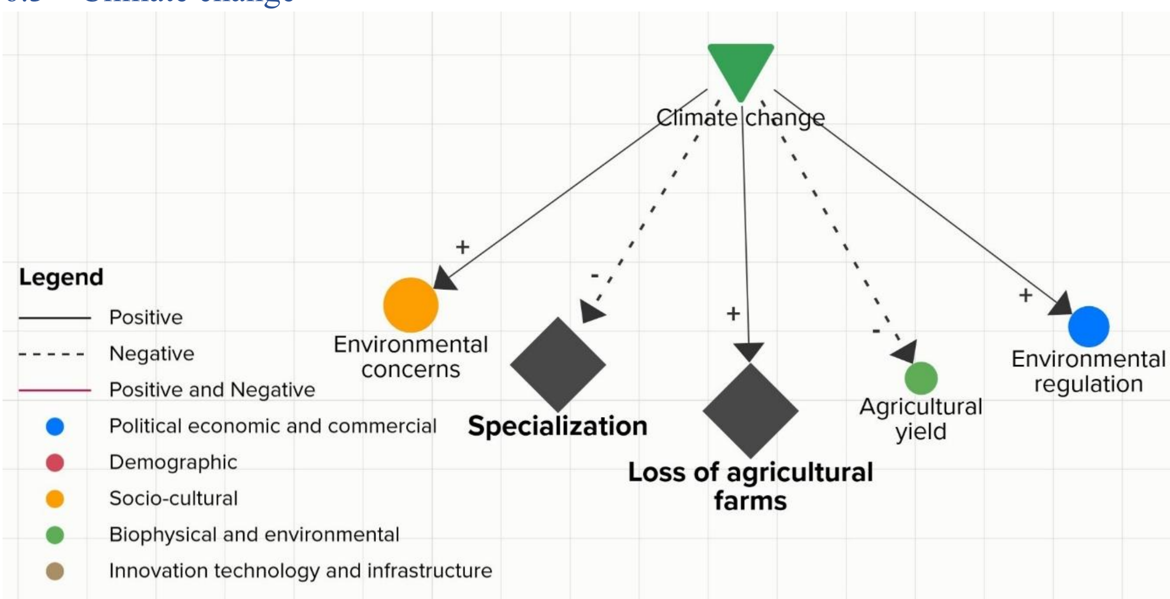

Figure 13 Factors and trends influenced by climate change. Source: author, 2024

Climate change is an exogenous factor with solely outgoing connections (see Figure 13), similar to the previous factors discussed. It directly influences trends such as specialization and the loss of agricultural farms. Additionally, the factors it affects span various dimensions, highlighting its interconnectedness with other aspects.

Climate change contributes to the growth of environmental concerns, environmental regulation and the trend loss of agricultural farms, and the decline of agricultural yield and specialization. Climate change directly impacts agricultural farms by making farming more difficult due to unfavourable conditions such as water scarcity and heat waves. These conditions lead to lower yields (Fayet & Verburg, 2023) and pose higher risks for specialized farms, which lack biodiversity and resilience, making them more susceptible to climate change effects (interviewees ID 2 and 6). Additionally, the severity of climate change raises concerns about farming's environmental footprint, highlighting the need for urgent action to mitigate these effects. To address these concerns and reduce the environmental footprint, implementing strict environmental regulations is one effective approach (European Environment Agency, 2023b; Peisker, 2023) .

One might inquire about how to address climate change. While mitigation strategies can be implemented and the EU is committed to achieving climate neutrality, the impacts and severity of climate change depend not only on the EU but also on the entire planet. Climate change is a global phenomenon concerning the atmospheric concentration of greenhouse gases. Steering climate change in a specific direction at the EU level is unfeasible (Baskin, 2019; Bruyninckx, 2019). However, it remains a crucial factor with system-wide effects. Therefore, it is valuable to examine its influence to anticipate potential consequences for EU agriculture, whether exacerbated or mitigated.

6.4 Urbanization

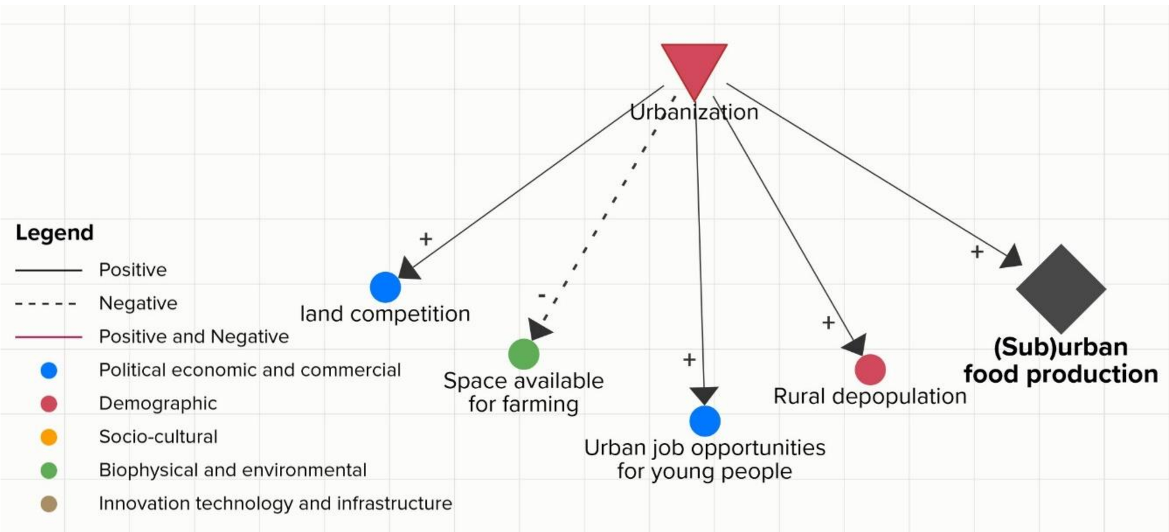

Figure 14 Factors and trend influenced by urbanization. Source: author, 2024

Urbanization exerts a significant influence on various factors, particularly contributing to the decline in agricultural farms and growth of suburban food production, as depicted in Figure 14. Urbanization has only outgoing connections showing its role great influencer without being influenced itself. Its influence goes beyond the demographic dimension to impact factors in the biophysical and environmental and political, economic and commercial dimensions.

Like climate change, a pertinent question emerges: how feasible is it influence urbanization and climate change in a certain direction to achieve desired system-wide effects? Currently, approximately 72% of the EU's total population resides in urban areas. This rapid pace of urbanization has compelled cities to adapt. Rather than having full control over or containing urbanization, cities are now faced with the challenge of accommodating it (European Investment Bank, 2018).

Therefore, rather than aiming to directly influence the course of urbanization—which appears to be a complex task—it is better to comprehend its influence on other factors and trends and to monitor its progression over time. This approach allows for better preparedness for further urbanization in the EU. Projections indicate that by 2100, approximately 80% of the population will be living in cities. The following paragraph explains the influence of urbanization on the factors and trend displayed in Figure 14.

Urbanization contributes to the growth of (sub)urban food production, rural depopulation, land competition, and urban job opportunities, especially for young people. However, it also leads to a decline in the space available for farming. As mentioned in Section 5.4, development pressures reduce the space available for farming and exacerbate competition for land, as multiple interests compete for land in these (sub)urban areas. As urban populations concentrate and grow, there is a greater demand for locally produced food to achieve city food self-sufficiency, thus encouraging suburban and urban food production initiatives (Artmann & Sartison, 2018a; Olsson et al., 2016). With a larger portion of the population now residing in urban areas, economic growth and job opportunities become concentrated there, offering young people better prospects in urban environments compared to rural areas (Keenleyside & Tucker, 2010).

6.5 Land prices

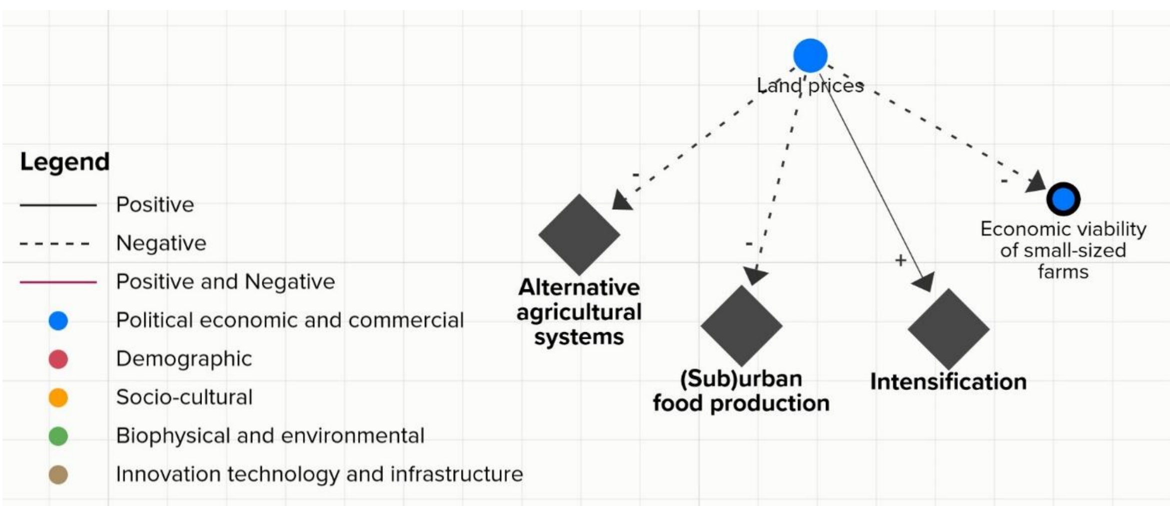

Figure 15 Factor and trends influenced by land prices. Source: author, 2024

Figure 15 demonstrates that land prices have influence on three agricultural trends: alternative agricultural systems, (sub)urban food production, and intensification. Land prices directly impact the economic viability of small-sized farms, which is linked to the trend of loss of agricultural farms. The land prices contribute to the decline of (sub)urban food production, alternative agricultural systems and the economic viability of small-size farms. In contrast it contributes to the growth of intensification.

As mentioned in Section 5.1, high land prices, which farmers must pay for access, represent a significant financial burden. These higher costs not only limit access to land but also lead to diminished income, intensifying the struggles particularly for small-size farms to remain economically viable as the fixed costs may outweigh the revenue (Keenleyside & Tucker, 2010; interviewee ID 1).Similarly, these high land prices pose obstacles for (sub)urban food production initiatives and alternative agricultural systems due to the negative implications they have on the overall costs (Interviewee ID 2 and 11).

6.6 Environmental concerns

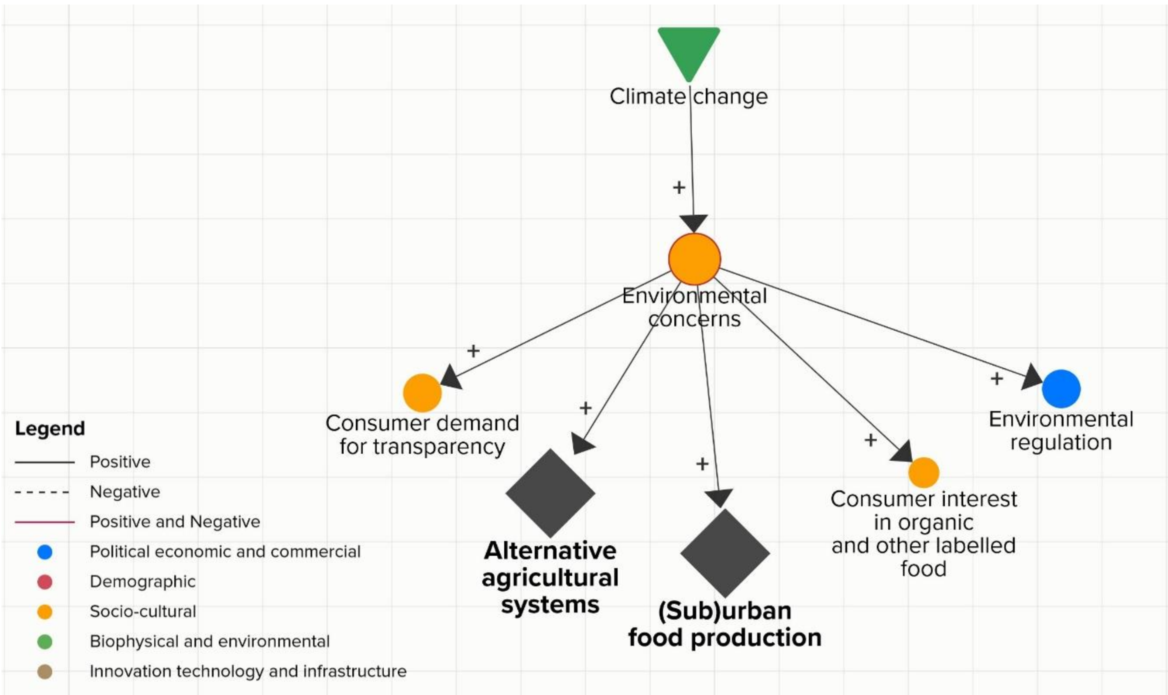

Figure 16 Factors and trends influenced by and influencing environmental concerns. Source: author, 2024

Figure 16 illustrates that environmental concerns have proven to be an important factor that exerts influence over others and the trends of sub(urban) food production and alternative agricultural systems. Note that this factor has one incoming connection. Environmental concerns are influenced by climate change, suggesting that an impact on climate change will result in effects on environmental concerns, simultaneously affecting factors with which environmental concerns has outgoing connections. It primarily affects factors in the socio-cultural dimension but also influences environmental regulation, which is part of the political, economic, and commercial dimension.

Environmental concerns contribute to the growth of (sub)urban food production and alternative agricultural systems, alongside other factors influenced by these concerns. This influence exerted by environmental concerns is explained in the following paragraphs of this section.

Numerous cities across the EU are currently facing multiple environmental issues concurrently. Key among these challenges are severe storms and flooding, air pollution, and the decline of biodiversity. Despite not being directly linked to food provision, these challenges have significantly heightened concerns regarding environmental sustainability in urban areas. Consequently, there is a growing emphasis on achieving environmental sustainability objectives, which in turn supports the development of initiatives aimed at addressing environmental challenges such as (sub)urban food production (European Environment Agency, 2020b). Suburban food production plays a pivotal role in attaining these objectives by delivering various environmental benefits, including better air quality, the biodiversity conservation, and the mitigation of the heat island effect (European Parliament. Directorate General for Parliamentary Research Services., 2017).

As highlighted in Section 2.4, EU agriculture is associated with numerous environmental challenges. This has sparked concerns about its environmental impact and prompted urgent action to address these issues and foster positive environmental outcomes. Consequently, as more individuals become aware of the environmental repercussions of EU agriculture, there is greater support and motivation for agricultural practices that prioritize environmental sustainability (European Environment Agency, 2023b; Fiorilla et al., 2022).

As awareness of the environmental impact of farming grows and spreads, consumers are becoming more insistent on transparency and labels tied to sustainable farming practices. This growing fuels support and advocacy for environmentally friendly agriculture (Fiorilla et al., 2022; Papatsiros et al., 2020). Additionally, these concerns surrounding the environmental impact of farming serve as a key driver, urging authorities to implement or strengthen regulations and acting as a source of legitimacy for broader environmental actions (Peisker, 2023).

6.7 Price of energy related inputs

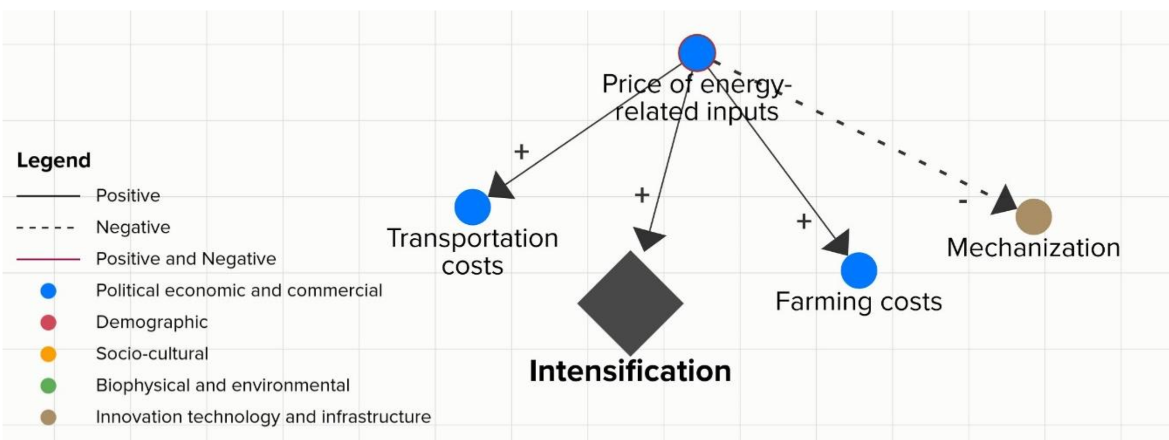

Figure 17 Factors and trend influenced by the price of energy-related inputs. Source: author, 2024

Among the prices of inputs, interviewee 1 highlighted that the price of energy-related inputs is the most important and influential factor affecting farmers' activities. This aspect is particularly connected to intensification and its influencing factors, as it affects the possibilities for mechanization and farming costs (see Figure 17).

The price of energy-related inputs directly affects the costs associated with activities that rely on them. For instance, fuel, a crucial energy input, influences transportation expenses. As fuel prices rise, transportation costs also increase accordingly (Volpe et al., 2013). Similarly, mechanization, which relies on fuel and energy for operation, is susceptible to fluctuations in energy input prices (European Agricultural Machinery Association, 2023). Farming expenses are further impacted by the rise in prices of energy-related inputs like fertilizers, essential for agriculture (European Parliament Research Service, 2023). Intensification, owing to its reliance on increased inputs, suffers a negative impact on economic viability when energy-related input costs escalate (Román, 2023).

6.8 Concentration of power by food processors and retailers

Interviewees 3, 6, and 8 emphasized the power concentrated in the hands of food processors and retailers, identifying this situation as a leverage point due to its influence over the entire EU food system. Interviewee 6 particularly elaborated on its impact, stating, "These entities operate largely behind the scenes but wield considerable power. They control food storage, manipulate markets, and can influence entire regions to focus on producing specific crops over others."

Interviewee 3 linked this leverage point to the overarching trend in the EU's food supply: vertical integration. Vertical integration involves a company's acquisition of other stages in the food chain that were previously managed by different entities (Hayes, 2024). He expressed concern about the increasing prevalence of this trend and advocated for actions to counter it.

The greater power concentration in the agribusiness sector, the more control fewer businesses will have over wages, prices, food availability, and policymaking (Omar & Thorsøe, 2023). This situation creates a power imbalance, disproportionately affecting EU farmers by reducing their leverage in the food market and EU policies. To illustrate this point, Omar & Thorsøe, (2023) asserted: "Corporate concentration in the EU harms small and medium-scale farmers through unfair trading practices, including surplus dumping and export monopolies in developing countries, with EU agri-food policies prioritizing agri-business investors and trading companies (para. 10)."

For a transition towards sustainability, interviewees 8 and 6 noted the importance of altering the behaviour of these actors in the food system. They suggested creating legislation or incentivizing them to achieve certain sustainability targets as levers to steer their behaviour towards sustainability.

6.9 Farmer's educational exchange and advisory services

The role of farmers' education and advisory services in supporting the transition to sustainable farming systems was identified as leverage point by interviewees 1 and 8. Interviewee 1 reflected on this, stating: "Investing in education, knowledge exchange, and advisory services is essential if we want farmers to change practices ingrained over generations." Likewise, interviewee 8 acknowledged the importance of training, knowledge exchange, and outreach projects in equipping farmers with the necessary knowledge and skills to shift towards sustainable farming practices.

6.10 Geopolitics

Interviewees 2 and 7 mentioned geopolitical events such as wars and EU enlargement as leverage points because of the impact they can have over the EU food system. Although it is not directed towards sustainable EU agriculture, they noted that this leverage point disrupts the entire system. These disruptions create windows of opportunities that can be used for advancing towards sustainability (Richter et al., 2021). Consider the example of the Farm to Fork strategy, as discussed in Section 2.3. The COVID-19 pandemic starkly demonstrated the fragility and unsustainable aspects of the EU food system, thereby creating opportunities for new policy initiatives aimed at improving sustainability, such as the F2F strategy (European Commission, 2020a).

Even though wars are not currently occurring within the territory of any EU member state, their impacts are still felt across the EU and globally. While people may primarily associate these conflicts with migration crises, interviewee 7 highlighted that they also affect food trade due to economic sanctions or trade restrictions. Food trade has become so normalized that countries specialize in what they excel at and rely on others for cheaper food products. When wars erupt, the flow of incoming and outgoing food supply halts. This can be catastrophic because countries are unprepared for shortages in certain imported products and surpluses of other food products intended for export to countries involved in conflict (ID 7).

The war in Ukraine serves as a prime example, illustrating how the EU and global food system are disrupted when war erupts. Russia and Ukraine are leading food, fertilizer, and energy exporters. Russia's blockade of Ukraine's food exports, along with economic sanctions and countersanctions from Russia, generated a shock in the global food and energy supply, resulting in a reduction in agrifood commodities and a global spike in food prices due to increased energy prices and fertilizers. The war in Ukraine exacerbated the vulnerabilities of the EU's food system and exposed the dependency of EU agriculture on key inputs such as energy, animal feed, and fertilizers. While food availability was not at risk in the EU, food affordability for low-income people was jeopardized (Caprile & Pichon, 2022).

"What is important is EU enlargement. So, if Ukraine would join the European Union, that would have an enormous effect on agriculture," said interviewee 7. As highlighted in this quote, another geopolitical event impacting the entire EU but particularly EU's agriculture is EU enlargement. Enlargement occurs when new countries join the European Union, a process that has historically transformed both the new member states and the EU itself. Beginning with six founding members, the EU has expanded to include 27 countries. All European countries can join the EU provided they meet certain economic and political criteria outlined in the Copenhagen criteria. Ukraine stands as one of the candidate countries actively pursuing EU membership (European Union, n.d).

Agriculture is deeply influenced by the process of enlargement for multiple reasons. For one, it is a shared competence between the EU and the member states. Secondly, farmers derive their income from the market and direct payments coming from the CAP's budget. Changes in the budget or how it is distributed directly affect farmers' income. Thirdly, new member states would have access to a free market with strong competitive forces that farmers need to cope with (Koester, 2001).

6.11 Research

Interviewees 3 and 5 underscored the societal impact of research. Both emphasized the importance of sharing research findings, and one of them suggested research topics for to support sustainability transformations.

Interviewee 5 expressed the importance of disseminating research results by highlighting how this information can inspire others to act towards sustainable agriculture or explore topics critical for this transition. As stated, "So I think telling the story of what you are doing with your research, telling the narrative to everyone. It can all lead to turning points for other people" (ID 5).

Similarly, interviewee 3 emphasized the importance of sharing research findings, referring to academia's performative function. He argued that research goes beyond mere observation or description of a phenomenon, asserting that the language used to present information actively shapes people's understanding and perception. Research, therefore, holds the power to enact change or reinforce existing norms and values through its communication and dissemination. Thus, careful attention must be given to how academia presents topics, as they influence society and the perception of individuals holding positions of power.

Elaborating on which research topics can advance sustainability transformations, interviewee 3 discussed his most recent project, which focuses on analyzing food waste practices that already yield positive results. He acknowledged that while these practices are not new, they achieve desired outcomes, such as reducing household food waste. He encourages further research into the factors contributing to the success of these and similar practices, to later incentivize and upscale them.

6.12 Current economic system

Interviewees 5 and 6 referred to the economic system influencing the EU agriculture as a locked-in factor that prevents transformative change and is deeply rooted in our society. Even though this factor does not appear in the subsystems maps, it is reflected in the following factors present in the agricultural specialization and intensification maps: price competition, trade agreements, competitive advantage, pursuit of efficiency, export orientation and economies of scale. Figure 18 illustrates how actors and processes in the food system are chained among themselves and cannot take any steps on their own, even if they want to or are asked to do so.

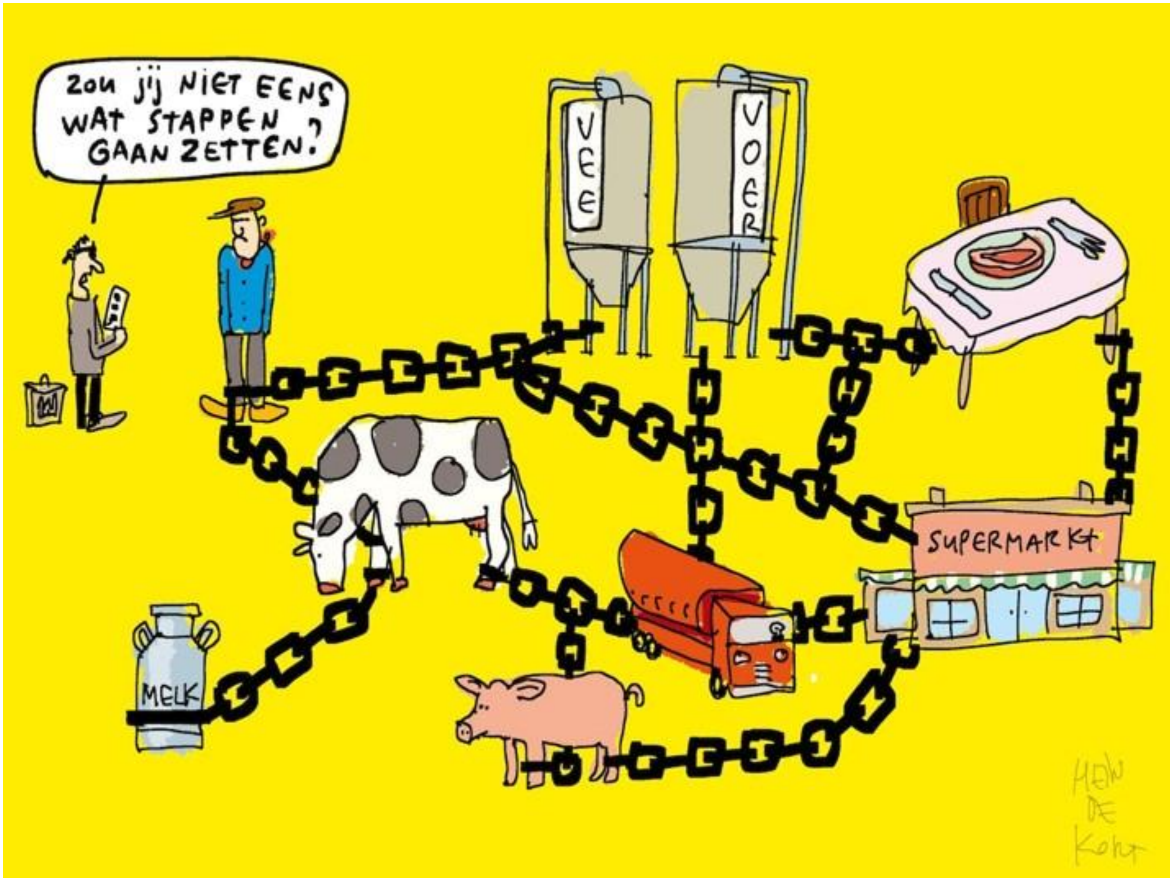

Figure 18 representation of how actors and processes in the food system are in a locked, facing difficulties changing what they do. Source: Hein de Kort, n.d. The English translation of the question in the image is: Why don't you start taking some steps?

Interviewee 6 explained how economic structures maintain the status quo in the current EU agriculture. He mentioned that our economy empowers capitalistic operators in the food system, giving them significant leverage in determining the fate of EU agriculture. As maximizing profit is their primary objective, it is challenging for them to change their behavior unless they lose their capacity to generate profits. According to him, significant change will only occur when they cease to profit from the current EU agricultural system.

Elaborating on the challenges of bringing about transformative change within our current economic system, interviewee 5 emphasized how deeply ingrained capitalism is in our society with the following quote: "It is easier to imagine that the world is destroyed than that we are stopping with capitalism". He reflected on how capitalism has permeated society to the extent that it influences our daily lives and choices. He even used the term "brainwashed" to describe how our behavior and mindset are affected by capitalism. Because our way of living is influenced by capitalism, it is difficult for us to envision an alternative economic system. Drawing on D. Meadows (1999), the difficulty in changing the economic system is due to its status as a deep leverage point. It affects the goals of the system and people's mindsets, which form the foundation of society and influence other aspects of the system, such as processes or parameters.

7 Discussion

This thesis explored the leverage points capable of driving transformative change towards sustainability in EU agriculture. Although previous studies have employed the concept of leverage points to tackle food system challenges, none have focused specifically on EU agriculture. Using an exploratory research design, this thesis adds to the understanding of leverage points for sustainable food systems, with a specific emphasis on EU agriculture. This knowledge equips society to address sustainability issues within the EU food system by indicating areas where interventions should be prioritized to achieve the desired and required transformative change.

This chapter is structured into five sections. The first section offers a summary of the main thesis findings. Following this, the second section delves into the implications of these findings, strategically aiming to catalyse transformative change. The third section explores how the interactions between leverage points can be harnessed to maximize their potential for sustainability transformations. The fourth section explains the need for an adaptive governance model to achieve a sustainable EU agriculture Finally, the fifth section critically reflects on the limitations of this research, providing a comprehensive overview of the study's scope and areas for future exploration.

7.1 Main findings

This section summarizes the main findings of this thesis for each sub research question. Additionally, it explores how these findings connect to previous research, emphasizing commonly identified leverage points.

Regarding RQ 1.1[4], the growth and decline of evolving trends in EU agriculture are shaped by various factors across multiple dimensions: political, economic, and commercial; demographic; socio-cultural; biophysical and environmental; and innovation, technology, and infrastructure. Chapter 5 offers an overview of the multifaceted and multidimensional nature of these trends. The thesis investigates five such trends: loss of agricultural farms, agricultural intensification, agricultural specialization, (sub)urban food production, and alternative agricultural systems. The loss of agricultural farms trend, identified through interviews, encompasses diverse aspects such as abandoned farmland, repurposing for activities like afforestation, and the dwindling number of small-scale farms. This trend is influenced by factors across all five dimensions. Similarly, alternative agricultural systems and (sub)urban food production are shaped by factors from all dimensions, with no single dimension predominating. In contrast, agricultural intensification and specialization are predominantly driven by economic considerations, with factors primarily falling within the economic, political, and commercial dimension.

[4] RQ 1.1. What are the factors contributing to the growth and decline of the evolving EU agricultural trends?

Regarding RQ 1.2[5], seven factors were identified as potential leverage points due to their high out-degree value and low in-degree value. **Technological innovation** emerges as a standout factor, exhibiting the highest out-degree value and zero incoming connections. It influences three out of the five agricultural trends and one overarching trend, as well as factors across various dimensions. The **Common Agricultural Policy (CAP)** follows as the second most influential factor. Like technological innovation, it impacts factors as well as three of the five agricultural trends and one overarching trend. The other potential leverage points with a high out-degree value and low in-degree value are **climate change**, **urbanization**, **environmental concerns**, **land prices**, and the **price of energy-related inputs**. These potential leverage points also directly influence agricultural trends and the factors influencing the development of these trends.

Regarding R.Q 1.3[6], seven key aspects were identified leverage points based on expert responses, with two of them already recognized through the calculations of in-degree and out-degree values of the factors influencing the trends: policy, which includes the CAP, and technological innovation. **Policy** emerged as the most frequently mentioned leverage point, with more than half of the interviewees highlighting its significance. Additionally, the **concentration of power among food processors and retailers** was identified as a leverage point due to its overarching influence on the EU food system. **Technological innovation** was also cited as a significant leverage point. However, caution is needed to avoid viewing it solely as a quick fix to optimize the current situation. There is a risk that it may inadvertently reinforce unsustainable practices instead of addressing their root causes. The importance of **farmers' education and advisory services** in facilitating the transition to sustainable farming systems was underscored as another leverage point. **Geopolitical events** such as wars and EU enlargement were also mentioned as leverage points, despite not being linked to sustainable agriculture, due to their potential to disrupt the entire food system. **Research** was identified as a leverage point because of its influence on society, including informing, providing solutions, and framing problems. Lastly, the **current economic system** influencing EU agriculture was described as a locked-in factor that impedes transformative change and is deeply entrenched in society.

7.1.1 Drawing connections to previous research: commonly identified leverage points

Riechers et al., (2021) point out three deep leverage points for sustainability transformations. One of them is shifting the economic growth paradigm to focus on human well-being. The authors argue that instead of mitigating the adverse effects of increasing production and consumption of goods, the emphasis should be on evaluating how the economy can support the three dimensions of sustainability and find alternatives to constant economic growth. This

[5] RQ 1.2 Based on the factors contributing to the growth and decline of the evolving EU agricultural trends, which ones are leverage points?

[6] RQ 1.3 What are the leverage points that experts identify within or outside the evolving EU agricultural trends?

leverage point relates to one of the main findings on the current economic system. Both the authors and experts acknowledge how challenging it is to alter this leverage point since economic growth is deeply ingrained in society. However, both emphasize it is due to the transformative potential it has to bring about sustainability.

Some of the findings from the articles presented in Section 3.6 overlap with the leverage points identified in this research. For instance, Poelman et al.'s (2023) findings on leverage points for healthy and sustainable local food environments, such as anti-lobbying from the food industry and the industry's willingness to change, are related to the leverage point of concentration of power by food processors and retailers. Experts recognized the significant influence of the food industry on decisions within the food system, exemplified by lobbying efforts. Similarly, they also acknowledged that the industry's willingness to change is pivotal, given its substantial power to influence decisions over prices, wages, and even the food produced. Additionally, Poelman et al. (2023) identified food policy as a leverage point, which coincides with the policy leverage identified in this research, particularly regarding the Common Agricultural Policy (CAP).

In their identification of leverage points to achieve global sustainability, two of Chan et al.'s (2020) findings relate to this research's leverage points. One is responsible technology, innovation, and investment, which aligns with technological innovation as a leverage point. The authors underscore the importance of technology and innovation being preemptive in driving sustainability transformations, rather than merely reacting to changes in the system. To illustrate, they contrast nature-based solutions, which generates changes to advance towards sustainability, with end-of-pipe technologies, which reactively mitigate negative outcomes after they occur (Chan et al., 2020). Placing the focus on responsible and preemptive technology and innovation addresses experts' concerns about how technology is perceived and implemented to prevent quick fixes that reinforce the current status quo.

The second finding is education and knowledge generation and sharing, which is related to farmers' educational exchange and advisory services (Chan et al., 2020). Given the thesis's focus on agriculture, the knowledge and education discussed are specific to farmers' needs. Experts emphasized the role of farmer educational exchange and advisory services in facilitating the transfer of knowledge about alternative and (sub)urban agricultural systems. Chan et al. (2020) elaborate on the role that this leverage point should play in pathways to sustainability transformations which can influence deep leverage points. Instead of imparting knowledge, education should build upon existing knowledge, foster social learning, and adopt a 'whole person' approach. This approach recognizes that students not only need specific job-related skills but also have emotional and social capabilities that should be considered and cultivated. Nurturing these capabilities can instil in farmers social values that encourage them to contemplate how they can contribute to sustainability and take action. According to Fischer & Riechers (2019), people's values represents a deep leverage point within the system that can be influenced.

7.2 Reflecting on the main findings in the light of transformative change

After identifying leverage points for sustainable EU agriculture, it is essential to consider their potential to catalyse transformative change. These leverage points represent areas within the system capable of yielding system-wide effects. However, realizing this potential depends on how they are influenced to support transformations towards a sustainable EU agriculture. Therefore, the subsequent sections in this chapter discuss how interventions at these points can support sustainability transformations. This particular section reflections on the results in the light of the following four key aspects of transformative change, as detailed in Section 3.3:

1. It describes a form of change that transcends mere adaptation, involving the rearrangement of existing or new elements within a system in fundamentally novel ways.
2. It encompasses not only technological changes but also changes in social and ecological systems.
3. Transformation often challenges the status quo, threatening those who benefit from current systems and structures.
4. The call for transformative change implies that previous efforts have been insufficient and inefficient; "More of the same" is not a relevant cure.

Considering the first aspect, when designing levers for these leverage points, one should consider novel approaches that not only alleviate symptoms but also restructure the system to address the underlying causes of these symptoms. Consider the example of policy, which was identified in both analyses as an important lever. It is crucial that interventions at this point, in the form of reforms, do not solely focus on adapting to better cope with the consequences of current agricultural challenges. Instead, policies should reconsider their foundations and past dependencies to cut ties with those that are no longer relevant and may contribute to sustainability issues.

Recent farmers' protests across Europe exemplify how mere policy adaptation is insufficient in addressing sustainability issues. As mentioned in Section 2.5, EU agriculture confronts multiple sustainability issues. In 2023, the new CAP reform was implemented, embracing sustainability objectives and introducing additional measures for farmers to adopt environmentally friendly farming practices. However, rather than feeling supported and encouraged to continue with their livelihoods and protect the natural environment, they feel burdened. Farmers are not opposed to protecting the environment and embracing sustainability; their discontent lies in how these goals are pursued and who bears the associated costs (Pronczuk & Moses, 2023). They already face numerous challenges such as inflation, a declining number of farmers, and pressure from lower and unfair competition with goods from outside the EU (Henley, 2024). In response, EU's approach has been to relax rules and create exemptions. For instance, it withdrew a proposed law to halve the use of pesticides in Europe (Riegert, 2024). Instead of making progress towards sustainability, EU agriculture remains stagnant as long as the CAP do not fundamentally rearrange how agriculture functions, acknowledging and addressing the root causes of sustainability issues.

Evaluating the elements and purposes of the system can pave the way for the identified leverage points to support transformative change. As mentioned in the conceptual framework, a system consists of elements, interlinkages, and purposes, with the latter having the highest potential to transform the system. By assessing which elements and purposes align with the desired state of EU agriculture, these leverage points can be used to reinforce existing elements, introduce new elements to the system, and generate purposes that support the envisioned transformation. Priority should be given to interventions at leverage points that can influence the purposes of the system. Continuing with the example of the CAP, this leverage point can be influenced to generate purposes that embrace the three dimensions of sustainability by introducing new goals and supporting or including elements to this policy that advanced towards the desired state (e.g., fair payment to farmers for both their produce and ecosystem services they provide).

Regarding the second aspect, leverage points belonging to the innovation, technology and infrastructure dimension should not be targeted in isolation but rather integrated with leverage points belonging to other dimensions. Technological innovation, as determined by degree distribution measurements, emerges as the factor with the highest potential to influence evolving EU agricultural trends. However, while it holds considerable influence, it should not be the sole focus for achieving EU sustainability. As discussed in Section 6.1, caution is necessary to avoid technological quick fixes that may obscure the root causes of sustainability issues. Therefore, interventions in technological innovation should be complemented by levers targeting leverage points of other dimensions, forming part of a comprehensive toolbox (e.g. Parsons & Barling's (2021) food policy toolbox) aimed at reframing social and ecological aspects of the system.

For instance, technological innovation can be targeted in combination with another leverage point, such as farmers' knowledge and skills. Interventions such as blockchain technology and specialized training for farmers can enable them to inform consumers about how food is produced and the impact it has on environment and society. Additionally training equips farmers with digital skills necessary to effectively utilize this technology to communicate the sustainability of their farming practices.

Regarding the third aspect, leverage points influencing the status quo are key to bring about transformative change. One of these leverage points identified by experts is the concentration of power by food processors and retailers. The main beneficiaries of the food system are food processors and retailers who have taken control over multiple stages of the food chain and have the leverage to lobby and bargain for their interests. The more power these actors have, the more control they exert over policies, agricultural inputs, prices, and wages. Thus, farmers are often at the mercy of their interests, having little power to negotiate. Omar & Thorsøe (2023) argue that for a just transition to sustainable food systems envisioned by the Farm to Fork strategy, there needs to be a rebalance of power and strengthening of the position of farms in the food system. For transformative change, this leverage point needs to be targeted to prevent power concentration and rethink how and who should benefit from the EU food system.

The adoption and enforcement of a legislative framework for sustainable food systems represent a pivotal policy lever to redistribute power and alter the prevailing status quo. Experts highlight that legislation could effectively steer the behaviour of food processors and retailers towards sustainability. The likelihood that these actors will voluntarily change their behaviour is low, given that they currently benefit the most from maintaining the status quo. Therefore, legislation mandating compliance is deemed more effective in driving sustainability transformations. Nevertheless, this lever encounters challenges with adoption, as it was expected to have already been implemented and is not currently part of the EU Commission's agenda for the year.

Regarding the fourth aspect, it is vital to govern interventions across all identified leverage points within a model that acknowledges the complexity and interconnectedness of dimensions within EU agricultural systems. Conventional methods have proven ineffective and insufficient in promoting sustainability, mainly due to their narrow focus and oversimplified approach. Even when interventions are innovative, their effectiveness can be hindered by governance systems that don't facilitate their ability to address the complex issues within EU agricultural systems, often encountering various obstacles along the way (Termeer et al., 2015). To exploit the transformative potential of leverage points and levers, it is beneficial to consider how governance can enable these transformations. Further exploration of a suitable governance model for transforming EU agriculture through identified leverage points is discussed in Section 6.

7.3 Maximizing the transformative potential of leverage points

As discussed in Chapter 3, the leverage points perspective postulates that achieving transformative change is improbable when only addressing shallow leverage points. Nevertheless, it acknowledges the practical challenges associated with addressing deeper leverage points, despite their potential for transformative change. Consequently, one may question: Which leverage points should take precedence in intervention efforts? Should priority be given to shallow, easily accessible points, or to deeper ones? Alternatively, could a balanced approach targeting both types be more effective?

Research conducted by Pérez-Ramírez et al. (2021) demonstrates how certain interventions, while easy to implement, only target shallow leverage points, yet can exploit the potential within the interlinkages of leverage points and form chains of leverage. These interventions, directed at shallow leverage points, can instigate changes across various levels of the system. To exemplify their argument, consider one of the examples in their research on human-nature connectedness using a participatory collective farming initiative. They consider the allocation of time for developing an agroecological project by individuals as a shallow leverage point. Although easily influenced, this point lacks the transformative potential compared to reshaping norms and values to foster a transition towards an agroecological paradigm, emphasizing the interconnectedness between humans and nature. Nonetheless, Pérez-Ramírez et al. emphasize that modifying this shallow leverage point to allow individuals to spend more time engaging outdoors in agroecological projects results in a heightened connection with nature among participants, indicating how this leverage point can contribute to changes in deeper leverage points.

Another example illustrating the potential of interactions between leverage points is showcased in the research by Manlosa et al. (2019). The authors investigated the interplay between different depths of leverage points for gender-related changes. They assert, “While changes at deep-leverage points drive the overall trajectory of a system, our findings suggest that changes at shallow-leverage points created important “sparks” that contributed to enabling conditions for deeper changes” (p.537). The authors describe how gender-aware policies paved the way for legitimizing women´s involvement in public life and take actions that were previously socially unaccepted. These interactions between leverage points amplify the potential for transformative change and facilitate engagement with deeper leverage points (Manlosa et al., 2019).

If there is transformative potential in the interactions between leverage points, how can one maximize this potential when intervening at shallow and deep leverage points? As outlined in the conceptual framework, leverage points exist along a spectrum of depth, where shallow leverage points pertain to causal approaches (changes stemming from variables influencing one another), and deep leverage points relate to teleological approaches (human intent). Riechers et al. (2021) argue that bridges between these approaches are essential for harnessing the potential for transformative change as they provide practical pathways to achieve desired outcomes. The authors regard directionality as a means of bridging approaches and maximize the potential of interventions at shallow and deep leverage points. Visioning exercises aimed at envisioning a desired state can be particularly useful in establishing such directionality (Rana et al., 2020; Riechers et al., 2021).

Having a common vision for the sustainability of the EU agriculture is key to harness the transformative potential of the leverage points. Schebesta & Candel's (2020) reflections on the transformative potential of the Farm to Fork (F2F) strategy note that one of the shortcomings of this strategy is the lack of a clear definition of sustainability. As explained in Section 2.3, sustainability encompasses multiple and contrasting. Despite the strategy's reference to sustainability, achieving it becomes challenging without a shared understanding of what sustainability entails. Therefore, visioning exercises for sustainable EU agriculture are crucial for harnessing the potential of intervening at both deep and shallow leverage points. The importance of this shared vision is also highlight by Parsons & Barling (2021) as it sets the basis for a coherent policy mix.

7.4 Implications for the governance of sustainability transformations in the EU agriculture

As mentioned in Section 7.2, the governance model plays a pivotal role in either facilitating or impeding interventions at leverage points for transformative change. Traditional governance models prove inadequate for the transformation of EU agriculture, as they fail, in the words of Donella Meadows, to 'dance with the system,' due to their often rigid and compartmentalized structures (Daviter, 2017; Folke et al., 2005). The conceptual framework elucidates that systems thinking entails embracing the uncertainty and complexity inherent in systems, and operating in adaptive, flexible, and learning-oriented manners. Consequently, this section explains three main reasons why adaptive governance is a suitable model to catalyze the transformative potential of leverage points for a sustainable EU agriculture.

Firstly, adaptive governance facilitates inclusivity as it fosters deliberation and transdisciplinary knowledge exchange (Glass & Newig, 2019). Inclusivity is an important aspect of both sustainability and systems thinking. As mentioned in Section 2.3, social acceptability and inclusivity are important components of sustainable EU agriculture. Additionally, Woodhill & Millican (2023) highlight that systems thinking involves "Recognizing that different people and different groups have legitimately different perspectives and see 'the system' differently (p. 8). Thus, the deliberation and transdisciplinary approaches of adaptive governance facilitate the engagement of diverse academic and non-academic stakeholders and co-creation of knowledge, which is necessary for a sustainable EU agriculture.

Secondly, adaptive governance fosters continuous learning. In systems where change is constant and often unpredictable, the ability to reflect upon and learn from these changes is crucial for effective response. This necessitates a governance model capable of monitoring shifts, innovating in response, and adapting to evolving circumstances (Glass & Newig, 2019; Schultz et al., 2015). The capacity for ongoing learning within adaptive governance contributes to these essential functions.

Thirdly, this governance model facilitates policy coherence through collaboration and coordination of actors involved in EU agriculture. Applying systems thinking to agriculture shows how different policy domains (e.g., urban and rural development) are interconnected and this influence one another. Traditionally, these policies domains have been treated in isolation which increases trade-offs between policies and reduces the possibilities to enhance synergies between them. Increasing collaboration and coordination between actors to achieve common goals is required for policy coherence, which is particularly relevant in Eu agriculture because as Schebesta & Candel (2020) mention that many EU and national actors can influence the sustainability of the agricultural system. Tensions often arises between them due to competing interest and different commitments and perspectives on how to achieve transformative change. Thus, adaptive governance can contribute for various policies to be aligned to maximize their synergies and reduce their trade-offs.

7.5 Limitations

This section reflects on the limitations of this research and how future research can overcome them.

Firstly, there is a bias in the interview sample towards academics, and they predominantly come from Western Europe. It was challenging to get in contact and schedule an interview with policymakers, policy advisors, and practitioners during the time allocated for the semi-structured interviews. Also, the geographical location of interviews could not include representatives from Southern Europe. Due to the diversity of perspectives that experts can bring depending on their background and role in the food system as well as the geographical areas they come from, this research could benefit from diversifying the perspectives presented.

Secondly, the analysis performed to identify leverage points focused on their impact rather than assessing the ease and who can influence them. While the definition of leverage points (see Section 3.4) is mostly linked to the impact these points have on the system's behaviour, Roxas et al. (2019) establish that a criterion for a leverage point selection is ensuring they can be influenced by an intervener. This aspect is not explored in this research, highlighting the need for follow-up research to investigate the ease of influencing the identified leverage points and determining who is able to do so.

Thirdly, while these maps effectively illustrate the factors influencing the development of agricultural trends, they fall short in depicting feedback loops, delays in influence, or ranking the importance of these factors. Understanding these reciprocal relationships would provide valuable insights for prioritizing areas of intervention. Currently, there is no ranking system to determine the relative importance of each factor, nor are there feedback loops to capture the dynamic interplay between them. As mentioned by interviewee ID 1, "The fact that you identify a dot, if you like, that there is a factor, it kind of gives them all equal status in the map whereas in practice some are going to turn out to be more important than others.

In response to this observation, it is essential to acknowledge that these maps serve as starting points for identifying areas where change can be initiated. Moving forward, it would be beneficial to develop causal loop diagrams to capture these aspects, adding another degree of complexity to the map. This action aligns with the follow-up steps proposed by PLAN'EAT researchers to address these concerns.

Fourthly, from the perspective of the interviewees' responses, it's important to acknowledge bias and the potential for different interpretations of a concept. Researchers may exhibit bias when they view research itself as a leverage point, as evidenced by one researcher mentioning their latest grant-funded project. Additionally, it's crucial to recognize the limitations in comparing interviewees' responses on the map of alternative agricultural systems, given the diverse range of farming practices encompassed within this category. Despite providing a definition of alternative farming systems, it still encompasses a wide range of practices. For example, one researcher may be thinking about organic agriculture while another may be considering permaculture. This variation raises questions about the comparability of their feedback on the subsystem map of alternative farming systems.

8 Conclusion and recommendations

By analyzing evolving EU agricultural trends, this thesis has described the factors influencing their development and identifies which could be leverage points for sustainability. The focus on evolving EU agricultural trends is to take advantage of their motion to ignite transformative change towards sustainable EU agriculture. The identification of factors influencing the growth and decline of these trends has shown the multidimensional nature of the trends and demonstrated how a couple of factors can exert influence over numerous trends and/or factors, thereby potentially triggering system-wide change. These factors leading to system-wide effects, along with those mentioned by experts to induce system-wide effects within or outside agriculture were identified as leverage points. This compilation of leverage points from various dimensions provides the opportunity to create and utilize chains of leverage, rather than concentrating on individual leverage points. This approach allows for maximizing their transformative potential more effectively.

As explained in Chapter 3, this thesis employed an exploratory research design due to limited existing knowledge on the topic and utilized a sequential mixed-methods approach to triangulate and complement results. A literature review was conducted to gather factors influencing evolving EU agricultural trends, which were subsequently mapped into subsystems maps. These maps illustrate that (sub)urban food production, alternative agricultural systems, and the loss of agricultural farms are shaped by multiple factors from all dimensions, with no single dimension predominating. In contrast, agricultural intensification and specialization are predominantly driven by economic considerations, with factors primarily falling within the economic, political, and commercial dimension. Through qualitative content analysis of expert interviews, these maps were refined, and leverage points were identified. Afterward, a social network analysis of the refined maps was conducted to identify factors exerting the most influence over the system while being the least influenced by others. These factors were added to the list of leverage points. Notably, the CAP and technological innovation emerge as key leverage points, identified through both data analysis methods.

The identification of leverage points within and beyond EU agricultural trends contributes to the EU's sustainability commitments expressed in the Farm to Fork Strategy. These leverage points serve to address the calls for transformative change and concerns regarding the strategy's capacity to achieve sustainability by highlighting areas where prioritized change would lead to system-wide effects.

This research has demonstrated that points within EU agriculture can lead to system-wide effects and, as part of a system, should not be approached as a recipe book for creating sustainable EU agriculture. Instead, I recommend practitioners approach them under an adaptive governance model, which fits the characteristics of the system and key aspects of transformative change. This governance model will enable the transformative potential of leverage points and enhance synergies among them. To fully utilize the transformative potential of leverage points, the interconnections between them should be utilized to influence other leverage points at different depths. There is no need to focus solely on one type of leverage point; instead, leverage the potential of their interlinkages to create a chain of leverage. Additionally, when utilizing these chains of leverage, it is important to ensure their coherence so that they are directed to achieve a common goal.

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10 Appendix I

10.1 Example of a table for the creating the subsystems maps

This section presents the table for (sub)urban food production trend, which was filled in with data on the first and second-order factors influencing its development.

Trend 4. Peri-urban and urban food production

Peri-urban and urban food production definition: "the production of food and non-food plants, as well as animal husbandry, in urban and peri-urban spaces (Santo, R., Palme, A. & Kim, B., 2016, p.1)."

Table 1. First order relations of (sub)urban food production

Trend	Variable	Effect	Dimension	Source
Peri-urban and urban food production	Space available for farming	+	Biophysical and environmental dimension	(Sartison & Artmann, 2020)
	Distance to reach the UFP area	-	Environmental and biophysical dimension	(Sartison & Artmann, 2020)
	Urban food policy	+	Economic and political dimension	(Olsson et al., 2016)
	Deregulation of national agricultural policy	+	Economic and political dimension	(Olsson et al., 2016)
	Demand for local food	+	Economic and political dimension	(Olsson et al., 2016)
	Civic engagement and participation	+	Socio-cultural dimension	(Sartison & Artmann, 2020)
	Political support for urban farming	+	Socio-cultural dimension	(Sartison & Artmann, 2020)
	Establishment and maintenance costs	-	Economic and political dimension	(Sartison & Artmann, 2020)
	Interest in transparency	+	Socio-cultural dimension	(Preiss et al., 2022)

	and sustainability			
	Innovative technologies	+	Innovation, technology and infrastructure dimension	(Preiss et al., 2022)
	Soil contamination	-	Biophysical and environmental dimension	(European Parliament. Directorate General for Parliamentary Research Services., 2017)
	Networking, marketing, and entrepreneurial farmers' skills	+	Socio-cultural dimension	(European Parliament. Directorate General for Parliamentary Research Services., 2017)
	Dependency on public funds, donations and grants	-	Economic and political dimension	(European Parliament. Directorate General for Parliamentary Research Services., 2017)

Table 2. Second order relations of (sub)urban food production

Variable (first-order factor)	Variable (second-order factor)	Effect	Dimension	Source
Space available for farming	Diverse land uses interests	-	Biophysical and environmental dimension	(Olsson et al., 2016)
	Urbanization	-	Demographic dimension	(Artmann & Sartison, 2018b)
	Multifunctional land-use	+	Biophysical and environmental dimension	(European Parliament. Directorate

				General for Parliamentary Research Services., 2017)
Urban food policy	Demand for Integration of urban farming into agricultural and spatial policies	+	Economic and political dimension	(European Parliament Research Service, 2014)
Civic engagement and participation	Negative perceptions about UFP	-	Socio-cultural dimension	(Artmann & Sartison, 2018b)
	Trust	+	Socio-cultural dimension	(Artmann & Sartison, 2018b)
	Citizens' motivation	+	Socio-cultural dimension	(Artmann & Sartison, 2018b)

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10.2 Participants' information sheet and consent form

Participant information sheet for PLAN'EAT

T2.2 expert interviews

As researchers of the PLAN'EAT project, we aim to better understand how the EU food system works. Those insights will be used to develop policy recommendations for improving sustainability and health of food consumption in the EU. Below you can find an explanation of the research.

EU food system map

In our research, we aim to better identify, understand, and influence mechanisms underlying food consumption. To realize this aim, we have developed an EU food system map that shows current trends in the food system, and factors influencing those trends. We will use this EU food system map to find places in the system where a change can have system-wide effects. Such places in the system where an intervention can have system-wide effects are called leverage points.

We have contacted you because we consider you to be an expert in your field and we hope your participation will help us improve the system map and locate leverage points. To do so, we have a series of questions we would like to ask you during an online interview. Participation in this study is completely voluntary. You can stop at any time, and you are not obliged to provide any explanation for discontinuing your participation.

Data collection

During the online interview, the following data will be collected from you: name, occupation, and opinions about the EU food system map and about the trends the map is describing. The researcher will record the online interview and make an automated transcript. This data will be used to improve the EU food system map and to locate leverage points.

Your data will be pseudonymized within a retention period of 6 months. After pseudonymization, your data will be stored securely and retained for a minimum of 10 years.

We retain the data so that other researchers have the opportunity to verify that the research was conducted correctly.

Part of the data we collect may be useful in pseudonymized form, for example for educational purposes and future research, including in very different research areas. We will make the data publicly available after proper pseudonymization. We ensure that we do not disclose anything that identifies you.

Do you regret your participation?

You may regret your participation. Even after participating, you can still stop. Please indicate this by contacting the researcher that interviewed you within 6 months after participation. Within that retention period we will be able to delete your data and prevent its use in publications upon your request. Sometimes we need to keep parts of your data so that, for example, the integrity of the study can be checked.

Questions

If you have any questions about the study or your privacy rights, such as accessing, changing, deleting, or updating your data, please contact the task leader.

Name: Erik Mathijs

Phone number: +32 16 32 14 50

Email: erik.mathijs@kuleuven.be

Consent form for audio-recorded and transcribed interview for the PLAN'EAT project (T2.2)

☐ I have read the participant information sheet and understand the purpose of the research.

☐ I understand that if I decide I no longer wish to take part in this research I can notify the researcher involved and withdraw within one month after the interview.

☐ I consent to the processing of my personal information for the purposes of this research. I understand that such information will be treated as strictly confidential and handled in accordance with the provisions of data protection legislation.

☐ I understand that the information I submit, including pseudonymized direct quotes, may be included in any resulting report.

☐ I understand that during the interview, audio and video recordings of my participation will be saved and automatically transcribed for accuracy, and I consent to the use of this material as part of the project.

☐ I agree the project named above has been explained to me to my satisfaction and I agree to take part in this research.

Date (YYYYMMDD): ______________________

Name: ______________________

Signature: ______________________

10.3 Task 2.2 PLAN'EAT interview guide

Instructions for the interviewer are in *italics.*

The text you as a researcher should read out loud is in **bold.**

Introduction to the research

Hello, I am [your name] working for the PLAN'EAT project. Thanks for participating in this study. What we will be doing next is discussing some questions about the EU food system map that you have received in advance. I hope that you can help us improve this map and help us locate leverage points. But before we start, I would like to check whether you have read and signed the consent form and/or if you have any questions about the conduct of this study.

Interview questions

1. **Can you tell me something about your expertise?**
   What is your professional occupation? What educational background do you have? What is your previous work experience? What led you to become interested in your field?

2. **What do you think about the current state of the EU food system?**
   What are the problems and opportunities? Health & sustainability? What are current modes of production, processing, retailing, and or consumption, and are those good or bad?

3. **How do you see the future of the EU food system evolving?**
   Where do you think the main changes are happening? Where do you think the EU food system is heading to? Is that desirable?

Share your screen/tab with the interviewee to present the EU food system map. Take a close look at each trend separately. First, show the EU food system map at large to allow the interviewee to reflect on the whole system map.

4. **To check whether this map is clear, what do you think the map represents?**

   What do you find striking in this map? Is there anything unclear?

Now, move to the zoomed in version of the map. The following questions mainly regard the zoomed in version of the map covering the area of expertise of the interviewee.

5. **What do you think can be rearranged or should be changed in this map?**

6. **What factors and/or interactions do you think are missing?**

7. **Do the arrows illustrate the correct kind of feedback and interaction?**
   Namely positive, negative or ambiguous? *Can you spot any mistakes?*

8. **What places in this map would have the largest influence on the system when that place would be modified?**

Which of these factors or interactions do you think have the largest potential to influence the system? On the basis of the EU food system map, what leverage points can be utilized to accelerate trends or innovations in a more sustainable and/or healthy trajectory?

9. **Can you think of places in the EU food system that might have a large influence on the system that are not properly reflected in this map?** Can you rank the leverage points in increasing order of influence on the food system?

10. **What do you think are the most important trends or innovations in the EU food system?**
How will values and worldviews be impacted if the leverage points are changed? Can you say which leverage points might be the easiest to realize? Can you think of other worldviews, values, and goals of the EU food system that are not represented in this map?

10.4 Task 2.2 PLAN'EAT interview summary instructions

Please summarize the interview in your own words in roughly 1 page. Pay close attention to recommendations for improving the causal loop diagrams, as the main focus of the interview is to validate the EU food system map and adjust the findings where necessary. The most relevant questions for validating the EU food system map are questions #5, #6, and #7 (see the section '2. During the interview').

Please provide the following information in the summary of the interview:

- Date of the interview:
- Name of the interviewer:
- Name of the interviewee:
- Interviewee ID:

10.5 Link to the maps in Kumu

Please use this link to view the subsystem maps of the evolving trends in the EU food supply, including the ones corresponding to agriculture: https://embed.kumu.io/600f42c8054cbdcbfcc8574f76abebe6