JYU Dissertations 730

Irene Kuhmonen

Imprisoned by the Regime?

Farmer Agency and Farm Resilience in the Making of a Sustainable Food System

JYVÄSKYLÄ UNIVERSITY
SCHOOL OF BUSINESS AND ECONOMICS

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ABSTRACT

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This work explores the role of farmers in the transformation towards a more sustainable agrifood system in Finland. Farmers play a critical role in this process, as the majority of environmental impacts in food systems take place at the farm level, as a result of farmers' choices. At the same time, farmers are acting as price-takers in the value chains of food, which can compromise their ability to act as transition agents. To make sense of farmers' transformative capacities, this thesis builds on the analytical dualism between agency and structure. The structural dimension was analysed through the concept of regime as a temporally stable organisation mode of the agrifood system. In turn, the transformative capacities of farmers were captured via the concept of resilience. When both structure and agency are seen as exerting causal powers on each other, it is possible to explore the extent to which farmers are able to 'act otherwise' in the contemporary food system.

The methodology consisted of both quantitative and qualitative approaches, drawing upon two sets of nationally and regionally representative farmer surveys, conducted in 2010 and 2018, and a literature review that explored the history of the Finnish agrifood system. The results suggest that while transformative farmers were motivated by social and sustainability goals, the most important factor driving their choices was economic profitability. From a farmer's point of view, economic viability and environmental sustainability were not mutually exclusive. Quite the contrary, those committed to farming as a livelihood were most likely to engage in a search for more sustainable pathways. However, due to a tightening cost-price squeeze and an increasing push towards economies of scale, the spectrum of economic viability was becoming more restricted. The same forces that constrain farmer agency and the economic viability of agriculture also contribute to sustainability problems in the food system. These forces originate from the characteristics of the contemporary food regime, especially fossil metabolism and desire for continuous growth. While farmers have the potential to be a transformative force for food system change, they currently lack both the resources needed for transformation and visions of its future direction.

Keywords: agency, agrifood system, critical realism, regime, resilience, social-ecological transformation, structure, sustainability transition, systems thinking

TIIVISTELMÄ

Kuhmonen, Irene
Regiimin kahlitsemat? Maanviljelijöiden toimijuus ja maatilojen resilienssi ruokajärjestelmän kestävyyssiirtymässä
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Maanviljelijät ovat ruokajärjestelmän kestävyyssiirtymän kannalta kenties tärkein toimijajoukko. Valtaosa ruokajärjestelmän ympäristövaikutuksista syntyy maataloudessa, maanviljelijöiden valintojen seurauksena. Samalla maanviljelijät ovat kuitenkin ruokaketjun vähävaltaisimpia osapuolia, joita kurittavat jatkuvat hintapaineet. Kysynkin tässä tutkimuksessa, millainen on maanviljelijöiden rooli ja toimijuus ruokajärjestelmän kestävyyssiirtymässä. Asetelma, jossa pyrin ymmärtämään viljelijöiden tosiasiallisia mahdollisuuksia 'toimia toisin', edellyttää rakenteen ja toimijuuden purkamista erillisiksi ilmiöiksi analyyttisen dualismin hengessä. Analysoin rakennetta regiimin käsitteen kautta. Regiimi edustaa tiettynä ajankohtana vallitsevaa systeemin dynaamisesti vakaata organisoitumistapaa. Viljelijöiden muutostoimijuutta tarkastelen puolestaan resilienssiteorian avulla.

Tutkimuksen aineistot koostuvat vuonna 2010 ja 2018 toteutetuista kansallisesti ja alueellisesti edustavista viljelijäkyselyistä sekä ruokajärjestelmän historiaa koskevasta kirjallisuuskatsauksesta. Tutkimuksen tulokset osoittavat, että tärkein maanviljelijöiden valintoja ohjaava tekijä on taloudellinen kannattavuus. Samalla muutoshakuisia viljelijöitä motivoivat kestävyystavoitteet ja tuotantoon kytkeytyvä sosiaalinen vastuu. Viljelijän näkökulmasta taloudelliset ja ympäristöön liittyvät tavoitteet eivät sulje toisiaan pois, vaan päinvastoin: kestävyysnäkökohdat olivat usein tärkeitä nimenomaan niille viljelijöille, joille maatalous on tärkeä toimeentulon lähde. Samalla kuitenkin maatalouden taloudellinen kannattavuus kytkeytyy jatkuvien hinta- ja kustannuspaineiden vuoksi koko ajan vahvemmin yksikkökoon kasvuun ja erikoistumiseen, mikä kaventaa viljelijöiden toimintatilaa. Nämä samat tekijät ovat myös ruokajärjestelmän kestävyysongelmien tärkeimpiä ajureita. Nämä kehityskulut kytkeytyvät vallitsevan ruokaregiimin toimintalogiikkaan, jota hallitsee fossiilienergiaan kytkeytyvä yhteiskunnallinen aineenvaihdunta ja jatkuvan kasvun logiikka. Vaikka viljelijöillä on potentiaalia toimia ruokajärjestelmän muutosta ajavana voimana, heiltä puuttuu sekä muutoksen vaatimia resursseja että visioita muutoksen suunnasta.

Avainsanat: kestävyyssiirtymä, kriittinen realismi, rakenne, resilienssi, ruokajärjestelmä, sosio-ekologinen transformaatio, systeemiajattelu, toimijuus

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FOREWORD

If I would have to be making a bet about which parts of this work most likely actually get to be read, my stakes would be high on the foreword. But now that I have your attention, I still suggest that you would have a look at some of the content stuff as well. I have taken a fascinating journey in and around the topic of food system transformation, and I would be happy to share some of those insights with you as well. This journey is now coming to an end. Having said that, as it happens to be in research, answering some questions tends to bring new puzzles to be solved, so I am by no means done with this topic, but eager to continue the explorations on food, sustainability, primary production and systemic change. I feel very privileged to be able to call research my profession, and now the time has come to extend this gratitude for all those people involved, those who have made it possible and have taken part in the journey of becoming a researcher. For even though doing one's PhD can be a solitary journey, it cannot be taken alone. There are those people who have taken on the paths I have been walking on now before me, on whose ideas I build my own understanding; there are those people who have afforded me with the necessary skills and resources to take on the journey; and then there are the people with whom I have been walking – and quite often the roles are a mixture of all of these.

An often-cited example of complexity, one of the building blocks of the theoretical framework I have adopted in this work, is the butterfly effect – the idea that due to complex, non-linear and cascading interactions, a small change in the initial conditions of a system can make a huge difference with respect to the end result. It is fascinating (and perplexing) to ponder on one's life course, whether there would have been many routes to end up where I find myself being now – was there a strong drive towards this path – or is this state the mere consequence of a game of chance? Either way, looking back, I can identify several nodes that have been critical for the observed end result – the fact that I am sitting at the kitchen table in my home in Vesanto on a chilly autumn Sunday morning, writing the foreword for this dissertation. One of those nodes was getting to know Hanna-Leena Pesonen, my custos and supervisor, while being employed by the Institute for Environmental Research (Ympäristöntutkimuskeskus or YMTK as all the former employees know the place), before embarking on an academic career. I was involved in a very interesting evaluation project of the Rural Development Programme but was still junior rank, when the senior researcher changed the workplace, and there was no one else with a matching expertise in the house. To be able to continue with the project, Hanna-Leena, as the chairwoman of the Institute's board and as a professor of Corporate Environmental Management (now also dean), possessed relevant knowledge of the field and promised to watch my back. The fruits of this work have carried all the way here, as it is the data from this project that I utilised for both the first and second articles of my dissertation. I am forever grateful for your trust, Hanna-Leena. When the time came ripe, it was easy to approach Hanna-Leena again and ask about the possibility to join the research team of Corporate Environmental

Management at Jyväskylä School of Business of Economics (JSBE). Hanna continued to watch my back for this project as well. Thank you for all your support over all these years.

I got another supervisor from JSBE – Marjo Siltaoja, now the associate professor of leadership and management. I can only imagine how your feelings have shifted from despair to faint hope and eventually relief with this project – or perhaps it is better that I don't try to imagine too much. From the very beginning, Marjo was going on all about theory, when I had come to work on a very practical, hands-on research, having decided to stay as far away from all conceptual-philosophical twists and turns as possible. As it turned out, it did not quite work like that. It was probably the first research seminar I attended where Marjo suggested that resilience could be a useful concept for my work, and where I was like " yeah I know what it's about but I don't think I want to go in that direction." Looking back, I don't know how much trouble I would have saved, being less stubborn and more open to new ideas from the beginning. I guess I have learned my deal of humility since. Marjo never pushed her ideas on me but rather forced me to look at my own ideas and work critically. Over time, this approach carried its fruits. I have enjoyed working with you and your twisted sense of humour, and I appreciate you having taken the time to comment on my work on notices that have tended to be rather short. I especially want to acknowledge the article we wrote together for this thesis, which was a great experience of co-writing, finding the overarching thread for the piece and building on each other's ideas.

I had the privilege of getting a third supervisor from the Natural Resources Institute Finland, Senior Scientist Jyrki Aakkula. I got to know Jyrki while working on the aforementioned evaluation project, and later he asked me to join the stakeholder group for an EU-wide research project he was working on. Jyrki has solid knowledge of the field of agri-environmental policies, and his contribution was invaluable especially when I was only trying to get a grasp of the field in terms of academic research. When reading a draft version of the dissertation manuscript, he commented that he now understands better the stumbling blocks of agrifood sustainability transitions. These words matter a lot to me – for what else could be the function of research than gaining and sharing understanding.

I want to express my gratitude to Associate Professor Anne Touboulic from Nottingham University, UK, and Professor Domenico Dentoni from Montpellier Business School, France, for agreeing to act as my pre-examiners, and Professor Dentoni for acting as the opponent for this thesis. They both provided perceptive and constructively critical comments on my work. Their input is further highlighted by the fact that they both have researched farmers and agrifood systems from the resilience perspective, and I consider myself fortunate to have these two esteemed academics to read my work. I came across Professor Dentoni's work relatively recently, but was excited to find out about a researcher with a business background and with similar approaches and arguments about the phenomenon I had investigated. Indeed, while agrifood systems have been extensively studied in the field of social sciences, management and organisational scholars addressing farmers and agrifood systems are substantially scarcer. Thus, it is a great honour that he took on the role of being my opponent.

My career in research so far has been characterised by exploring the grounds in between and taking turns into the unknown. I received my master's in human geography with a strong emphasis on social sciences but ended up working with environmental research with a strong emphasis on natural sciences – enabled by minors in biology, environmental sciences and forestry. I retained the interest towards environmental social sciences and was able to participate in projects where this approach was prevailing. This was largely due to the influence of two people wherein I identify two further critical nodes, as in the spirit of butterfly effects. Sanna Penttinen was my tutor when beginning the studies in Joensuu, and when I was looking for a topic for master's thesis, she introduced me to a project called NorWat, in which I did the thesis in relation to the role of local people in maintaining and managing agricultural landscapes. During this project I got to know Hannu Salo, a researcher at YMTK, who was running projects with an emphasis on the social side of sustainability phenomena. I owe it entirely to Hannu for being introduced to the world of evaluation studies, which let loose my interest towards agrifood systems and the role of farmers in their transformation processes. This interest eventually turned into a research plan submitted to the doctoral training at the School of Business and Economics, which I figured was a good platform for understanding farmers as entrepreneurs and the conflicting pressures they are facing. So I wish to thank you Sanna and Hannu both for mentoring and for the friendship that has lasted over the years!

While the years at the doctoral training have prepared me for academic research with all its conventions, I learned important skills both during my undergraduate studies at the University of Eastern Finland (formerly University of Joensuu) as well as the years spent at the Institute for Environmental Research (formerly part of University of Jyväskylä). The department of geography had an open and warm atmosphere, and it is still today a pleasure to visit the place where the foundations for the knowledge on which this dissertation is built was cast. Many of the fellow students grew to be lifelong friends. Once a geographer, always a geographer! The time at YMTK was invaluable for growing to be a researcher; it taught how to plan research projects, apply for funding for them, conduct research at the field, report research findings, present research results, interact with stakeholders, and so much more. I have fond memories of all the field work as well as days at the office – I think we had a strong community and a sense of togetherness that I will not cease to cherish. Thank you Emmi, Anne, Terhi, Hannu, Jussi, Heikki, Hessu, Janne, Henna, Kirsi, Mika, Toni, Jarmo, Anu, Katja, Ilkka, Tony, Tero, Arja, Pekka and all the others with whom I had the privilege to work with over the years.

The evaluation project I was involved with – MASKE as it was called among those involved – was in many ways an influential project for my academic career and personal life. I wish to thank the whole research team: Reijo Keränen, Liisa

Kytölä, Perttu Pyykkönen, Jouni Ponnikas, and especially Tuomas Kuhmonen. Usually the thanks directed to our loved ones are expressed at the end, but I would not do justice to you Tuomas, did I not acknowledge your contribution already here. What started out as a professional collaboration grew to be so much more, in you I found my soulmate. We are the supportive co-authors and reviewer 2's for each other, we are the mirrors to reflect on our ideas, we are the soil on which they can grow. Your continuing love and support, taking emotional, practical and intellectual forms, has been critical for me. As a team, we are more than the sum of our parts. Thank you for everything is an understatement, yet it says it all. I love you.

Doing research that is important at a personal level can be both highly rewarding and nerve-wracking. Questions of rural livelihoods and sustainable use of natural resources have been of interest to me throughout my whole career and studies. When embarking on the academic career ten years ago at the business school, I might have been a bit of an oddball with this kind of a non-trendy research topic, but surprisingly, questions of food system transformation turned out to be the most topical in the midst of the escalating global instabilities. Fortunately, the spirit within Corporate Environmental Management (CEM) has always been welcoming and very versatile – coming from a total non-business background initially, I have never felt like being an outsider in the group. I wish to thank all the colleagues at CEM with whom I have had the privilege to work and share ideas, lunches and various meetings over the years: Annukka, Tiina, Marileena, Stefan, Minna, Milla, Bhavesh, Atalay, Venla, Sirpa, Sami, Meri, Maija, and Bonn – along with all the previous CEM colleagues; Taneli, Salvatore, Sari, Kristiina – and others. I also wish to thank all the students who have attended my courses, all their questions and the classroom discussions we have had; they have provided important points for reflections throughout these years. Many of the colleagues have grown to be dear friends. Especially the friendship with my dear colleague Annukka Näyhä has been a constant source of joy and gratitude. I am thankful for being able to share the darkest moments and brightest joys, in work and beyond, with a compassionate soul. You have indeed been a friend in need.

I have received funding for this PhD project from Keski-Suomen Kulttuurirahasto, Oiva Kuusiston säätiö and Jyväskylä School of Business and Economics. I am grateful for these organisations for enabling my research work. The representatives of the foundations were always very helpful when arrangements had to be done in between the grant periods for example due to maternity leaves. I have also worked in a number of research projects (Kotietu, MAKE, Ruokavarma, Biodiful, and regional evaluation studies) during the time of preparing the PhD thesis. While many of these projects were not directly related to the thesis work, each project has been important for the development of my thinking, research skills and understanding about the phenomenon my research is by and large dealing with. I want to express my gratitude for all the organisations that have funded this work over these years: Ministry of Agriculture and Forestry, The National Rural Policy Council, Strategic Research

Council for the Academy of Finland and the regional Centres for Economic Development, Transport and the Environment in Eastern Finland, Southeast Finland, Häme and Western Finland.

Research on the social aspects of sustainability phenomena would be impossible without the contribution of people providing information for the researcher. Thus, I would like to take the opportunity here to thank each and every farmer that has ever filled in any research survey – mine or others'. I know you get many invitations to participate, and I appreciate the time you have taken to tell about your work. I would also like to thank all those farmers with whom I have had discussions over the years, in research settings or in mundane encounters. The insights you have provided me have been critical for understanding food system transformations.

Stocks take time to change as flows take time to flow. Networks are one of the most important stocks an academic can have. This stock has names – more than I will end up mentioning here. As a young academic, I felt a bit overwhelmed by everybody telling that networking is important, as in, how does one do that in practice? In the end however, I have found myself reaching out to people with similar research interests, and being reached out to. No one hardly ever said no, I am not interested, so I want to take this opportunity to encourage any young scholar out there starting out their journey, wondering how does one do it in practice. These connections have resulted in collaborations in the form of papers, research ideas, conference sessions, and even an edited book is on its way. And perhaps best of all, many of these people I now consider friends. Maija Halonen, thank you for dragging me back to the roots to think about transitions in the light of geography. Kaisa Raatikainen, our ideas keep brewing but I am sure they will still see the daylight. Johanna Yletyinen, it was a pleasure to find a like-minded person like you. Minna Käyrä, we have surely come a long way on our thinking in and around degrowth. Of the variety of projects that have been underway in the past years, many others deserve to be mentioned. I wish to acknowledge Kotietu project with all the team members in which we designed alternative futures for the Finnish food system and especially the project leader Arto Huuskonen. Through the Ruokavarma project I met the most proficient team at E2 Research and Finnish Futures Research Centre – especially Atte, Marjatta, Riikka, Kaisa and Anni – with whom I hope to be able to collaborate in the future as well. I also wish to mention Antonia Husberg and Jarmo Salonen from the Ministry of Agriculture and Forestry acting as representatives of the funder, who have been very supportive of our research projects. A big shout-out goes also to the board of the Finnish Society for Rural Research and Development: Mari, Pasi, Aapo, Olli, Henrik, Pilvi, Seija, Ella and others. I consider this team as the safe space for thinking out loud on questions concerning rural livelihoods and sustainability.

I am currently employed by the Biodiful project funded by Strategic Research Council, which entails a large team of enthusiastic researchers determined to halt biodiversity loss through biodiversity-respectful leadership. I wish to thank especially the team from WP4 with whom we have explored biodiversity-respectful leadership in the food system's business context. Tiina Onkila, thank you for believing in me and for being the most empathetic head of department and work package leader. Satu Teerikangas, thank you for your encouragement and uplifting spirits. Milla Unkila, Marileena Mäkelä and Marja Turunen, thank you for all the insightful discussions along the way. Thank you also Saska, Matti, Anne, Ville, Natasha, Anu, Sari, Outi, Maria and all the others with whom we have been writing, planning to write, and ideating alternative futures. I sure hope more is on its way!

Doing one's PhD is, at the end of the day, all about perseverance – especially when it lasts altogether over 10 years, with all the twists and turns. While there have been moments of self-doubt and despair, I grew up in an environment where my ability to accomplish things was never questioned. Thank you äiti and iskä, Paula and Pauli, for that, and for always being there, for all the practical help you have provided to our family in the midst of these 'ruuhkavuodet'. Thank you Eeva, Arto, Anna, Otso, Jaako, Iivo, Lauri, Leo, Niina and Kai for your support, for being there and sharing the path of life with me. Thank you to my childhood friends from Vaajakoski: Eevastiina, Anni, Eeva, Miia and Anu – I am grateful for our bond that has lasted all these years. To all the friends I have gotten to know during the time in Hankasalmi, Jyväskylä and Vesanto, with whom we have shared walks in the forests with dogs, horseback rides, birthday parties and glasses (or two) of wine – and so much more: thank you for being there and for listening to my rants and providing the perspective. To somewhere beyond my comprehension, thank you Saara, Otto and Ave – I wish you could have shared these moments with me. Thank you for taking me as part of the family so full-heartedly. You will be forever missed. To my dearest Iida and Niilo. The world of ours is a loan from you and the generations to come. You are my biggest motivation to continue working for a better future. I know I have worked too long days at times and I probably will not be able to repay that, but you need to know that you mean the world to me and I love you with all my heart. And finally, to all my furry, four-legged friends, Eini, Helmi, Santtu and Kaapo: because life is a paradox, you drive me nuts and keep me sane. Let's keep it that way.

Vesanto, 12.11.2023

Irene Kuhmonen

ORIGINAL PUBLICATIONS

I. Kuhmonen, I. 2017. Adoption of the agri-environmental measures: The role of motivations and perceived effectiveness. XV Congress of the European Association of Agricultural Economists. Parma, Italy 31.8.2017.

II. Kuhmonen, I. 2020. The resilience of Finnish farms: Exploring the interplay between agency and structure. Journal of Rural Studies 80: 360-371.

III. Kuhmonen, I. and Siltaoja, M. 2022. Farming on the margins: Just transition and the resilience of peripheral farms. Environmental Innovation and Societal Transitions 43: 343-357.

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I. Sole author.

II. Sole author.

III. Irene Kuhmonen designed the overall study setting, analysed the data and wrote methods and results sections. Both authors contributed to the theoretical framing of the study and writing the introduction, conceptual framework, discussion and conclusions sections.

IV. Irene Kuhmonen designed the overall study setting. Both authors contributed to collecting and analysing the data and writing the manuscript.

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ABBREVIATIONS

CAP	Common agricultural policy
GHG	Greenhouse gas
MLP	Multi-level perspective
RDP	Rural development programme
SES	Social-ecological system
STS	Socio-technical system
TRB	Traditional rural biotope

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ORIGINAL PUBLICATIONS

1 INTRODUCTION

1.1 Setting the scene

Food systems are at centre stage of global sustainability problems. Contemporary food production practices have altered nutrient cycles, caused biodiversity loss and contributed to climate change to an extent that they have undermined the very resilience of the food system. Drivers of these developments have been linked to, for example, intensive input use, monocultures, chemicalisation, metabolism based on fossil fuels, growing consumption of animal products and expansion of agricultural land (Béné et al., 2019b; Benton et al., 2021; FAO, 2022; Helenius et al., 2020; Knickel et al., 2017; Tilman et al., 2002). As these problems have a deeply systemic nature, addressing them requires systemic solutions, encompassing the entire food chain from primary production to processing, retailing and consumption patterns, as well as other food system activities from agricultural policies to trade agreements and food cultures. Depending on the research tradition, these solutions can be conceptualised as socio-technical sustainability transitions or social-ecological transformations.

While a food system sustainability transition inevitably concerns the entire food system, the majority of environmental impacts in food production take place in agriculture at the beginning of food chains (Mbow et al., 2019; Repar et al., 2017; van der Werf & Petit, 2002). Thus, farmers play the role of gatekeepers, which is perhaps more important than that of any other actor group within the food system. In their day-to-day farm management, farmers are constantly making production choices that can be observed in environmental impacts ranging from land use changes to nutrient leakages and from soil depletion to landscape maintenance and biodiversity effects (Feola & Binder, 2010; van Vliet et al., 2015; Vermunt et al., 2020). This focal role that farmers hold has indeed been widely acknowledged in both research and practical policymaking. In the EU, for example, agri-environmental policies are built on the idea of compensating farmers for financial losses caused by adopting a variety of environmentally friendly farming practices. Firms operating in the value chains of food are increasingly monitoring the environmental commitments of farmers and the environmental footprints of the food they sell and process. A large body of literature has emerged to help understand farmer decision-making and agency in bringing about transformative change in the food system (e.g., Ahnström et al., 2009; Blackstock et al., 2010; Brown et al., 2021; Burton, 2014; Knowler & Bradshaw, 2007; Siebert et al., 2006).

Despite massive efforts in both research and policymaking to promote and understand farmers' sustainability commitments, the effects seem to be mixed. While the environmental measures of the EU's Common Agricultural Policy (CAP), for example, have halted negative developments in domains such as nutrient runoffs, they have not been able to reverse the trend of biodiversity loss and have contributed to furthering the lock-in of existing systemic structures and power constellations (Batáry et al., 2015; Brown et al., 2021; Kuhmonen, 2018; Kuokkanen et al., 2017; Lehtonen & Rankinen, 2015; Reif & Vermouzek, 2019). Moreover, halting negative developments is insufficient, considering the massive leaps required by returning to a safe operating space in terms of planetary boundaries (Campbell et al., 2017). In sum, the sustainability initiatives targeted at or initiated by farmers within the agrifood system seem to be producing small, incremental improvements when actually a major change in the course of the system's development would be needed. If prompting farmers is not producing the desired results, many are asking if it is time to start phasing out the most environmentally unsustainable modes of farming (Frank & Schanz, 2022; Huan-Niemi et al., 2020; van Oers et al., 2021).

At the same time, increasing concerns have been voiced about farmers' abilities to act as transition agents in the first place. The power constellations among actors in different parts of the food chain are uneven, and farmers act mostly as price-takers in the value chains of food (Clapp, 2021; Gottlieb & Joshi, 2010; IPES-Food, 2017). Increasing production costs together with stagnating product prices create a cost-price squeeze, which demands adaptive responses from farmers – such as scaling up, intensifying production, specialising in niche products, looking for additional sources of income or exiting farming (de Rooij et al., 2014; Milestad et al., 2012; Preissel et al., 2017; Stringer et al., 2020; van der Ploeg et al., 2000). Thus, while added value ends up in the hands of downstream actors, the responsibility for addressing environmental problems is placed solely on the farmers (Glover & Touboulic, 2020). In this vein, a number of scholars have paid attention to farmers' adaptive and transformative capacities, or to the lack of them (Contzen & Crettaz, 2019; Eakin et al., 2016; Gosnell et al., 2019; Harrahill et al., 2023; Himanen et al., 2016), as well as to the social inequalities and tensions related to transition processes (Davis et al., 2022; Gottlieb & Joshi, 2010; Kaljonen et al., 2021; Puupponen et al., 2023; Tschersich & Kok, 2022).

Thus, depending on the perspective one takes, farmers seem to have all the power to make more sustainable choices in the course of their daily work, or they can appear as the most powerless group of actors, struggling at the mercy of more powerful food system actors, such as suppliers, retailers, policymakers and consumers. These contrasting perspectives echo some of the most fundamental questions in social theory; the relationship between agency and structure. The voluntaristic tradition of the agency—structure nexus emphasises the free will of the agents and their capability to make deliberate, reflexive and conscious choices, whereas the determinist tradition prioritises the all-encompassing power of the social context in determining a course of social action (Elder-Vass, 2010). Although this debate has been ongoing for decades, it has not lost its relevance, especially in the context of sustainability transitions. Literature on sustainability transitions highlights the role of systemic structures and dynamics in both confining and enabling processes of social change (de Haan & Rotmans, 2018; Upham & Gathen, 2021). The theoretical foundations of the transition literature in relation to the structure—agency nexus are largely built on structuration theory (Geels & Schot, 2010; Kok, 2023; Upham & Gathen, 2021), which can be seen as a compromise between the deterministic and voluntaristic approaches. In structuration theory, structure and agency are seen as 'two sides of the same coin', as each side is being constantly made and remade in an inseparable interaction (Giddens, 1984; Mingers, 2014). Consequently, processes related to structural changes – sustainability transitions included – require individual and collective agency; they do not simply emerge from thin air but are rooted in groups of people acting otherwise.

However, the theory of structuration has been critiqued by critical realists, who argue that the central conflation upon which structuration theory is built is wrong about the relationship between agency and structure (Archer, 1995, 2000; Elder-Vass, 2010; Sorrell, 2018). According to the philosophy of structuration, just by being born into a certain systemic structure, an individual becomes responsible for that structure which the individual either reproduces or remakes through his or her own actions. Critical realists, in contrast, acknowledge that structure precedes agency (Elder-Vass, 2010; Hatt, 2013; Trosper, 2005). The essence of critical realism as a scientific ontology lies in stratification, the idea that entities in a systemic hierarchy – such as agents and structures – both have causal powers on each other in their own right, and neither the agents nor the structure can be reduced to be a manifestation of the other (Archer, 1995, 2000; Elder-Vass, 2010). Thus, while agents may have the power to reproduce or transform the structure, it remains external to agents who did not choose this specific structure – it was not their making in the first place (Archer, 1995; Elder-Vass, 2010; Sorrell, 2018).

As the basic tenets of structuration theory can be argued as being voluntaristic, the explanations offered for both action and inaction tend to revolve around individuals – even though, in principle, the theory acknowledges the existence of structural constraints. If agents are positioned as having all-encompassing powers to eventually change the very system in which they operate, or their potential to make such changes is not discussed, the power imbalances that might just make all the difference for realising the needed changes are ignored. The consequences of this are far from anecdotal or confined to the sphere of academic debate. If the actions of farmers in tackling sustainability issues are perceived to arise (largely) from their personal inclinations and commitments, their inaction or inability to act as transition agents similarly becomes a personal question. Based on such an understanding, also unspoken, the road to blame and feelings of guilt is paved – even if initially with good intentions. Perhaps not surprisingly, this is exactly the discussion that prevails, for example, in Finland, in the context of the explorations of this research project (Puupponen et al., 2022). Such a set-up is prone to strengthen the prevailing power positions and discursive lock-ins instead of building trust, common visions and ambitions for urgently needed transformation policies.

To make sense of farmers' capabilities to act as transition agents, I employ two concepts that provide the necessary lenses to capture the dynamics of agency and structure in the food system context: resilience and regime. The transformative capacities of farmers can be conceptualised through the concept of resilience (Darnhofer, 2014; Folke, 2006; Reyers et al., 2018). When resilience is defined as the ability of a system to deliver on its central functions, such as food production (also in times of hardships and within the boundaries set by ecological sustainability), it provides analytical tools for understanding why and under which conditions farms continue to function as farms, when they transform profoundly or cease to exist. Regime, in contrast, represents the structural context. It is not a synonym for the system, but rather it can be understood as a temporally stable mode of organisation of a socio-technical system anchored around specific institutional logics and rules, technologies, and relationships between actors (de Haan & Rotmans, 2011; Fuenfschilling & Truffer, 2014; Geels & Schot, 2007, 2010; Rip & Kemp, 1998). I utilise the concept of resilience in analysing the processes related to farmer agency taking place at the farm level. The resilience strategies are then framed and contrasted against the backdrop of the regime as the institutional and material setting forming the structural dimension of the agency—structure nexus, which also connects the analysis to the theme of sustainability transitions. In the next section, the research questions, structure and contributions of the thesis are explored in more detail.

1.2 Research questions and structure of the thesis

The overarching aim of this research is to understand ***the role of farmers as agents in the food system's sustainability transition***. Thus, I approach farmers' agency as being guided, not determined, by the conditions of the regime. However, the question about the strength of structural forces on farmer agency remain. How much and to what extent the structural context guides agency – what is the latitude of farmers to exercise their agency? Can the agency of farmers be a true source of transformative change at the level of the food system? Such a research task requires understanding several aspects of the structure—agency nexus around food systems. First, I aim to understand what drives farmers' choices. Second, with the regime as a structural setting that defines the 'agentic leeway' of farmers, I ask what the essential properties and rules of the regime are that guide the farmers' agency. Third, to understand how farmers act under the pressures exerted by the contemporary regime in terms of both the cost—price squeeze and mounting demands for a sustainability transition, I ask how and which farmers remain resilient under such conditions. Finally, addressing these questions should also shed light on the question of regime reproduction versus transformation: to what extent do farmers contribute to the sustainability transition of the food system.

This research consists of four independent articles that discuss different aspects of farmer agency, resilience and food system structure. Article 1 (Kuhmonen, 2017) explored farmers' self-stated decision rationales for adopting certain agri-environmental practices. This study shed light on the institutional environment on the part of agri-environmental policies in which farmers operate, and revealed how farmers use different decision rationales for various kinds of measures offered by the policy scheme. Article 2 (Kuhmonen, 2020) analysed the emergence of farm-level resilience as the interplay between the food system structure and farmers' agency. Article 3 (Kuhmonen & Siltaoja, 2022) analysed the transformative capacities of farmers in a peripheral setting in the resilience framework. Article 4 (Kuhmonen & Kuhmonen, 2023) analysed the long-term transition dynamics of the Finnish agrifood system and identified six regimes and their essential properties during a history of 700 years. Table 1 synthesises the research questions in relation to the original articles. While insights regarding specific research questions have been derived from the articles, some articles have contributed more significantly to certain questions, as outlined in the table.

TABLE 1 Research questions and original articles of the thesis.

RQa.	**What drives farmers' choices?**
	Article 1: Adoption of the agri-environmental measures: The role of motivations and perceived effectiveness
RQb.	**Who is resilient in the face of a sustainability transition?**
	Article 2. The resilience of Finnish farms: Exploring the interplay between agency and structure
	Article 3. Farming on the margins: Just transition and the resilience of peripheral farms
RQc.	**What are the regime rules that guide farmers' agency?**
	Article 4. Transitions through the dynamics of adaptive cycles: Evolution of the Finnish agrifood system
RQd.	**To what extent farmers as agents contribute to the sustainability transition of the food system?**
	All articles

This thesis is divided into two parts: the synthesis chapter, which consists of six sections, and the four original articles. The aim of the synthesis chapter is to bring together the findings of the original research articles under the umbrella of the agency—structure discussion. The introduction section continues by describing the empirical context: the Finnish food system. The second section lays out the ontological, theoretical and conceptual foundations of the research. The central concepts discussed, regime and resilience, are embedded in two distinct but complementary research traditions: socio-technical sustainability transitions and social-ecological systems. Both these research streams have been influenced by systems thinking, which is discussed in the second section. Both of these streams have also struggled with conceptualising agency and structure (Davidson, 2010; Kok, 2023; Olsson et al., 2014; Sorrell, 2018; Svensson & Nikoleris, 2018). With this in mind, I draw from critical realism, especially the ideas concerning the analytical dualism between agency and structure. Critical realism and systems thinking thus serve as major ontological foundations upon which I build argumentation throughout the research process. Despite the seemingly disparate philosophical roots of these two approaches, they converge and complement each other (see Mingers, 2014). In the second section, I also discuss the concepts of regime and resilience and provide insights and examples of them in the food system context. Finally, I develop a conceptualisation of transformative sustainability agency. In the third section, I present the methodological choices made during the research process as well as the data used. The fourth section summarises the findings of the research articles, the fifth section discusses the findings in light of the research questions, and the sixth section provides the conclusions.

1.3 Empirical context: the Finnish food system

The empirical context for my explorations is Finland. Finland is a northern, industrialised country with a population of 5.5 million people. On average, the population density is low, but the majority of the population dwell in cities and in the southern and western areas of the country. The growing season (with an average daily temperature over 5°C) is relatively short but varies from over 185 days in the southwestern parts of Finland to less than 105 days in the northernmost parts (Finnish Meteorological Institute, 2023). Finland is the northernmost country in the world that produces bread grains. Agricultural land covers, on average, 7.5% of its land area and is concentrated especially on the southern and western parts of the country, where agricultural land covers 10%–30% of the land area (Natural Resources Institute Finland, 2022). Since 1995, Finland has been a member of the European Union, and consequently, its agricultural policies have been integrated with the Common Agricultural Policy (CAP) of the EU. The core of CAP lies in common markets for agricultural products and favouring of European production (Kuhmonen et al., 2015). Adverse climatic conditions impede the competitiveness of Finnish production, which has been countered by the payment of national subsidies to even out differences with continental Europe. Depending on the price relations during the past 10 years, the contribution of agricultural subsidies to total farm income has varied between 26% and 32% (Economydoctor, 2023b). Subsidies consist of direct payments funded by the EU (CAP pillar I), rural development support funded by the EU (CAP pillar II) and nationally funded support (Ministry of Agriculture and Forestry, 2023).

In 2022, there were 43,611 farms in Finland (Natural Resources Institute Finland, 2022). The number of farms has decreased by more than half since the mid-1990s, while the average farm size has more than doubled. The majority of farms are crop farms, which are especially concentrated in the southern and western parts of the country. The distribution of animal husbandry reflects the production conditions of fodder plants: cattle and dairy production is located in the central, eastern and northern parts of the country, where the growing conditions are better suited for grass cultivation, whereas pig and poultry production is located in the western parts of the country, in areas suitable for cereal cultivation (Ylivainio et al., 2015; Figure 1). The most commonly cultivated plants in terms of hectares are cereals (47% of agricultural land, mostly barley and oats), followed by grass (35%; Natural Resources Institute Finland, 2023a). Most of the agricultural output produced on Finnish farms is fed to production animals (Natural Resources Institute Finland, 2021).

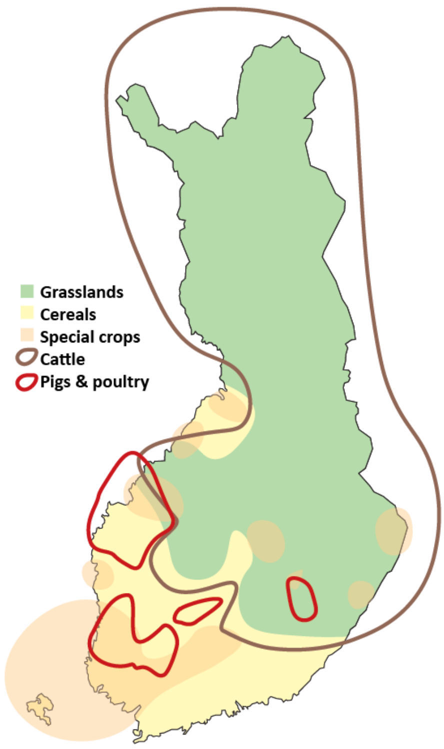

FIGURE 1 Specialisation of production areas in Finland. Adapted from Ylivainio et al. (2015).

The most critical questions related to the environmental sustainability of the Finnish food system concern the eutrophication of waterways (both inland waters and the Baltic Sea), the decline of agricultural biodiversity and the contribution of food production to climate change. Eutrophication and biodiversity loss have been driven by the increasing input use and intensification of agricultural production practices in the 20th century, especially since the war years in the 1940s. Fertilizer use peaked in the 1970s (Ylivainio et al., 2015), which has weakened the water and ecosystem quality of receiving waterbodies. Consequently, the nutrient question began to gain traction in societal debate in the 1980s (Aakkula et al., 2006; Hildén et al., 2012). However, it was not until EU membership in 1995 that a wide array of agri-environmental policies was established, targeted especially at mitigating nutrient runoffs and protecting agricultural biodiversity (Kröger, 2008). Later, objectives related to soil quality and climate change mitigation grew in importance (Aakkula et al., 2006). The adoption rates of agri-environmental subsidies have been high since their inception, as they have formed an elementary part of the payments directed to farmers.

As a consequence of agri-environmental policies, the trends in nutrient balances – manifesting the nutrient leaching potential from fields – have turned downward (Figure 2). However, this trend is not observable as improvement in the ecological quality of waters, which can be credited to a number of factors. First, surpluses of nutrient balances mean that more nutrients are entering fields than leaving them in yields. Second, the long history of specialised, intensive agriculture has resulted in regionally high phosphorus content in the soil, which results in an elevated risk of nutrient leaching. Areas prone to nutrient leaching are largely situated in the catchment area of the Archipelago Sea on the southwestern coast of Finland. The Archipelago Sea is a shallow and biodiverse sea with a catchment area dominated by productive clay soils. The production conditions are favourable to both the cultivation of cereals, followed by pig and poultry production fed by cereals, as well as nutrient-intensive special crops. The concentration of nutrient-intensive production creates local excesses of manure, furthering the nutrient problem. Third, increasing runoff due to climate change counteracts efforts to mitigate nutrient leakages (Aakkula & Leppänen, 2014).

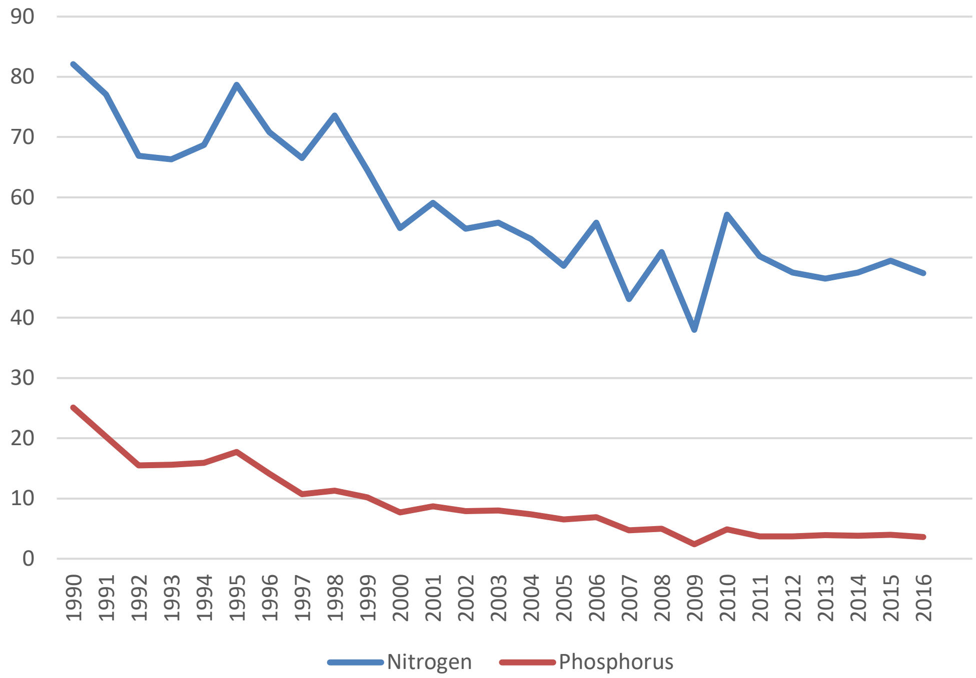

FIGURE 2 *Nutrient balances of nitrogen and phosphorus (kg/ha) 1990-2016 (data source: Natural Resources Institute Finland, 2018). Nutrient balance indicates the difference between nutrient inputs (in the form of fertilisers or manure added to the fields) and nutrient outputs (in the form of harvested yield).*

The carbon question in the agricultural context concerns both soil carbon and atmospheric carbon. The role of soil condition in promoting carbon capture and agricultural productivity has recently received increasing attention, partly due to observations about decreasing carbon content in agricultural soils (Hyvönen et al., 2020). The total carbon emissions from agriculture decreased from the beginning of the 1990s by 13% but remained on a steady level throughout the 2000s (Statistics Finland, 2022; Figure 3). Agriculture currently contributes 88% of the greenhouse gas (GHG) emissions in the food system (Kaljonen et al., 2022) and 22% of all GHG emissions in Finland in 2020 (Statistics Finland, 2022). The majority of carbon emissions in agriculture come from peatlands and the enteric fermentation of ruminants, most importantly cattle (Statistics Finland 2022; see Figure 3). This makes mitigating climate change in the agricultural context largely a question of production choices: to decrease GHG emissions, the scope of animal production should decrease, and peatlands should either be removed from conventional agricultural production or their cultivation methods reformed. The question is difficult in terms of the regionally uneven distribution of peatlands; most of them are located in the northern parts of the country and are used for producing cattle fodder. The growth of cattle production units in the north-western parts of the country, rich in peatlands, has resulted in land clearing due to an unavailability of fields for purchase for enlarging farms (Huttunen, 2015; Niskanen & Lehtonen, 2014).

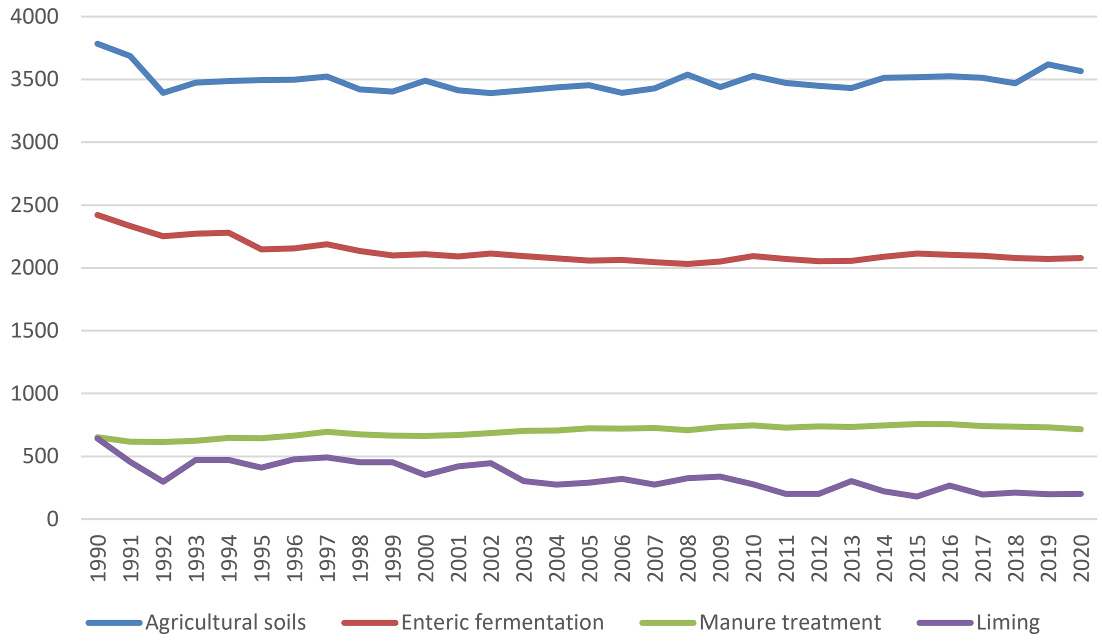

FIGURE 3 Greenhouse gas emissions from agriculture in Finland in 1990–2020 (1,000 tonnes of CO_2-equivalents; Statistics Finland, 2022).[1]

Biodiversity in agroecosystems is related to the intensity of agricultural practices, such as the use of chemicals, level of mechanisation and specialisation, variety of cultivated species and crops, drainage and irrigation practices, land clearing, abandonment of agricultural land and land parcelling (Soini & Aakkula, 2007). The development trends of these factors have been variable. While the use of chemicals in agriculture has decreased since the 1990s (Birge, 2021) and prescriptions of agri-environmental measures have ensured the maintenance of field edges, the populations of species dwelling in agricultural environments are declining (Hyvönen & Huusela-Veistola, 2007; Vepsäläinen, 2007). For example, the populations of bird species nesting in agricultural environments have been steadily decreasing (Figure 4; Luonnontila, 2023). Agricultural landscapes are becoming more monotonous, which weakens the quality of habitats for many species dependent on open, semi-natural environments (Herzon et al., 2014). Agricultural biodiversity benefits especially from mixing crop production with the husbandry of grazing animals. In Finland, the highest biodiversity occurs in seminatural areas, such as traditional rural biotopes (TRB), the number of which has decreased starkly during the last century due to the abandonment and intensification of land use on previously extensively grazed and mowed meadows and wood-pastures (Herzon et al., 2022; Raatikainen et al., 2017). Species dwelling in open areas, such as TRBs, are the second biggest group of endangered species in Finland after forest-dwelling species, and the greatest threat to the habitats of these species is afforestation (Hyvärinen et al., 2019).

[1] The field burning of agricultural residues and urea application were excluded from the graph due to their small values, which varied between 1,000 and 5,000 tonnes of CO_2-equivalents.

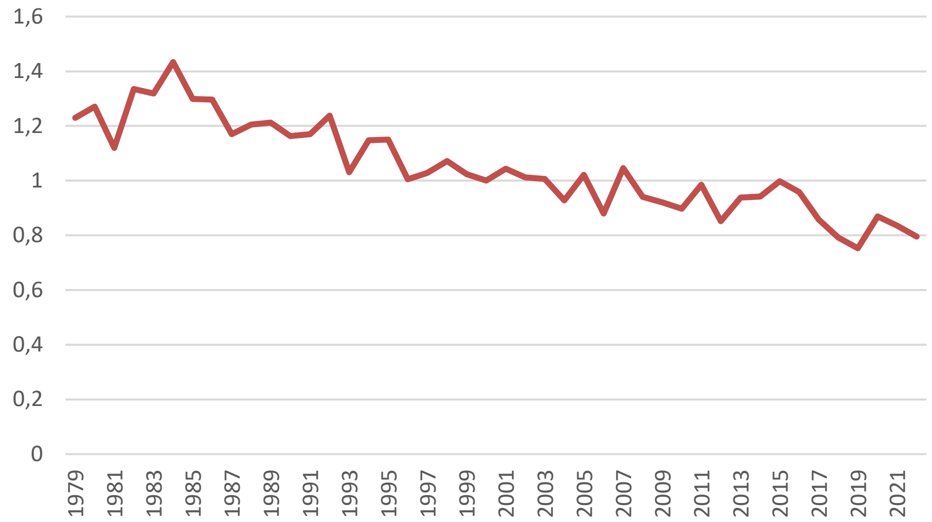

FIGURE 4 Indicator index describing the development of populations of birds nesting in agricultural habitats, 1979-2022 (Luonnontila, 2023).

In sum, the trends of specialisation and centralisation are driving many negative developments in relation to environmental sustainability in the agrifood system. To understand the drivers of regional specialisation and centralisation taking place in the Finnish agrifood system, it is useful to inspect the phenomenon from the farm perspective as well. Even though the majority of Finnish farms are crop farms, the majority of agricultural income comes from dairy and cattle farming (Economydoctor, 2023a; Natural Resources Institute Finland, 2022). On crop farms, agricultural income contributes to 28-33% of household income, whereas on dairy farms, it forms 78% of household income (the average on all farms is 46%; Statistics Finland, 2023). Cattle farming typically provides a source of income for an entire farm family or at least one of the spouses, which contributes to its popularity in areas where there is a paucity of non-farm jobs, typically in the eastern and northern parts of the country (Kuhmonen & Niittykangas, 2008). In contrast, as crop production is typically a part-time job, it is a more frequent choice in the southern and western parts of Finland, which have more vibrant job markets.

Structural development in the farming sector has been intensive during the past 30 years. While farm sizes have been growing, the average farm income (in real terms) has fallen by 33% from 2000 to 2018 (Figure 5). The financial situation of Finnish farmers has been described as chronically in a state of crisis (Karhinen, 2019). The consequences of a cost-price squeeze, in which income from products is stagnating or declining but costs increase, are seen in the declining number of active farms and the growth of the remaining farms. Growth has become a prerequisite of farm existence: when prices paid for agricultural products do not keep up with the development of farming costs, farmers need to seek economies of scale in order to safeguard a living from agriculture. Growth is a critical question especially in animal husbandry, which is more labour intensive than crop cultivation, and which is oftentimes supposed to provide a living for the farmer or the entire farm family. However, farm growth is not simply about the reallocation of farmland, especially in areas where there are few alternative sources of income. Such is the case, for example, in Ostrobothnia, which is rich in peatlands and where there are many farms willing to continue – thus facing the need for growth and enlargement – and few willing to rent or sell their fields (Huttunen, 2015). When agricultural land is scarce but forests are abundant, clearing the forests for farmland to be able to grow and make a living in agriculture becomes a logical choice. Thus, the mechanism behind the clearing of agricultural land is a food system tuned around growth, specialisation and centralisation.

FIGURE 5 Income development (1000 €/farm) vs. farm size (ha) from 2000 to 2018. Agricultural income in 2018 prices. Data source: Natural Resources Institute Finland.

Price pressures are exerted on farms via the food production chain, which in Finland is extremely centralised. The grocery sector in Finland is governed by just three major actors, through which the absolute majority – 92.4% – of foods and other groceries reach consumers (PTY, 2022). The degree of concentration is significant in comparison with many other European counterparts, where, in 2015, five of the largest grocery retailers held shares varying from 47% in Poland to 74% in Austria (Špička, 2016). The centralisation process throughout the food chain – at the level of farms, processing and retail – has been strengthened during Finland's EU membership from 1995 onwards (Hyvönen, 2014; Koistinen, 2009; Muilu et al., 2016). Competitiveness varies in different parts of the food chain; while retail and trade perform well, competitiveness in the farming sector is weak (Kotilainen et al. 2010). Retail and trade dominate the food markets (Niemi & Liu, 2016), and during the 2000s, the share of primary production from food prices decreased while that of trade and retail grew (Peltoniemi & Niemi, 2016).

Even though the financial situation in the farming sector is constrained, so far Finland has remained relatively self-sufficient in terms of the central foodstuffs of grains, milk and meat, but not oil and protein plants (Jansik et al., 2021). Food imports to Finland have almost doubled from 2000 to 2016 (Knuuttila & Vatanen, 2021) and self-sufficiency rates have been in constant decline especially in meat and oil and protein crops (Lehikoinen, 2020; Sandström et al., 2014). This trend increasingly displaces environmental impacts related to food production beyond Finnish borders (Sandström et al., 2014). The competitive advantage of Finnish agricultural production has traditionally been in dairy. Dairy exports to Russia were especially important in the sector until 2014, when sanctions placed on Russia due to the Crimean invasion halted those exports. Since then, the profitability problems on Finnish farms have been accentuated further due to the increasing costs of production resulting from the combined effect of the Covid-19 pandemic and the further Russian invasion of Ukraine in 2022 (Latvala et al., 2022).

While Finnish exports to Russia stopped in 2014, imports from Russia did not. Indeed, the self-sufficiency of Finnish food production relies on imported system-external inputs: fuels, energy, synthetic fertilisers, sowing seeds, pesticides and machinery, as well as animal feeds and other inputs needed in animal husbandry (Jansik et al., 2021). In terms of metabolic flows, the most important of these inputs are fuels and fertilisers. The dependency of the farming sector on fossil fuels on all these fronts indicates that the food system is very much embedded in the fossil economy, which at the same time is also a key driver for its centralisation development (Koppelmäki, 2022; Kuhmonen et al., 2022). Continuous inflow of virgin nutrients to the agrifood system also effectively prevents the efforts of creating a more closed system for the circulation of nutrients.

While the need for a food system transformation has been widely acknowledged, there is a paucity of future visions guiding its future development. A majority of effort to tackle the variety of problems described above has an incremental orientation: questions related to eutrophication, biodiversity loss, profitability of farming or climate change are treated as separate issues with their own diagnoses and suggested solutions. On top of this, there is a need to address the justice aspects of transition policies especially those aimed at climate change mitigation, which are likely to hit hard many peripheral areas in the country. However, the root causes of the sustainability problems depicted above are at least closely intertwined. With this in mind, the next section offers conceptual tools for understanding and analysing the food system structure and the possibilities of determined agency for changing this very structure.

2 THEORETICAL AND CONCEPTUAL BACKGROUND

In this section, I discuss the ontological, theoretical and conceptual underpinnings of the research. In terms of ontology, I draw from two main lines of thinking, critical realism and systems thinking, which I discuss in the first part of this section. I then move on to discussing the concepts of regime and resilience, which are the analytical devices employed in exposing the agency–structure nexus in the food system context. I end with a discussion about transformative sustainability agency applied to the food system context.

2.1 Ontological foundations

2.1.1 Critical realism

Critical realism is an ontology that takes the 'real' world as its starting point; it acknowledges that there is an external world that exists independently of human perception. At the same time, however, critical realists argue that it is one that its observer can never fully know – knowledge about the world is potentially fallible from the outset (Sayer, 2000; Mingers, 2014). Critical realism accommodates criticism of positivist and realist traditions by accepting that social explanations are always value laden, and they either reproduce the status quo or present alternatives to it (Jessop, 2005). However, despite the gap between the real and the observed, critical realism does not fully abandon the quest to understand the 'real' nature of the world, unlike, for example, the phenomenological tradition. Critical realism is critical because, as the epithet suggests, despite accepting the sphere of 'real', it does not assume that observations produced about the real would as such reveal meaningful understanding about the real world – in contrast with naïve realism or positivist traditions (Sayer, 2000). This basic aim of critical realism has been aptly expressed by Mingers (2014, 16) as being:

> …to establish that there is an independently existing world of objects and structures that are causally active, giving rise to the actual events that do and do not occur; but at the same time, to accept the criticisms of naïve realism and to recognize that our observations and knowledge can never be pure and unmediated, but are relative to our time period and culture.

Critical realism operates in three domains as originally laid down by Roy Bhaskar ([1976] 2008): **the real, actual and empirical** (Figure 6; see also Jessop, 2005; Mingers, 2014; Sayer, 2000). In this conceptualisation, the real captures the complexity of life and the real world: all the mechanisms and structures with their enduring properties and the causal powers of objects and their capabilities to act in certain ways (one could call this the 'genotype' of entities). The actual refers to events taking place as a result of the causal power possessed by entities in the domain of the real, which sometimes actualise and sometimes not (in a similar vein, the actual is then the 'phenotype' of the entities). The empirical then refers to the bulk of the events that are observed. For an observer, analytical separation between these domains is important: they must not only be aware of the possible biases produced by perception and the methods used in scientific enquiry, thus affecting what becomes visible in the domain of the empirical, but also understand the difference between the real and the actual. The actualisation of an event is, from the point of view of critical realism, context dependent: while an event is actualised as a result of the emergent properties of the entities involved, there were probably a multitude of forces at play that contributed to the specific event and the emergent properties in producing this outcome in this specific situation (Sayer, 2000). Thus, it might be of as much importance to understand why the same event did not take place in some other context with other kinds of contextual forces at play.

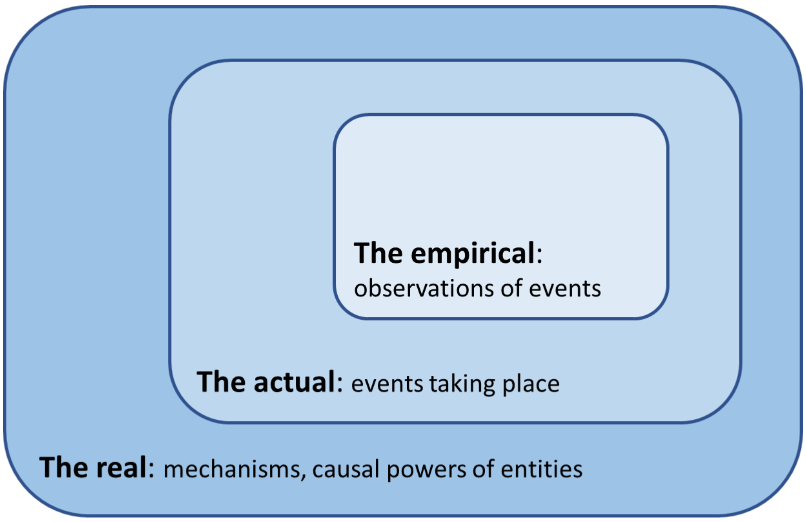

FIGURE 6 Three domains of critical realism (according to Bhaskar, 2008).

Emergence is a central concept in critical realism (Mingers, 2014). Emergence means that the causal powers that an entity possesses are derived from the way it is organised as a whole (Elder-Vass, 2010). In other words, these causal powers emerge from the entire organisation of the entity – both the parts and the relationships between the parts (Elder-Vass, 2010). If the parts of the entity possess these same causal powers when isolated, then there is no emergence (Trosper, 2005). Thus, 'emergent properties result from the properties of the components and the particular structure of relationships between the components that constitute the entity' (Mingers, 2014; 30). Entities can be structures, systems, organisations or agents acting within the social realm. The causal powers these entities possess act in two ways: downwards and upwards (Archer, 1995; Elder-Vass, 2010). Thus, the social system within which an agent operates has causal powers over the agents, but the agent can also exert causal powers on the system.

Downward and upward causation relates to the **stratification** of social reality. Stratification refers to the hierarchical ordering of things in critical realism (Elder-Vass, 2010). Critical realism takes as its starting point that the different 'strata' of systems have (emergent) causal powers as such (Elder-Vass, 2010). In practice, this means that the food system has emergent causal powers on the social system it is a part of (upward causation), as does the social system on the food system (downward causation). In downward causation, the social system constrains and enables the behaviour of the food system: the fossil-fuelled, capitalist economic system as such dictates to a large extent the variety of ways in which a food system can organise. In upward causation, the food system affects the social system, for example, through the spatial organisation pattern of food production activities or through the social impacts of food scarcities.

In terms of critical realism, the question of **agency** and **structure** is, in effect, a special case of stratification: the structure represents the system (or a set of systems) at a higher hierarchical level, whereas the agent represents the entity at a lower hierarchical level. In this vein, critical realism views structure and agency as ontologically separate phenomena (*the analytical dualism* of agency and structure; Archer, 1995). While structuration theory and the work of Anthony Giddens have been of utmost importance for developing the concepts of structure, agency and social power, there is a critical difference between the standpoints of critical realism and structuration theory towards agency and structure. Giddens (1984) essentially rejects the dualism of agency and structure and approaches them as 'two sides of the same coin' (*the duality of structure*), continually shaping each other: if it was not for the agency of agents, there would be no structure – thus, the agents could, in principle, choose to undo the structure at any given time and cease to reproduce it by their actions. Giddens (1984, 17) himself states this more elegantly:

> (---) social systems, as reproduced by social practices, do not have 'structures' but rather exhibit 'structural properties' and (---) structure exists, as time-space-presence, only in instantiations of such practices and as memory traces orienting the conduct of knowledgeable human agents.

In effect, he argues that structures do not have causal properties, which is in stark contrast to the basic premises of critical realism. Indeed, the development of critical realism and especially the work of Margaret Archer (for example, 1995,

2000) can be read partly as a critique of the conflationary tenet of structuration theory. Archer (1995, 71) argues that understanding the temporal divergence between agency and structure is central to the analytical dualism she promotes:

> Structures (as emergent entities) are not only irreducible to people, they pre-exist them, and people are not puppets of structures because they have their own emergent properties which mean they either reproduce or transform social structure, rather than creating it.

In other words: structure cannot be reduced to the '"carried" reproduced practices' (Giddens, 1984; 170) that play out as properties of social systems, but the structure is real in the sense that it has true causal powers on agents, which is why the structure is not reducible to the agents who form the structure (Mingers, 2014). Svensson and Nikoleris (2018, 469) define structure as being about 'how the different parts of the system are related to each other and by extension what kinds of emergent properties and powers the system has in virtue of these relations'. The causal powers of structures are thus due to the emergence brought about by the relationships between actors and entities working in it. The nature of these factors is discussed in more detail in Section 2.2.

However, as in the stratification model more generally, the causal powers work both ways; not only does structure have causal power on agents, but agents can also affect the structure (Elder-Vass, 2010). Many definitions of agency highlight the importance of voluntary choice and autonomous will free from external constraints (Barnes, 2000). To Giddens (1984, 9), for example, 'agency concerns events [in which] the individual could (---) have acted differently'. Agency thus relates to an individual's capacities (Giddens, 1984), to the deliberate influence upon the course of events (Bandura, 2006) and possession of a set of powers (Archer, 1995). In such an understanding about agency, it is reduced to concern only those instances in which the causality between agency and structure flows from agency towards structure, not the other way around. However, Emirbayer and Mische (1998, 1004) argue that agency is present in 'all empirical instances of human action', and take a broader view on agency as

> a temporally embedded process of social engagement, informed by the past (in its habitual aspect), but also oriented toward the future (as a capacity to imagine alternative possibilities) and toward the present (as a capacity to contextualise past habits and future projects within the contingencies of the moment).

Agency should then be viewed more as a product of two-way interactions between the agent and their environment (Kok et al., 2021), rather than as an attribute of the actor. These relationships cannot be understood without addressing the role of social power: the ability to draw resources from the environment or utilise them within it (Arts & Tatenhove, 2004). Power positions, in turn, are largely reconstructed in the structural setting; people rarely choose to occupy underprivileged positions (Archer, 2000). In practice, two-way interactions mean that agents are predisposed towards '*specific courses of action* for the promotion of their interests' (Archer, 1995: 216; emphasis in the original). These situational logics imply that the causal force of structure comes in the form of the distribution of costs and benefits that guide path-dependent action. Even if the actor opposes the source of rewarding, the rewards are real, and will invite further impediments when embarking on this path (Archer, 1995: 209). Thus, the structural setting makes certain outcomes in terms of the agents' behaviour more likely than others, and when multiplied, the consequences of the agents' choices reinforce structural development. It is no wonder then that 'structural development' is the very word that is used to depict the prevailing trends in the farming sector: growth of farm sizes, centralisation of production and reduction of the number of farms. This development that feeds into the structure of the agrifood system is the consequence of thousands of individual choices made at the farm level; however, the choices were made because of the causal powers prevailing in the structural context, such as a push towards economies of scale, cost-price squeeze and benefits from aggregation. While these developments are generally viewed as desirable and positive from the viewpoint of the sector's competitiveness, they also give rise to unintended consequences, such as negative environmental externalities. How these causal powers arise, how unintended consequences are born and how emergence works can be approached by means of systems thinking, which is the topic of the next section.

2.1.2 Systems thinking

The roots of systems thinking lie in cybernetics and the open system approach, the development of which from the 1940s onwards led to the emergence of concepts, theories and approaches such as complexity theory, general systems theory, chaos theory and systems thinking (Burrell & Morgan, 1979; Mingers, 2014). Systems thinking deals with complex adaptive systems, which are distinct from complicated, mechanistic systems. Complex adaptive systems comprise both tangible and intangible elements and their relationships; they are self-organising and lack central coordination; and they adapt, learn and evolve (Boulton et al., 2015; Mitchell, 2009). Systems thinking has been important for the development of both social-ecological systems research (SES) and resilience theory, which build directly upon it (Allen et al., 2014; Chandler, 2014; Gunderson et al., 2002), as well as for socio-technical systems research (STS) and especially the branch of transition management (de Haan & Rotmans, 2011; Kok et al., 2021; Rotmans & Loorbach, 2009).

Emergence is a central theme for both critical realism and systems thinking. Both systems thinking and complexity theory offer more general explanations for emergence, operating in the domain of the real, whereas specific theories serve to provide more local explanations of patterns and behaviours observed in the domain of the actual (see Byrne & Callaghan, 2014: 84). In complexity theory, the behaviour of complex systems is seen to produce emergent phenomena – outcomes that cannot be predicted from the way the parts in the system behave. A complex system is more than the sum of its parts. As Mingers (2014, 29) puts it:

> The most fundamental idea of systems thinking is the anti-reductionist one that we cannot explain the behaviour of objects and entities purely in terms of the nature and constitution of their *parts* or *components*.

System theorists regularly refer to a 'ghost in the machine' of a system. In the language of critical realism, it is the emergent causal powers that entities possess that create this 'ghost'. These causal powers lie in the assemblage and the relationships of the whole; the specific way these parts are organised produces causal effects that would not be observable if not for this manner of organising (Elder-Vass, 2010; Mingers, 2014). Emergent phenomena relevant to the topic of this thesis include regime shifts, resilience and sustainability. All of these phenomena arise from the behaviour of the system as a whole; they cannot be engineered by twisting a single component within the system. Systems theorists often refer to the unintended consequences that the behaviour of complex systems produces, which is what resilience and sustainability research is devoted to studying (Meadows, 2008; Walker & Salt, 2006). The mechanisms behind such an emergence relate to **non-linearity**.

The behaviours and relationships within mechanistic, closed systems are linear, predictable and non-debatable – there is hardly much disagreement about how a car functions or the role of certain parts in its functioning (Meadows, 2008). However, the same does not apply to complex systems. Complex systems are nonlinear, which makes their behaviour difficult to predict in the long term (Boulding, 1956; Boulton et al., 2015; Byrne & Callaghan, 2014). In the spirit of chaos theory, even the smallest difference in initial conditions can produce large deviations in the long-term predictions about the behaviour of the system (Mitchell, 2009). This also applies in the other direction: Removing a part from a car will produce predictable consequences for the car's functioning, but the same cannot be said for complex systems. Removing several parts from a system may not affect its behaviour at all until a critical tipping point is reached. This is when even a relatively small change can produce large-scale cascading effects in the system. This is central for sustainability science: so far, the large-scale anthropogenic changes on the Earth system have not caused a corresponding large-scale collapse of ecosystem functions due to their adaptive buffering capacities. However, when such a critical tipping point is reached, the cascading effects may be detrimental for the very existence of humankind. These limits or tipping points are captured in the concept of planetary or Earth system boundaries (Rockström et al., 2023).

Non-linearity arises from the **openness** of complex systems. Closed systems – such as those studied in classical physics – are typically mechanistic systems that work under linear Newtonian laws: the relationships between such systems are deterministic, reductive, reversible and causal (Boulton et al., 2015: 33). In closed systems, the whole can be understood by studying its components: the social structure can be understood by understanding the behaviour of agents in it or vice versa; the social structure can be understood by looking at the functions it fulfils, as in functionalism (Donaldson, 1996). Despite the attractiveness of such explanations, they only tell half the story, for social systems are not closed but open systems. They exchange matter, energy and information with other systems, their neighbouring systems, aggregate systems and subsystems, and they have blurry, hard-to-define boundaries (Boulton et al. 2015, Byrne and Callaghan 2014).

From such openness, it follows that open systems hardly ever find a 'perfect balance' or an optimal solution – the conditions within the system are in constant flux. These balancing or compromising forces among the different subfunctions and interests within a system are clearly visible in the governance of natural resources, where it is impossible to find an 'optimal combination of rules' to cater to the needs of all stakeholders (Ostrom, 2005; 220).

In being open, complex adaptive systems are **dynamically stable systems**, which means that they exhibit movement between several near-equilibrium states (Folke, 2006; Rotmans & Loorbach, 2010). The same idea is also captured by the concept of punctuated equilibrium (Mitchell, 2009), which suggests that systems dynamics alternate between long periods of incremental development and short periods of radical, quantum change (Demers, 2007). Such dynamics imply that in the long run, the behaviour of a system may be difficult to predict, but within a shorter time horizon, it tends to converge around certain basins of attraction, or alternative equilibrium states. This idea is recurring in different conceptualisations of social change, especially in the fields of social-ecological systems (SES) and socio-technical sustainability transitions (STS) research. Whereas SES research is more concerned with the stability of systems facing disruptive change, STS research has addressed deliberate processes aimed at changing systems (Erbaugh et al., 2021; Olsson et al., 2014). This difference relates to varying knowledge interests. SES research originally emphasised the ecological side of coupled social–ecological systems, with the overarching aim of promoting the capacity of these systems to remain functional despite human-induced stresses. This ambition is reflected in the concept of resilience – the capacity of systems to retain their functionality despite stresses and shocks. In turn, STS research has studied the change dynamics in coupled socio-technical systems with the outspoken aim of changing the way they function for the sake of sustainability. However, these differences have slowly waned, with SES scholars increasingly addressing questions traditionally embraced by STS scholars and vice versa (Olsson et al., 2014). Critical discussion in these fields has centred on similar themes: the role of agency in bringing about structural changes, and the political and power dimensions in processes of change.

In the next section, I examine these dynamics in more detail. I adopt the concept of regime as a central device to unpack these dynamics from various perspectives.

2.2 Regime

As open, complex systems, societies can organise in a variety of ways. This diversity can be captured by the concept of regime, which represents a specific, temporally stable mode of organisation within a system (de Haan & Rotmans, 2011). Thus, the system and regime are not synonymous. The stratified model of reality from critical realism offers a useful ontological analogy for understanding the difference between systems and regimes: the system operates in the domain of the real – the system has certain powers and capacities to produce a variety of emergent behaviours (the *genotype*), but in the domain of the actual, only some of those properties actualise as regimes within a certain time-space-scape (the *phenotype*). It is the path dependency of regimes built on certain institutionalised structures that determines what kind of behaviours the system can eventually exhibit when accommodating a certain stability domain and which behaviours become suppressed. Regime also acts as the central device for understanding the relationship between stability and change at the level of social structures; upon a regime shift, the system faces the possibility of transformative change. In this section, I inspect the concept of regime from a multitude of viewpoints: from the viewpoint of systems thinking (regime as a stability domain), from the viewpoint of socio-technical sustainability transition studies, from the viewpoint of institutional theory (regime as an institutionalised structure), from the viewpoints of social-ecological systems and critical realism (regime transformation: from morphogenesis to adaptive cycles) and from the viewpoint of the political economy of food (food regimes). All of these approaches offer important insights for understanding the structure–agency nexus in the agrifood system context.

2.2.1 Regime as a stability domain

In system terms, regimes can be conceptualised as the **changing stability domains of a system**. A sustainability transition requires radical systemic changes in society, which can be conceptualised as a move into a new stability domain – or as a regime shift (de Haan & Rotmans, 2011; Fuenfschilling & Truffer, 2014). The system is, as a complex adaptive system, (self-)organised to serve a specific purpose, such as the provision of food, energy, mobility or housing, but it can do this in a variety of ways. This variety can be captured through the concept of an **attractor**: each temporally stable mode of organisation of a system – i.e., a regime – organises around a set of attractors. Attractors are 'powers' around which the system dynamics centre within a specific period of time (Kuhmonen, 2017). Thus, the stability in regimes is dependent on effective attractors, which limit the possibilities towards which the system can evolve within a specific development trajectory (Kauffman, 1993). Attractors may take on material as well as socially constructed forms. In the latter case, they 'serve as reference points in social processes associated with the construction, mobilization, establishment, contestation, and resistance of power' (Hatt, 2013: 34).

Which attractors are effective in a system at a given time results from the endeavours of agents within it and the variety of structural constraints and possibilities present. These attractors guide the development of a regime in a certain direction; this direction makes some things possible but rules out others. For example, in the contemporary Finnish food system, it would not be possible for a large share of the population to feed themselves as hunters and gatherers. The path dependency of regimes is the result of systemic feedback: while reinforcing or amplifying (positive) feedback causes the system to grow and evolve on a specific track, balancing (negative) feedback locks the system

(Meadows, 2008). The switch from one equilibrium state to another is where the system can transform radically, whereas in an equilibrist state, the system only experiences incremental changes (Boulton et al., 2015; Byrne & Callaghan 2014; Holling, 2001). This makes the long-term evolution of complex systems cyclical, and this is also why a systems approach accommodates both incremental and radical types of social change.

A system thus faces a dearth of possibilities in terms of organising. This variety extends all the way to the **perspectives and views** people have about how the food system *should* be organised. Complicated but simple – closed – systems organise in one given way that does not give rise to fierce discursive struggles, whereas the understandings and perspectives of complex systems tend to differ (Figure 7). The stability of systems exists not only in the material reality of organising social life but is also manifest in the manner of speaking about the world, as well as in the norms, values and world views (as will be discussed in relation to institutional theory in Section 2.2.3 and in relation to the directionality of transitions in Section 2.4.3). They also live in the social representations and discourses that depict them – or more generally, the culture 'as supplying directional guidance for agency' (Archer, 1995, p. 229) and in the counterdiscourses that arise as alternatives to the dominant ways of organising social life (Tolbert & Zucker, 1999). Discourses are 'ideas, concepts, and categorisations that are produced, reproduced and transformed in a particular set of practices and through which meaning is given to physical and social realities' (Hajer, 1995: 44), thus, they take part in the reproduction of the rules that guide the behaviour of actors within a specific regime. Ultimately, socially constructed discourses and narratives act as sense-making tools that contribute to building cognitive schemas and shaping behaviour (Beratan, 2007; Upham & Gathen, 2021).

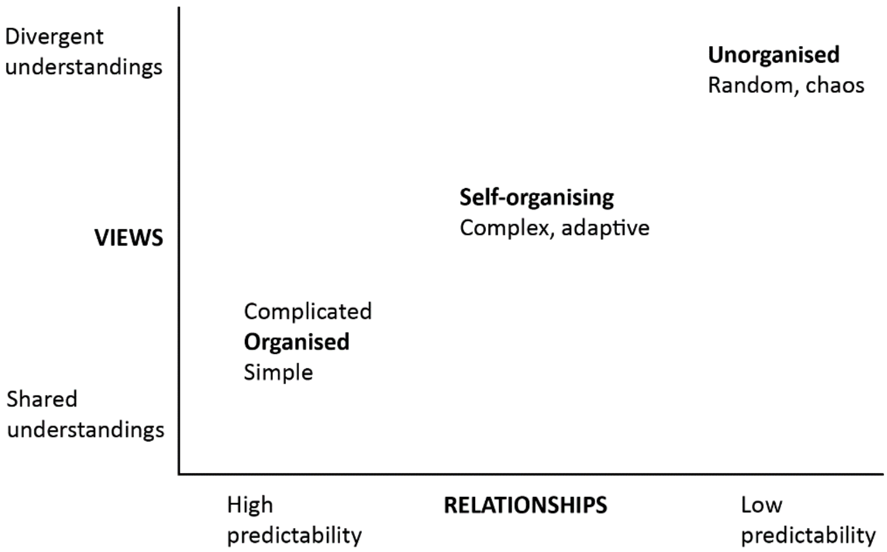

FIGURE 7 Views and relationships of complicated (closed) systems vs. complex (open) systems (adapted from Hargreaves, 2010; Vataja, 2023).

2.2.2 Regime in socio-technical sustainability transition studies

Research on sustainability transitions explores the dynamics of system-level social change: How transition processes unfold. Sustainability transitions have been defined as 'long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption' (Markard et al., 2012: 956). The roots of transition research can be traced to science and technology studies, or the sociology of technology and evolutionary economics (Geels and Schot, 2010). Sustainability transition research has a strongly normative character, as it has the in-built aim of promoting certain forms of change at the expense of others. The **multi-level perspective (MLP)** is a central conceptual tool widely used in transition studies that describes how transitions take place among three levels: regimes, niches and landscape (Figure 8).

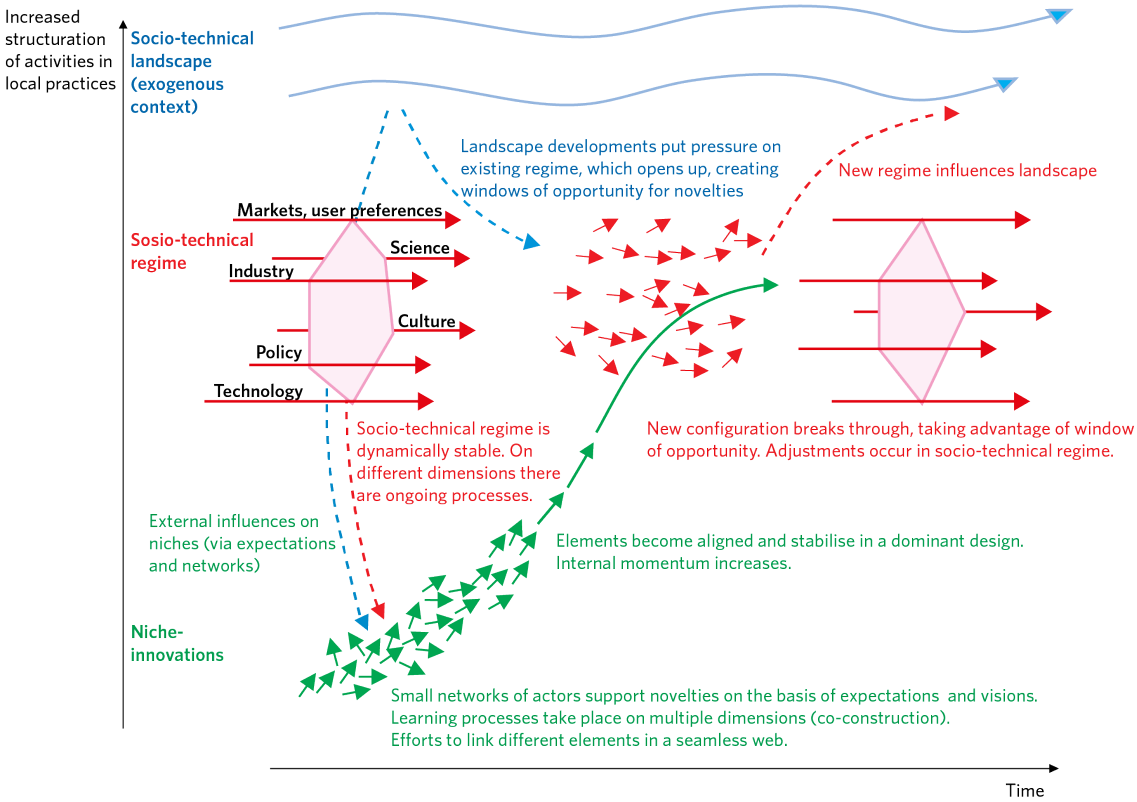

FIGURE 8 The multi-level perspective (based on Geels, 2002; Geels & Schot, 2010).

Within the MLP, **regimes** are patterned development trajectories of systems that consist of routines, regulations and standards and interlinkages between lifestyles and technologies; they also feature path dependencies and sunk investments (Geels & Schot, 2007). A regime is a structural context for social action that builds on a semi-coherent rule set and the institutions developed to guard these rules (Geels and Schot, 2010; Kanger, 2021). All these features make regimes persistent and resistant to change but not immutable. Research in the context of agrifood systems has indicated that contemporary agrifood regimes are largely in a state of lock-in (Béné, 2022; Conti et al., 2021; Vermunt et al., 2022). The lock-in features systemic barriers that makes adopting more sustainable methods of production difficult, such as recycling nutrients (Kuokkanen et al., 2016), adopting legumes as part of crop rotations (Magrini et al., 2016) and adopting agroecological farm management practices (Vanloqueren & Baret, 2009) or nature-inclusive farming practices (Vermunt et al., 2020). This lock-in extends to various facets of the food system, including technologies, institutional settings, individual attitudes, political economy, infrastructure, and research and innovation priorities (Conti et al., 2021). In the Finnish context, lock-in has been identified as especially strong in relation to the public governance and policies guiding production activities within the system and the power hegemony in the retail sector (Kuokkanen et al., 2016).

Niches are loose collections of experimental projects carried out by 'dedicated actors who are willing to invest resources in the new technology' (Geels & Schot, 2010: 22). This dedication protects the niches from selection criteria established in the regimes, which makes them a likely source of novelty (thus, the term incubation place) and transformative sustainability agency (Geels & Schot, 2010: 22). Examples of niche innovations in the agrifood system context include organic farming (Hörisch, 2018), permaculture (Ingram, 2018), production of legumes (Kaljonen et al., 2022), circular economy in food systems (Klein et al., 2022), mission-oriented agricultural innovations (Klerkx & Begemann, 2020), plant-based milks and meat substitutes (Mylan et al., 2019; Tziva et al., 2020), agroecology (Anderson et al., 2019) and alternative food networks (Bui et al., 2016). The transformative power of niches comes about via maturation of niche innovations coupled with a window of opportunity, which may enable a breakthrough that changes the configuration at the regime level (Geels & Schot, 2007). However, while many niche innovations in the food system context have been adopted as part of the dominant regime constellation (such as organic farming or plant-based milks), so far, they have not changed the rules or configuration of the regime but rather have carved out their own positions within it.

Landscape, in turn, is conceptualised as a factor external to the regime or niche actors' agency, which, however, creates pressure on the regime and may eventually open up a window of opportunity for renewal of the regime and/or the upscaling of niche innovations (Geels & Schot, 2007; Kanger, 2021). Factors categorised as belonging to the landscape include slow change processes, such as climate change or industrialisation development, and rapid external shocks, such as wars or sudden price fluctuations (van Driel & Schot, 2005). Regime developments create further effects that may eventually turn into landscape pressures – for example, the continued use of fossil fuels contributes to climate pressures. While there has been some controversy in what constitutes the landscape (Geels, 2011; Kanger, 2021), in line with de Haan and Rotmans (2011), I argue that landscape should be conceptualised in relation to the focal system as the aggregate effect of adjacent, higher-scale or embedded systems. Conceptualised as this, the interactions between the focal system and the landscape level can be comprehended as two-way movement instead of the landscape simply exerting pressure upon the focal system.

While the MLP framework concentrates on the emergence and spread of new (sustainable) innovations, it does not explicitly account for the phase-out of existing (unsustainable) industries and regimes. However, the regimes have lifecycles that follow the phases of emergence, upscaling or growth, consolidation or maturity, destabilisation and decline (Kanger, 2021b; Markard, 2020). The X-curve framework addresses the phases and sequences related to regime build-up and breakdown (Figure 9; Hebinck et al., 2022; Rotmans et al., 2001). The X-curve framework has been inspired by the concept of the adaptive cycle developed in the field of social–ecological resilience studies (Hebinck et al., 2022), which is discussed in Section 2.2.4 in more detail. In the food system context, destabilisation and phase-out have received increasing attention (Frank & Schanz, 2022; Kuokkanen et al., 2018; Leeuwis et al., 2021; van Oers et al., 2021). The Finnish examples especially concern the efforts to cut the scope of animal production (Huan-Niemi et al., 2020) and remove peatlands from agricultural production (Huan-Niemi et al., 2023). However, in comparison with promoting niche-level innovations, phase-out and destabilisation are much more politically sensitive topics, as they concern questions of farmer livelihoods and regionally uneven policy outcomes (Huan-Niemi et al., 2020; Lehtonen et al., 2022).

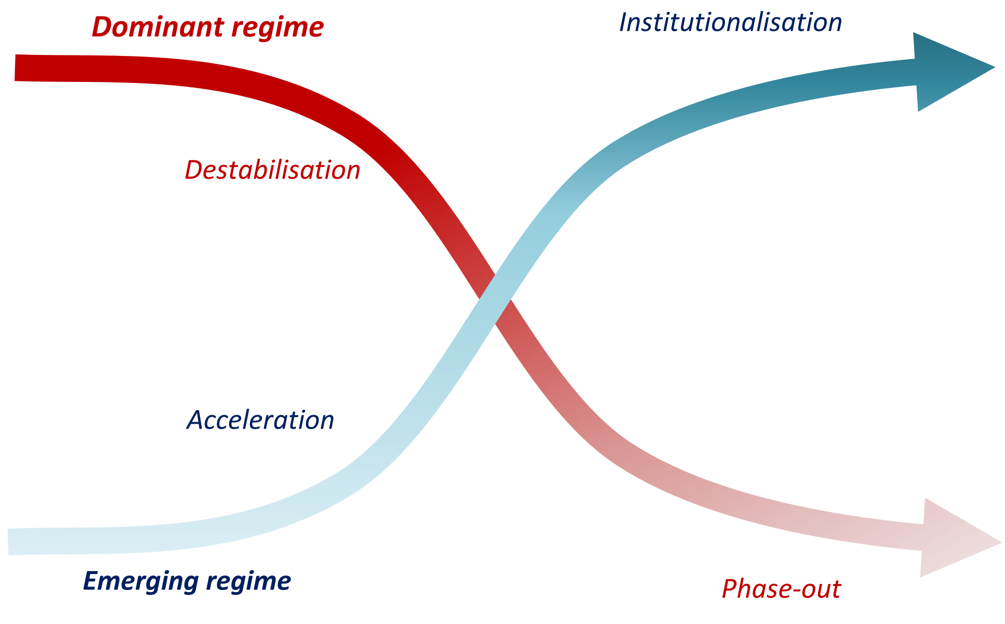

FIGURE 9 *The X-curve showing the patterns of regime build-up and breakdown (following Hebinck et al., 2022; Loorbach et al., 2017).*

2.2.3 Regime as an institutionalised structure

Fuenfschilling and Truffer (2014) suggest conceptualising socio-technical regimes based on **institutional theory**, which 'highlights cultural influences on decision-making and formal structures' (Barley & Tolbert, 1997: 93). Institutional theory emerged as a counterforce to rationalistic explanations of organisational behaviour to account for the paradoxical observation that in the effort of making rational choices, organisational actors happen to build an iron cage that constrains their agency (DiMaggio & Powell, 1983). Within institutional theory, the power of social structures on the actors operating within them can be explained in terms of socially constructed rule systems that instigate specific routines (Jeppersson, 1991; Scott, 2008). The mechanisms by which actors adopt rule sets are based on coercion and power, on normative pressure wherein the actors seek legitimacy with the 'generally accepted' norm system and on mimetic isomorphism, wherein successful actors are imitated by others (DiMaggio & Powell, 1983).

Institutional rule systems consist of three pillars: the cultural–cognitive, normative and regulative (Scott, 2008). The set of cultural–cognitive rules entails the domain of what the members of the focal system believe to be true. This dimension is the bedrock on which social activities build: it is about the assumptions of social reality that tend to be taken for granted (DiMaggio & Powell, 1983; Scott, 2008). In turn, the guiding question for the normative domain is what is believed to be moral. The normative rule system emphasises values and norms; the 'legitimate means to pursue valued ends' (Scott, 2008: 55). Roles are important carriers for the normative dimension; it is through roles and identities that many of the internalised norms that individuals hold become real (Jepperson, 1991; Scott, 2008). The regulative domain defines the limits within which the system actors must operate by means of enforcing rules, laws, governance systems, protocols and standards. If deviating from the normative rule system incurs shame, deviating from the regulative rule system incurs more concrete penalties and sanctions (Scott, 2008). Thus, a regime corresponds with an institutionalised structure of a social system, ultimately affecting (but not determining) the way the actors operating within the system think, feel and act.

The development of institutional theory has been influenced by structuration theory (Barley & Tolbert, 1997; DiMaggio & Powell, 1983; Scott, 2008), which suffers from certain shortcomings from the viewpoint of critical realism, as discussed previously in Section 2.1.1. The explanatory scheme adopted from institutional theory to account for the characteristics of socio-technical regimes rests within rule systems, although the theoretical tradition within institutional theory is rich and extends beyond rule systems. The rule systems themselves do not address the structural constraints that make actors more or less well positioned to comply with those rules (Archer, 1995; Svensson & Nikoleris, 2018) – there is much more going on in regimes than just what agents perceive. For example, Kok et al. (2021) and Svensson & Nikoleris (2018) highlight the importance of **material and spatial conditions** as well as **power**

relations as contributing to the stability of regimes. Svensson and Nikoleris (2018) argue that if regimes were only about rules, their effect on actors should be only (socio-)cognitive: the actors need to be aware of the rules and mediate their effect in conscious decision-making processes – which is not the case. Instead, the regimes also exert very material constraints on the actors' agency. Thus, addressing questions of stability and change in social systems requires attention to their metabolism (Fischer-Kowalski, 2011; Haberl et al., 2011), spatiality as well as infrastructures and technologies – to which the questions of path dependencies and sunk costs are strongly interwoven. The glue that binds together these structural constellations, ranging from rule systems to materialities, is power. Power is practiced through the roles that the actors occupy, and in this vein, it is also the bridging concept between agency and structure (Wittmayer et al., 2017). In addition, power is strongly connected to questions of materiality and spatiality: the contemporary regime reproduces certain spatial constellations that create competitive advantages in some areas and disadvantages in others.

The level of institutionalisation of a regime contributes to its strength towards agents operating within it (Fuenfschilling & Binz, 2018), but also indicates how prone it is to destabilise. Transition theory explains the destabilisation of existing regimes through the lock-in mechanisms of the institutionalised regimes, which results in incongruency and further efforts and investments in optimisation of the regimes. When coupled with continued external landscape-level pressures, these developments eventually lead to the destabilisation of the incumbent regimes (Geels & Schot, 2010; de Haan & Rotmans, 2011). According to Geels and Schot (2010: 44), 'regimes become unstable when actors begin to diverge and disagree on basic rules'. However, Sorrell (2018) and Svensson and Nikoleris (2018) argue that socio-technical transition theory does not do very well in explaining why some regimes become unstable and others do not or accounting for the dynamics of lock-in and path-dependency that make some more resistant to change and others more prone to it. For this end, exploring regimes from the viewpoints of morphogenesis, as suggested by Margaret Archer in the framework of critical realism, and adaptive cycles, developed as part of the resilience theory, may provide fruitful insights.

2.2.4 Regime transformation: from morphogenesis to adaptive cycles

Radical, transformational systemic changes equate with regime shifts – the system moving into a new stability domain, defined by a new set of attractors. These attractors define the rule set of a system. However, explicating the difference between incremental and radical transformations tends to remain ambiguous (Feola, 2015; Fisher et al., 2022). The frameworks of morphogenesis (from critical realism) and adaptive cycles (from resilience theory) offer tools for conceptualising transformational renewal of social systems. These frameworks also share notable similarities. Both of them address the dynamics of systemic change. Whereas morphogenesis addresses changes taking place in social systems, the adaptive cycle was originally developed to describe the cyclicity of changes taking place in ecological and then social-ecological systems.

The essence of Archer's (1995) morphogenetic approach rests in the analytical dualism between agency and structure: Human agency creates the structures of social systems, which in turn shape agency. The morphogenetic approach consists of three phases: structural conditioning (T1), social interaction (T2-T3) and structural elaboration (T4; Archer, 1995). Structural conditioning represents cultural inheritance and highlights the binding and constraining role of structures in terms of the path dependence and lock-in of vested interests and opportunity costs (Archer, 1995). In the phase of structural conditioning, resources tend to concentrate, which also leads to a 'fewer (---) number of parties who will be able strategically to transact societal change' (Archer, 1995: 298). The density of this cultural 'intelligibilia' (Lyon and Parkins 2013) tends to grow over time, which affects the system actors' capacity to absorb deviations. This leads to agents questioning the existing structure (social interaction) and eventually deliberately transforming it (structural elaboration). According to Archer, the state of cultural conditioning can be upheld for long periods of time, especially if prevailing power relations suppress any attempts at change. The morphogenetic model thus entails both radical and incremental forms of social change: morphostasis, during which the agents reproduce the social structure and maintain the social norms, and morphogenesis, during which they deliberately transform it.

In resilience theory, systemic transformations are captured by the heuristic of **adaptive cycles** (Figure 10). The concept of the adaptive cycle is based on the idea that the development of social–ecological systems, such as agrifood systems, proceeds in four stages: exploitation, conservation, release and reorganisation (Fath et al., 2015; Holling & Gunderson, 2002; Sundstrom & Allen, 2019; Walker & Salt, 2006). The formation of a dominant regime around specific attractors occurs during the reorganisation phase, and in the exploitation phase, the regime grows, offering many new possibilities for the actors within the system. Slowly, the system starts to stabilise, which manifests in increasing levels of path dependency. In the conservation phase, the regime becomes rigid to the extent of lock-in, where it allows only a little leeway for the actors to exercise their agency. The tight and multiple connections between the system elements in the conservation phase make the system vulnerable, and an external (or internal) disturbance can push the system over a resilience threshold, causing a collapse of the system in the release phase. After that, the system can start the cycle on a new trajectory – implying a move to a new stability domain – or reorganise more or less within the same basin of attraction. Thus, crises offer a window of opportunity for systemic transformations (Folke et al., 2010; Herrfahrdt-Pähle et al., 2020; Moore et al., 2014). The phase from exploitation to conservation, where the behaviour of the system is more or less predictable, is called the front loop, and it is where systems tend to spend most of their time (Walker et al., 2002). The chaotic and typically relatively short-lived release phase and unpredictable reorganisation phase form the back loop of the cycle.

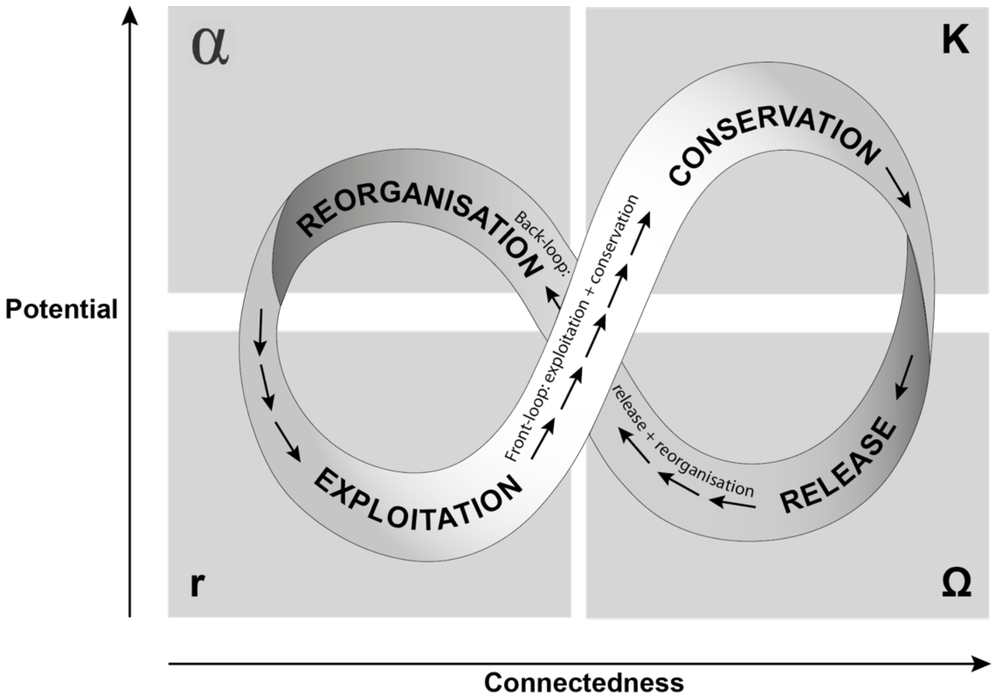

FIGURE 10 Adaptive cycle (based on Holling & Gunderson, 2002: 34).

The commonalities between the adaptive cycle and morphogenesis are striking, and surprisingly little explored so far – with the notable exceptions of Lyon & Parkins (2013) and Trosper (2005). Lyon and Parkins utilised both frameworks in their analysis of the transformation of rural resource communities and thereby developing a social theory of resilience. Indeed, integrating ideas concerning morphogenesis explicitly addresses one of the most recurring concerns and criticisms that both resilience theory and socio-technical transition research are facing, namely inadequate theorising on the role of human agency in relation to transformations towards sustainability (see also Geels, 2022). Morphogenesis emphasises the role of social action and agency for change, whereas the adaptive cycle – firmly rooted in resilience theory – emphasises the role of resilience thresholds and the (in)ability of the system to withstand shocks. However, aspects concerning the social side of social–ecological systems are present in the adaptive cycle as well, and for example, Westley et al. (2013) have shown that the adaptive cycle provides possibilities for conceptualising transformative sustainability agency.

An important aspect in the convergence between morphogenesis and adaptive cycles relates to the role of centralisation and concentration of resources to the hands of the few, which aligns with deepening path dependency and lock-in of the regime. Such developments slowly push the system actors towards more and more confined roles, thus reducing the possibilities for system agents to manifest their agency as in 'acting otherwise' – and eventually reducing the opportunities for the emergence of novelty and innovation (Westley et al., 2013). The relationship between agency and structure in both Archer's model of morphogenesis and the adaptive cycle can thus be seen as alternating and cyclic: the role of structural constraints increases during the front loop of the adaptive cycle, which represents the phase of structural conditioning and morphostasis. Increasing tensions within the system contribute to the creation of counternarratives, the growth of which creates further pressure on the dominant regime (Westley et al., 2013). The internal contradictions mobilise people to act on the structural constraints and eventually transform them (morphogenesis). In terms of the adaptive cycle, the system crosses the resilience threshold and is thrown into the backloop of the cycle. This means that agency needs to be evaluated differently in times of incremental change and radical change: 'acting otherwise' becomes an influential power when exercised by social collectives, which gives rise to morphogenesis, but mobilising such powers requires the presence of strong tensions in the system, even a crisis. This fluctuation between the 'forces' of agency and structure is captured in Figure 11.

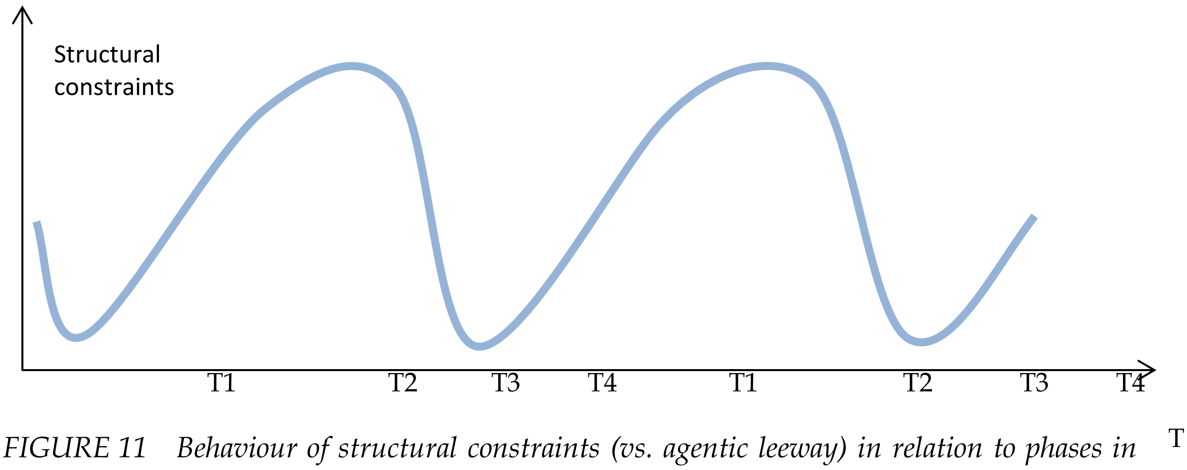

FIGURE 11 Behaviour of structural constraints (vs. agentic leeway) in relation to phases in the morphpogenetic cycle. T1: structural conditioning, T2–T3: social interaction and T4: structural elaboration. Based on Archer (1995).

2.2.5 Food regimes

The food system represents the structure that forms the backbone of farmers' agency. It is the system that keeps us fed (Sage, 2022), and it comprises all the stages of the food value chain from the production of food to processing, retail and consumption, as well as input production and ancillary activities related to the central function of the food system, including governance, food policies and politics and research (Karttunen et al., 2019; Sage, 2022; van Bers et al., 2019; Zurek et al., 2022). Food systems operate on different spatial scales, and their modes of organisation vary throughout those scales (Dornelles et al., 2022; Gaitán-Cremaschi et al., 2019; Sage, 2022). On a global scale, this variety has been captured in the concept of food regime.

Food regime theory (Friedmann & McMichael, 1989; McMichael, 2009), developed in the field of political economy, captures the historically changing power constellations related to the production and consumption patterns of food. McMichael (2013, 21) defines food regimes as representing 'the institutional relations that organize changing forms of food provisioning'. The food regime concept has been used as 'a conceptual tool to define periods or projects of rule based in particular forms of agriculture, social diets, and power relations on a geopolitical scale' (McMichael, 2012: 101; referring to Friedmann & McMichael, 1989). Friedmann (2005) notes that the rules upon which the organisation of food regimes is based are implicit. Once established, they start to look natural to the extent that the regime 'appears to work without rules', and the behaviour of the system becomes predictable (2005: 232) – as in the cultural-cognitive processes of regime institutionalisation. In turn, regime shifts are driven by growing internal tensions within the regimes, which eventually leads to 'many of the rules which had been implicit become named and contested' (Friedmann, 2005: 229). Thus, the concept resonates with the idea of a (global) stability domain or a socio-technical metaregime operating at the global scale and offers a useful analytical tool to understand the structural dimension of food system dynamics.

Friedmann and McMichael (1989) identified three food regimes with consecutively increasing global interdependencies. The first (1870s–1930s) was based on a combination of tropical imports from the southern colonial economies combined with grain and livestock exports from the settler colonies. The second (1940s–1970s) was based on both the green revolution and re-routing food surpluses as food aid to the (decolonised) south, along with the growing power of the agribusiness. The third (1980s onward) was based on financialised corporate agribusiness capital, global animal protein chains and a supermarket revolution (Bernstein, 2015; Friedmann & McMichael, 1989; McMichael, 2009). The third global food regime has also been conceptualised as the agro-industrial regime and, especially its later developments, as corporate (environmental) food regime (Friedmann, 2005; Lamine et al., 2012).

This **agro-industrial food regime** is built on 'strong liberalisation and commoditisation of corporate supply chains' (Campbell, 2009: 310), as well as 'cheap food prices and pressure on the costs of production' (Dumont et al., 2020: 105). In this regime, the concentration in agri-food value chains is by and large strong but varies by commodity type, with very high rates of global concentration occurring in seeds and agrochemicals, whereas in grocery retail, the concentration takes place at the domestic level (Clapp, 2022b). Concentration is driven by the financialisation of the sector whereby large (activist) investors are pushing for more revenues, for example, along with technological change (e.g. hybrid seeds) and a changing regulatory environment (e.g. intellectual property rights of plant varieties; Clapp, 2022b). Concentration is also visible in the oligopolistic supermarket structure, whereby food markets, especially in Europe and the US, are controlled by a small number of supermarket chains (Reigada & de Castro, 2022). The metabolism of the agro-industrial regime relies on fossil fuels, inorganic fertilisers, pesticides and herbicides; the production methods are intensive, specialised and strongly mechanised and dominated by economies of scale (Constance & Moseley, 2018; McMichael, 2009; van Dijk & van der Ploeg, 1995). Animal production takes place in large, industrial production sites that are decoupled from the local resource base and the animal feeds, especially soy, are transported from large distances (the 'intensive meat complex'; Friedmann & McMichael, 1989).

The agro-industrial food regime has boosted the productivity of food production significantly, and consequently, increased the availability and supply diversity of food for the majority of the world's population, as well as increased trade dependencies (Kummu et al., 2020; Porkka et al., 2013; Sage, 2022). At the same time, growing corporate control, financialisation and technology development have resulted in standardised and harmonised food production and processing practices, making supply chains substitutable and washing away regional food identities (Campbell, 2009; Clapp, 2022a; Lamine et al., 2012). Fossil metabolism that fails to recycle nutrients fed into the system, limitless expansion of food systems and missing ecological feedback have given rise to severe environmental problems ranging from climate change to biodiversity loss, environmental degradation and eutrophication (Campbell, 2009; Helenius et al., 2020).

These concerns have been embraced by food system actors, resulting in what Friedmann (2005) labels the **corporate environmental food regime**. It has emerged as a result of both tightening environmental policies and corporate-led social responsibility practices but is manifested as incremental changes within the ruleset of the dominant system (Constance, 2018) rather than as fundamental reorganisation of the system – which is what a sustainability transition would imply. Indeed, it seems many of the concepts with radical transformative potential, such as agroecology or climate-smart agriculture, have been or risk being co-opted by the dominant regime without any fundamental, structural changes taking place within the regime (Dumont et al., 2020; Schiller et al., 2020; Taylor, 2018).

The corporate environmental food regime builds on an audit culture, incorporating various schemes, labels and food safety measurements in its toolbox (Campbell, 2009; Campbell et al., 2012; Lamine, 2015). However, such an approach is prone to marginalise producers that are not well positioned culturally or resource-wise to meet the demands of the audit culture (Campbell, 2009; Freidberg, 2017; Lamine, 2015; Reigada & de Castro, 2022). The concentration of power in agrifood systems serves corporate interests but has consequences for sustainability, equity and justice aspects, and the agency of various food system actors – especially farmers as the primary producers of food (Clapp, 2022b). Farmers act as price-takers within the food system (Vermunt et al., 2020), and concentration squeezes their incomes and reduces their decision space (Friedmann, 2005; IPES-Food, 2017). Powerful firms in the concentrated markets of agri-food value chains 'have more capacity to shape those markets in ways that may be good for their own bottom line, but which may impose costs on others' (Clapp, 2022b: 57). This setting is exacerbated by the costs incurred by various environmental and sustainability policies: the corporate-driven regime passes the costs of compliance – the 'environmental buck' – on to farmers without compensating them for the increased costs and workload, further tightening the cost-price squeeze felt by farmers, eventually removing their agency (Fuchs & Kalfagianni, 2010; Glover & Touboulic, 2020).

Taken together, even though the corporate environmental food regime has addressed many of the pressing sustainability concerns, it has not provided an overarching solution to the sustainability crisis wherein the food system is involved, but it has squeezed farmer incomes and strengthened many of the inequalities within the food system, both in the value chains and in terms of global exchange patterns. How farmers, farming systems and food systems adapt and change in line with these pressures may be analysed through the concept of resilience, which is the topic of the next section.

2.3 Resilience theory

Resilience is an emergent, systemic property that relates to how a system responds to disturbances, stresses and shocks and how it sustains its core functions when facing such disruptions (Fath et al., 2015; Helfgott, 2018; van der Merwe et al., 2018). Resilience theory offers tools to understand and conceptualise the multiscalarity of transformations in social–ecological systems and the varying responses of systems and system agents to transformation pressures. I begin this section by looking at the concept itself to carve out a clear starting point for later explorations. I continue by discussing different types of resilience that can be thought of as different pathways of transformation (or stability) and end with an overview of the characteristics of resilient systems applied to the farming and food system context.

2.3.1 Defining resilience

The origin of the concept of social–ecological resilience can be dated to the field of ecology and especially to the pioneering work of C.S. Holling, who studied the stability of ecosystems and populations and identified the existence of multiple stability domains (Folke, 2006). In his seminal work 'Resilience and Stability of Ecological Systems', Holling defined resilience as 'the persistence of relationships within a system and (---) as a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist' (Holling, 1973: 17). Hence, in accounts crafted in the domain of ecology, resilience has had a conservative tone: the focus of explorations has been on how an ecosystem could remain within a current stability domain and not shift towards potentially less productive or ecologically less diverse system states, such as from clear to turbid lakes, from biodiverse wetlands to drained areas prone to both flooding and wildfires, from rangelands to salinised lands, from tropical forests to eroded grasslands and so on (Peterson, 2002; Walker & Salt, 2006).

However, many social scientists and sustainability transition scholars have been wary of the conservative tenets manifested in the original, prescriptive definitions of resilience (Geels, 2010; Hatt, 2013; Smith & Stirling, 2010; Stone-

Jovicich, 2015) that seem to imply that to remain resilient, a system should remain within whichever stability domain it happens to be at any given time. Such an interpretation risks the co-optation of the resilience framework to justify the maintenance of the status quo (Darnhofer, 2021; Rotz & Fraser, 2018). Even though resilience scholars have from the beginning made a clear separation from conceptualisations of 'engineering resilience' focused on 'bounce-back' types of resilience and instead stress the importance of adaptation, change and reorganisation (Walker, 2020), the commonly cited definitions of resilience do, indeed, underscore the importance of stability thresholds. This tenet is visible, for example, in the definition given by Walker and Salt (2006, 32) as resilience being about 'the capacity of a system to absorb disturbance; to undergo change and still retain essentially *the same function, structure, and feedbacks*' (emphasis added). In this vein, if the system transforms so as to move into a new stability domain, it can be interpreted as losing its resilience – regardless of whether this happens to safeguard the future resilience of the system, as in the case of sustainability transitions.[2]

To this end, differentiating between the resilience of a system and the resilience of a specific regime might provide some clarity. The social–ecological system is self-organised as a complex adaptive system to serve a specific purpose or reach a certain goal (Westley et al., 2002). Social–ecological systems are in place for a reason: food systems exist to feed the people that rely on them, just as mobility systems are in place to cater for the needs of people to move, and energy systems are organised to provide heat and electricity for societies. Systems can perform their functions and achieve their goals in a variety of ways, self-organised as regimes, as discussed in the previous section. Thus, if resilience requires the stability of certain structures and feedback in the face of adversity, does this mean that resilience is a property of a certain regime, not the system itself? From the perspective of resilience of the entire system, retaining the core function(s) – being able to deliver on it at all times – is much more focal (van der Merwe et al., 2018). The conceptual differences between resilient regimes and resilient systems can be read in concepts such as descriptive versus normative resilience or desirable versus undesirable resilience (Dornelles et al., 2020; van der Merwe et al., 2018). A certain system state – a regime – may be extremely resilient and locked in (e.g. consider the social metabolism based on fossil fuels and the difficulty of diverting away from them), but this is not desirable resilience, as in the long run, this kind of system behaviour will cannibalise the prerequisites for the long-term resilience of the system.

Definitions of **food system resilience** place emphasis on the main function of food systems: maintaining food security (Zurek et al., 2022). In this vein, for example, Seekell et al. (2017: 1) define food system resilience as 'all people hav[ing] economic access to a sufficient amount of food to satisfy their nutritional needs'. Bullock et al. (2017: 880) add elements of persistence in the face of

[2] However, for example Olsson et al. (2014) argue that this is a misinterpretation, as scales are of utmost importance for resilience; for a system to remain resilient at large scale, its subsystems must be able to transform when necessary.

disturbance to their definition of resilience in the context of food security as 'maintaining production of sufficient and nutritious food in the face of chronic and acute environmental perturbations'. Further, Hertel et al. (2023) emphasise that resilient food systems must also be financially equitable, supportive of the community, and minimise the harmful impacts on the natural environment.

At **farming system** level, defining resilience can be a bit more complicated. First, observing resilience requires asking whose resilience we are talking about in the first place. If resilience is defined from the perspective of the farm operator, it may relate to the ability of the farm to provide an income, regardless of whether the farm function relates to the food system functions (e.g., producing food vs. providing tourism services). However, if resilience is approached from a food system perspective, provision of the overall food system function needs to be considered. For example, Meuwissen et al. (2019: 2) define the resilience of a farming system

> as its ability to ensure the provision of the system functions in the face of increasingly complex and accumulating economic, social, environmental and institutional shocks and stresses, through capacities of robustness, adaptability and transformability.

Further, they see the system functions as consisting of two dimensions: (1) the provision of private goods, which entail the production of food and bio-based resources, as well as the provision of a reasonable livelihood for people involved in farming and (2) the provision of public goods, which translates to maintaining natural resources in good condition. Similarly, throughout this work, I conceptualise farm-level resilience as relating to a farm's capacity to contribute to the central food system function of food production.

2.3.2 Resilience as persistence, adaptability and transformability

When resilience is seen as the capacity of a system to fulfil its functions without undermining the long-term prospects for functioning, a resilient system should be able to transform and move into a new stability domain when necessary. Accordingly, resilience can take various forms as **persistence, adaptability or transformability** (Figure 12; Darnhofer, 2014; Folke et al., 2010; Meuwissen et al., 2019; Walker et al., 2004). These are fundamentally different strategies for a system to remain resilient, and they generally cannot coexist within the same system at the same time (Walker, 2020).

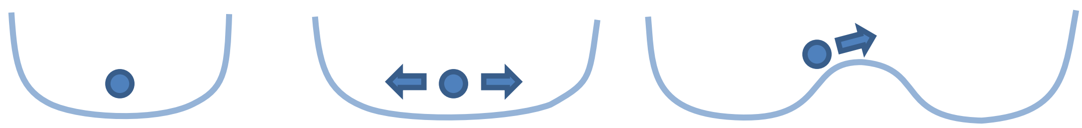

FIGURE 12 Resilience in relation to stability domains as persistence, adaptability and transformability (after Darnhofer, 2014 and Meuwissen et al., 2019).

Persistent or robust systems absorb perturbations without changing their structure (Darnhofer, 2014; Folke et al., 2010). Persistence requires buffering capacities that allow a system to absorb shocks without substantial changes taking place within the system itself (Darnhofer, 2014). Many of the strategies aimed at building resilience target persistent type of resilience; their idea is to guarantee the smooth functioning of a system, even in the face of adversity (Darnhofer, 2014, 2021; Sundstrom et al., 2023). However, the perverse quality of resilience is that the more robust a system is, the less resilient it will be in the long run (Walker, 2020). What follows is that a resilient system needs to be able to *adapt,* learn and actively manage and influence its behaviour. Adaptive type of resilience requires the capacity to build on what already exists, to combine resources in a new way and to acquire new resources, but without changing the way the system currently functions (Darnhofer, 2014). Yet sometimes adaptation and incremental changes are not enough for the system to remain resilient. This is when *transformability* – the ability of a system to shift towards a new stability domain – becomes necessary. Moore et al. (2014) argue that transformation, as distinct from adaptation, takes place when the dominant feedbacks within a system change and when the changes extend beyond the focal system under inspection. Transformation implies adopting a new set of rules and is thus akin to a regime shift.

Systems typically manifest different resilience strategies in different phases of the adaptive cycle. The adaptive cycle indicates the continuous movement of a system through the phases of exploitation, conservation, release and reorganisation. The cycle is not deterministic, and the resilience strategies of various subsystems affect the fate of the larger-scale system, while the larger-scale system also conditions the strategies at the lower levels. The movement between phases of the adaptive cycle is affected by the interrelationships among the scalar hierarchy of embedded systems, which are captured in the term **panarchy** (Holling et al., 2002). The concept of panarchy is based on a stratified understanding of reality, similarly to critical realism, which approaches reality as being constructed of embedded or overlapping entities. In the language of social–ecological systems, these entities are systems that inhabit different geographical scales – for example, a national-level food system consists of subsystems on smaller geographical scales, such as (regional) supply systems of various products and (local) farm systems, which further consist of field-level ecosystems and so on. At the same time, the food system is part of a transnational food system such as that of EU and the global food system. All of these systems have their own dynamics of adaptive cycles, but on different timescales. As a rule of thumb, the smaller the scale, the faster the cycles and vice versa (Holling et al., 2002). Resilience in effect requires such dynamic cross-scale interactions; adaptive resilience on a larger scale might, for example, require transformative resilience at smaller scales (Olsson et al., 2014).

A resilient system is able to navigate all the phases of the adaptive cycle while delivering its central functions (Fath et al., 2015). A system will then manifest adaptable or persistent types of resilience when navigating the cycle while staying within the same attraction basin, and a transformable type when it moves into a new stability domain in the reorganisation phase. Resilience strategies have been explored in food and farming system contexts in numerous contributions. The strategies of persistence, adaptability and transformability entail tensions and contradictions, as a persistent strategy may work against the development of capacities for adaptation or transformation (Ashkenazy et al., 2018; Darnhofer, 2010). Different strategies should be seen as preconditions and capabilities, not as automatic responses (Darnhofer, 2014). Their activation requires resources, and their manifestations in farm development trajectories can be fluid (Nicholas-Davies et al., 2021). Adaptability and transformability seem to perform well under long-term challenges (Bertolozzi-Caredio et al., 2022), but their activation may be impeded by strong place and occupational attachment (Marshall et al., 2012). Robustness or persistence is a common strategy among farmers (Nera et al., 2020), and, for example, the Covid-19 crisis activated more of the persistent types of coping capacities than adaptive or transformative capacities (Meuwissen et al., 2021). As a whole, the literature implies that the resources required by farm-level transformation may be hard to mobilise, and the lock-in condition at higher levels of the food system impedes the efforts towards transformation.

If a system is unable to adapt or transform, it may become stuck in a **systemic trap**. They are of two main types: a rigidity trap and a poverty trap (Holling et al., 2002). Adaptation and transformation require both resources and capacities. The poverty trap can occur when the system has exhausted its resource base, is not able to reorganise after collapse and is constantly fighting for its existence (Allison & Hobbs, 2004; Holling et al., 2002). If a system is rich resource-wise but lacks adaptive or transformative capacities, it may become stuck in a rigidity trap. This is most likely to occur during the conservation phase of the adaptive cycle, when streamlining and specialisation of system functions reduce diversity and lead to the system becoming overconnected and at the same time reducing opportunities for learning. The rigidity trap is the utmost example of path dependency: the system cannot transform and prevents transformations at the lower scales as well. This causes the system to continue to exploit both the natural resources and people upon which it is dependent, which makes it more prone to reorganise through collapse (Méndez et al., 2019; Robards et al., 2011). Systems stuck in rigidity traps have high potential, are very connected and resilient to attempts to shift their trajectories (Holling et al., 2002). Research on rigidity traps in the agrifood system context suggests that their formation is enhanced by orientation towards control, stability and efficiency (Uden et al., 2018) and by the inability of dominant actors to reorient because of huge amounts of sunk costs – until the capital base is completely exhausted (Allison & Hobbs, 2004).

2.3.3 Adaptive and transformative capacities

Resilient social–ecological systems in general and food systems specifically share a number of characteristics that allow them to navigate the adaptive cycle and fulfil their function. These characteristics can be thought of as the adaptive and transformative capacities of the system. Some of these capacities are characteristics of the systems in general, while others may be possessed by individual agents operating within the system. A synthesis of system attributes enhancing resilience is presented in Table 2. The synthesis is based in part of social-ecological systems on Resilience Alliance (2010) and Walker (2020), and in part of food systems on Cabell & Oelofse (2012) and Tittonell (2020). In the synthesis, the main attributes of diversity, modularity and openness form the basis for resilient systems. The more detailed indicators presented in the food system context are related to these three main attributes. In addition to attributes operating at the systemic level, attributes describing the behaviour of agents are presented in their own category.

TABLE 2 Synthesis of attributes enhancing resilience of social–ecological systems in general (Resilience Alliance, 2010; Walker, 2020) and in food systems specifically (Cabell & Oelofse, 2012; Tittonell, 2020).

General resilience		**Food system resilience**	
Resilience Alliance (2010)	*Walker (2020)*	*Cabell & Oelofse (2012)*	*Tittonell (2020)*
Diversity	Response diversity	Functional & response diversity	Functional diversity and redundancy Response diversity
		Spatial & temporal heterogeneity	Space and time heterogeneity
Modularity	Modularity	Social self-organisation	Social self-organisation
		Ecological self-regulation	Self-regulation
Openness		Appropriate level of connectedness	Connectivity
		Coupled with local natural capital	Building of natural capital
		Globally autonomous and locally interdependent	Autonomy and local interdependency
	Exposure to disturbance	Exposure to disturbance	
Agency			
	Ability to respond quickly to shocks and changes in the system Capability of transformation Thinking, planning and managing across scales Guiding, not steering	Reflective and shared learning Honouring legacy Building human capital Reasonable profitability	Reflective learning and human capital Capitalising local knowledge

Recurring themes important for analysing resilience in a farm system context include diversity and systemic 'slack'; modularity and locality; self-organisation, learning and agency; and cross-scale interactions. The attributes of resilience behave differently during the phases of the adaptive cycle: a system in the early exploitation phase is diverse, capable of self-organisation and learning and has room for the system agents to manifest their agency, whereas in the late conservation phase, the system is highly institutionalised and offers few opportunities for self-organisation; it has squeezed diversity and is overconnected. In the rest of this section, these aspects are discussed in more detail.

Increasing **diversity** is central to enhancing the resilience of food systems, but the contemporary food regime has been moving in the wrong direction from the point of view of resilience (Clapp, 2022; Hertel et al., 2023; Hodbod & Eakin, 2015). As Wood et al. (2023) state, 'food systems are currently losing diversity at multiple scales and from production to consumption, compromising both health and environmental sustainability'. In particular, the prevailing economies of scale and trend of specialisation have decreased the economic resilience of farms (de Roest et al., 2018). The resilience-enhancing aspects of diversity apply to biological and crop diversity, as well as to the diversity of farm management practices, production systems, livelihood options, trade relations, food cultures and nutrition (Abson et al., 2013; Birthal & Hazrana, 2019; Bullock et al., 2017; Darnhofer et al., 2010; Gassner et al., 2020; Kummu et al., 2020; Matsushita et al., 2016; Szymczak et al., 2020; Wood et al., 2023). In practice, diversity often implies redundancy (Rimhanen et al., 2023), which is a source of additional costs. Considering the aspirations of the agro-industrial food regime towards decreasing rather than increasing redundancy, streamlining operations and increasing overall efficiency, it is no wonder that enhancing resilience through diversity is not an easy task. For example, Darnhofer (2010) demonstrates that strategies that strengthen resilience at the farm level in effect compete for the initially scarce resources.

Modularity means that a system has 'nested and networked structures, where specific sub-units of a system have relatively greater internal integration than external integration, and where units can be combined in complementary and to some extent substitutable ways' (Eakin et al., 2017: 766). Resilient systems should have a modular structure; they should be open and connected to other systems, but not overconnected. What follows is that localisation is often – explicitly or implicitly – seen as a beneficial strategy to foster the resilience of food systems. Localisation would entail benefits from a resilience point of view due to recoupling many food system variables, decoupling of which has been associated with increased vulnerability or lock-in within the food system (Allison & Hobbs, 2004). Rist et al. (2014: 1), for example, argue that 'sustained anthropogenic inputs of external resources can lead to a ''coercion'' of resilience' and that 'the global interconnectedness of many production systems can camouflage signals indicating resilience loss'. Relatedly, Sundstrom et al. (2023) maintain that a high dependency of anthropogenic inputs leads to vulnerability and coerced resilience regimes. In the Finnish context, Himanen et al. (2016) highlight the role of nutrient and energy sovereignty in enhancing resilience. Lamine (2015) argues that it is not necessarily relocalisation but territorialisation that would provide the appropriate level of modularity and thus enhance resilience of food systems. However, Wood et al. (2023) argue that the local–

global debate does not provide the necessary tools to solve concurrent sustainability crises, but as the vulnerabilities of the food system have their root causes in scalar interactions, their solutions must cross scales as well.

In addition to an emphasis on more local solutions in many existing resilience proposals, resilience requires more bottom-up types of approaches in relation to **self-organisation, learning and agency**. Many studies exploring resilience in the farm system context report that the ability to collaborate (de Roest et al., 2018), support for learning (Knickel et al., 2018; Manyise & Dentoni, 2021), learning through experimentation (Darnhofer et al., 2010) and existence of communities of practice (Gosnell et al., 2019) are central in initiatives that aim to enhance farm-level resilience. However, resilience emerges from larger **cross-scale interactions** (Herman et al., 2018; Rathi, 2022). Córdoba Vargas et al. (2020: 419) argue that the 'unequal economic and political factors that hinder resilience' need to be taken into account. Bertolozzi-Caredio et al. (2022) identify institutional challenges as the main threats to resilience, and Darnhofer (2014) emphasises that even though resilience approaches draw attention to farmers' abilities to adapt and change, resilience should not be understood as simply the responsibility of individuals. Farmers and the farm level may even be overemphasised in interventions addressing the resilience of food or farming systems, as farmers are just one group among many, often much more powerful actors in the food systems (Meuwissen et al., 2020). In this vein, the last section of this theoretical-conceptual review concentrates on farmers' sustainability agency from the viewpoint of the agency–structure nexus and distribution of power.

2.4 Transformative sustainability agency

In the preceding sections of this theoretical-conceptual review, I have discussed the structural context of agrifood systems by focusing on the concept of regime and exploring the concept of resilience to build ground for understanding why systems and the agents within them behave the way they do. However, despite the strong structural forces presented above, farmers are not puppets of the system but manifest a multitude of values and preferences in their daily work. This raises the question of how farmers' individual agentic capabilities align and manifest themselves in the food system as the structural setting.

The scholarship on both social–ecological resilience thinking and socio-technical sustainability transitions has been criticised for their cursory treatment of human agency, questions of power and the framings and discourses of the contents of 'a resilient system' or 'a sustainable regime' (Avelino & Wittmayer, 2016; Lyon & Parkins, 2013; Olsson et al., 2014; Rauschmayer et al., 2015; Stone-Jovicich, 2015; Westley et al., 2013). As a response, a wealth of studies have addressed questions of transformative agency in the context of both social–ecological transformations and socio–technical transitions, as well as their interfaces. The approaches taken in these studies can be roughly divided into two main categories: (1) explorations of the subjective experiences, motivations and perceptions of the actors, and (2) more structurally oriented accounts of the actors' power positions, as well as the rules and resources that shape their behaviour (Upham & Gathen, 2021).

In this section, I first explore the topic of sustainability agency in the farming context, reflecting on the first of the above-mentioned viewpoints. Much of that scholarship focuses on farmers' decision-making patterns and management practices – which are but one aspect of agency and need to be complemented with analyses of the structural conditions and power relations to be able to unfold the capacity of 'acting otherwise'. I then present a framework that addresses the interface between agency and structure. I end with a brief discussion of how questions of transition agency feed into discussions of power and the directionality of transitions.

2.4.1 Ingredients of sustainability agency

Transformative sustainability agency can be approached from a multitude of perspectives. Teerikangas et al. (2021) list a number of approaches towards understanding sustainability agency, from approaches within social cognitive psychology to conceptualisations crafted in the sociology and management literature. These approaches vary in their takes on duality versus dualism in the structure–agency debate, in determinism versus voluntarism and temporal orientations towards the past or future. Agency and structure are necessarily intertwined – it is impossible to firmly separate the effect of socialisation to a certain worldview and value base from one's own convictions and inclinations; however, for analytical purposes such separation is necessary. Sustainability agency can be seen as composed of single decision situations whereby an agent makes choices with concrete sustainability implications. Even though the scope of this research project does not extend to analysing these decision situations, useful indications about where to look for their ingredients and antecedents are offered by Fishbein and Ajzen's reasoned action approach (2010) (former versions of the approach are also known as theory of planned behaviour or theory of reasoned action). The theory posits that behaviour can be explained by intentions, which are then explained by attitudes towards the behaviour, norm perceptions and perceived behavioural control (i.e. self-efficacy), coupled with the absence or presence of environmental and skill constraints. Thus, to analyse agency from the viewpoint of individual agents as decision-makers, it is necessary to consider (1) intentions; (2) capabilities and capacities; (3) beliefs, attitudes and values; (4) social norms; (5) perceptions that intermediate information between the individual and the environment; and (6) environmental constraints and facilitators. From this list, environmental constraints and facilitators have been discussed broadly in relation to the concept of regime – these factors represent, by and large, the structural context. The structural context is also present in social norms, as discussed in Section 2.2.3.

In the farming context, the aspects related to farmers' agency, decision-making and choices have been studied extensively, as the environmental impacts caused by food system activities are the direct consequence of farming strategies and practices. However, many of the framings adopted in this stream of research lack a direct relation to studies on sustainability transitions and transformations. These studies have addressed farmers' behavioural tendencies and decision-making structures in relation to environmental questions (Feola & Binder, 2010; Malawska & Topping, 2016; Schlüter et al., 2017); their adoption of environmentally friendly farming practices (Brown et al., 2021; Malek & Verburg, 2020; Siebert et al., 2006); farming styles, practices, strategies and trajectories (Huttunen, 2015; Lamine, 2011; Sutherland et al., 2012; Wilson, 2008); and adaptive management of farming systems (Andrade, 2016; Milestad et al., 2012; Peltomaa, 2015; Stringer et al., 2020), among others. This literature has convincingly shown that farmers indeed hold a variety of motivations beyond economic ones. The findings from this actor-oriented stream of research generally suggest that sustainable choices, actions and practices are more likely to take place (1) when the farmer holds high environmental values and attitudes, (2) when the farmer has knowledge and access to information about sustainable farm management, (3) when the social network is supportive of such practices – thus, they are considered culturally acceptable, and (4) when the farmer's goals and the farm system align with the prescriptions or requirements of the specific measures.

When integrating the factors distilled from the reasoned action approach and the empirical findings concerning farmers' behaviour, the commonalities are obvious: understanding farmer agency requires reflection on perceptual tendencies, intentionality, values, attitudes and social norms, as well as on the knowledge base, capacities and capabilities. All instances of agency are distilled through **perception**, which is not a 'passive reflection of the external world but rather a very active construction of the human nervous system' (Mingers, 2014: 5). Perception and meaning making are at the heart of agency in interpreting the structural context and overarching goals the farmer holds (Brédart & Stassart, 2017; Darnhofer et al., 2012; Schlüter et al., 2017). Perceptions reflect 'the shared conceptions that constitute the nature of social reality and the frames through which meaning is made' (Scott, 2008: 57). Thus, what the actor perceives as 'natural' – which can be seen to a great extent as a social construct – is manifest at the level of intuitive decision-making and tacit knowledge (Nuthall & Old, 2018). The role of perception in decision-making is captured in the model in Figure 13, which describes the relationships among perception, behaviour and consequences and information about the behaviour feeding back to the individual actor to guide future behaviours. All these stages are affected by the structural context, in which the characteristics of the agents predispose them to certain cognitive schemas and norms as well as material resources and power positions to make use of the resources, and a specific kind of socio-cultural environment that enables certain actions – which can be conceptualised as the regime.

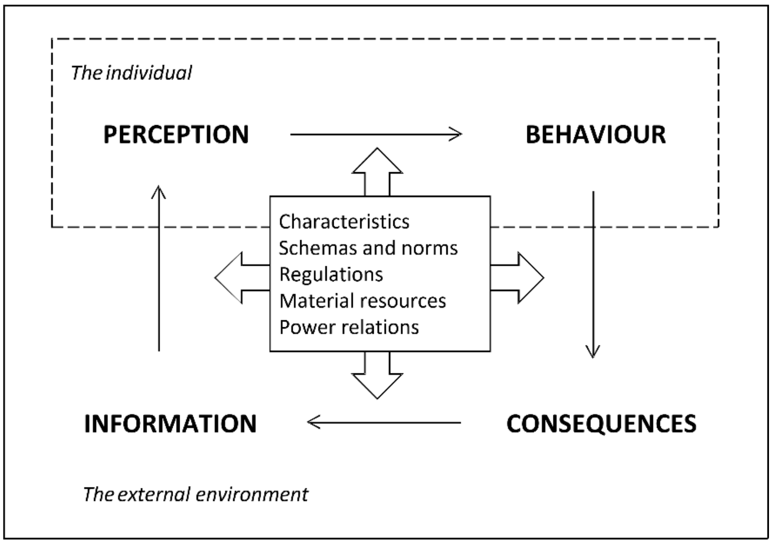

FIGURE 13 Perceptions intermediate behaviours: a simplified model (adaptation based on Meyfroidt, 2012, and Schlüter et al., 2017).

If agency is understood as a deliberate capacity to act (otherwise), **intentionality and reflexivity** must be central ingredients of agency (Archer, 1995; Giddens, 1984). Mingers (2014, 21) argues that being an agent requires 'some degree of interpretation and understanding of the meaning of the actions undertaken' – even though agents need not (and cannot) be fully aware of all the consequences of their actions. Farmers' choices revolve around their overarching goals (Brodt et al., 2006; Darnhofer et al., 2012; Lindenberg & Steg, 2007; Preissel et al., 2017). These goals have a long-term perspective, but they can still change over time (Darnhofer et al., 2012; Preissel et al., 2017). One of the most frequently identified goals of farmers in the extant literature relates to farm continuity (Barbieri & Mahoney, 2009; Glover & Reay, 2015; Preissel et al., 2017; Siebert et al., 2006). Farming is at its heart a form of economic activity, and the 'bottom line' remains an important motivator for decision-making at the farm level.

The likelihood of adopting sustainable farm management practices is related to the **beliefs, attitudes and values** of farmers (Sorvali, 2023), as well as **social norms** – both internalised norms and those working as perceived pressures to act in a certain way (Wang et al., 2023). For example, the culturally shared notion of 'good farming' has been frequently reported as affecting farmers' behaviour (Huttunen & Peltomaa, 2016; Silvasti, 2003; Thomas et al., 2019). Social capital can play a role in both directions, hindering or promoting the adoption of sustainable practices (Rust et al., 2020). However, none of these are enough to produce sustainable choices if farmers lack the necessary skills and **capacities** (Morgan et al., 2015; Price & Leviston, 2014). Skills can also be seen as a sign of a certain kind of cultural capital, and deviation from conventional farming practice also means learning a set of new skills as well as adopting different manifestations of being a good, skilled farmer (Huttunen & Oosterveer, 2017; Thomas et al., 2019).

Decision-making can be seen as a continuous act of optimising among the goals, available resources, constraints and possibilities available in the operational environment. Indeed, farmers typically aim at maximising **fitness** among the options available at the farm level and those offered by subsidy schemes (Lobley & Potter, 1998; Zimmermann & Britz, 2016). Runhaar et al. (2020) note that the availability of different institutional logics within a regime offers more opportunities for agency, whereas strongly coherent regimes constrain agency more. Logics and rules are not just about market structure and agricultural policies; material issues, such as land-use planning and nature conservation, can similarly strongly constrain farmers' room to manoeuvre in certain contexts (Slätmo, 2016). They also extend all the way to the social and cultural context, where changing expectations related to, for example, parenting, recreational activities and spousal roles can drive farmers towards pathways not deemed desirable from the point of view of sustainability transitions (Burton & Farstad, 2020).

Farmers' agency emerges from the interplay between individual behaviour and structural context. Even though agency entails choices and decision-making, it is more than the sum of actors' choices; it is at the heart of complexity of social systems. It is about the control that individuals have over their own circumstances (Clapp et al., 2022), and as such, it can work to either reinforce the existing system structures or change them. The structural context does not determine the outcomes of farmers' decision-making, yet it represents a strong constraining force due to which choices are also not the direct outcome of values, attitudes or worldviews – especially when they have been made and remade in a process of social construction affected by the cultural (structural) context. Rather, the relationship between agency and structure should be approached from the perspective of a feasibility space or fitness landscape, in which some choices are more probable than others but ultimately depend on the individual preferences of the farmer as an actor (Schiere et al., 2012). The next section discusses the interface between agency and structure through the concepts of roles and social power.

2.4.2 At the interface between agency and structure

Sustainable farm management has been approached lately increasingly as a systemic endeavour rather than as a matter of individual properties and values (e.g., Farstad et al., 2022; Gosnell et al., 2019; Ollivier et al., 2018). Farming system research highlights the importance of the contextuality of agency, where 'specific farming systems emerge from the co-evolution of farmers' perception and projects with the context in which they farm, biophysical as well as socio-economic' (Schiere et al., 2012: 349). Similar approaches have been taken in research analysing farm-level transitional pathways, farm trajectories and farming styles (Lamine, 2011; Sutherland et al., 2012; van der Ploeg, 2000; Wilson, 2008). This stream of research attempts to build a more robust understanding about why some farmers embark on pathways towards more sustainable farming styles and the role of trigger events in giving rise to the path dependency of farm development. The need to better account for the adaptiveness of farm management in relation to a changing operational environment has resulted in various contributions that evaluate farmers' adaptive strategies, reflecting the efforts of balancing between the drivers and constraints presented by the external context and the management goals and motivations of the farmers (Andrade, 2016; Brédart & Stassart, 2017; Maes & Passel, 2017; Milestad et al., 2012; Peltomaa, 2015; Singh et al., 2016; Stringer et al., 2020).

Sustainable pathways are not evenly accessible to farmers due to a number of contextual and structural factors (Wilson, 2008). Radical, transformational change agency is most likely to arise from niches (Bünger & Schiller, 2022; Hörisch, 2018), but committing to a niche-level, transformative movement and acting as a change agent are endeavours that require resources and commitment from the individual (Hörisch, 2018). Such actions can also encounter resistance from social networks due to niche actors working against the rules of the contemporary regime (Herman et al., 2018). Thus, transformative agency cannot be expected from the majority of the farmer population. The regime places strong constraining forces on farmers, which affects their potential to utilise the available resources.

The ability to draw or utilise resources from/in the structure corresponds with the actors' power positions in the system (Arts & Tatenhove, 2004; Davidson, 2010): power can be seen as a bridging concept between agency and structure. The power positions of actors operating in the system are related to the roles that they play (Avelino & Wittmayer, 2016; Trosper, 2005). Roles are the conceptual vehicle through which power 'crosses the middle ground' between agency and structure; power is related to the actors exercising it, but it is also a quality of the structure. The power position is strongly linked to structure but not predetermined by it; personal characteristics and capacities may assist in enlarging a power position. Power is an important aspect of agency in that it defines the 'operational space' or the 'room to manoeuvre' for actors. This power can be used to either reinforce the status quo or to challenge and transform it (Avelino, 2017; Trosper, 2005).

A model contextualising agency and structure is presented in Figure 14. This framework acknowledges the dual causal forces that structure and agency have on each other, but keeps these two entities analytically distinct from each other. Roles and power are the carrier of the interaction between agency and structure in this framework. The model incorporates four central dimensions or concepts from the agency–structure nexus that, I argue, are essential for understanding transformative sustainability agency: (1) the institutional foundations of regimes as discussed in Section 2.2.3, (2) roles as bridging vehicles between agency and structure, (3) resources and capacities that individuals have at their disposal facilitating their agency, and (4) power positions that provide agents with varying amounts of resources. All these dimensions are strongly intertwined, but have their own unique characteristics that support inclusion in the model as distinct factors. Following Svensson & Nikoleris (2018), the model conceptualises structure through the institutional dimensions of cultural-cognitive, normative and regulative, accompanied by materiality. Actors utilise the resources in this structural setting with the capacities they have, those deriving both from their personal characteristics and those intrinsic to the role position they occupy (Rauschmayer et al., 2015). Agency is manifested through roles (Wittmayer et al., 2017), and when taking on such roles, actors bring their personal characteristics along. The roles also entail a number of constraints and possibilities. For example, each actor in the food system has different transformative potential when occupying different roles: a farmer is bound by the constraints of the food chain's financial realities and the political and legislative environment, but that farmer may be, at the same time, acting in a political role that affects that very political and legislative environment. Similarly, the CEO of a retail company holds substantial power in the food system, but as a consumer, he or she occupies the same kind of power position as millions of other consumers. Even though a person takes on all these roles, bringing the same perceptual reality with them, the roles and power associated with them are distinct.

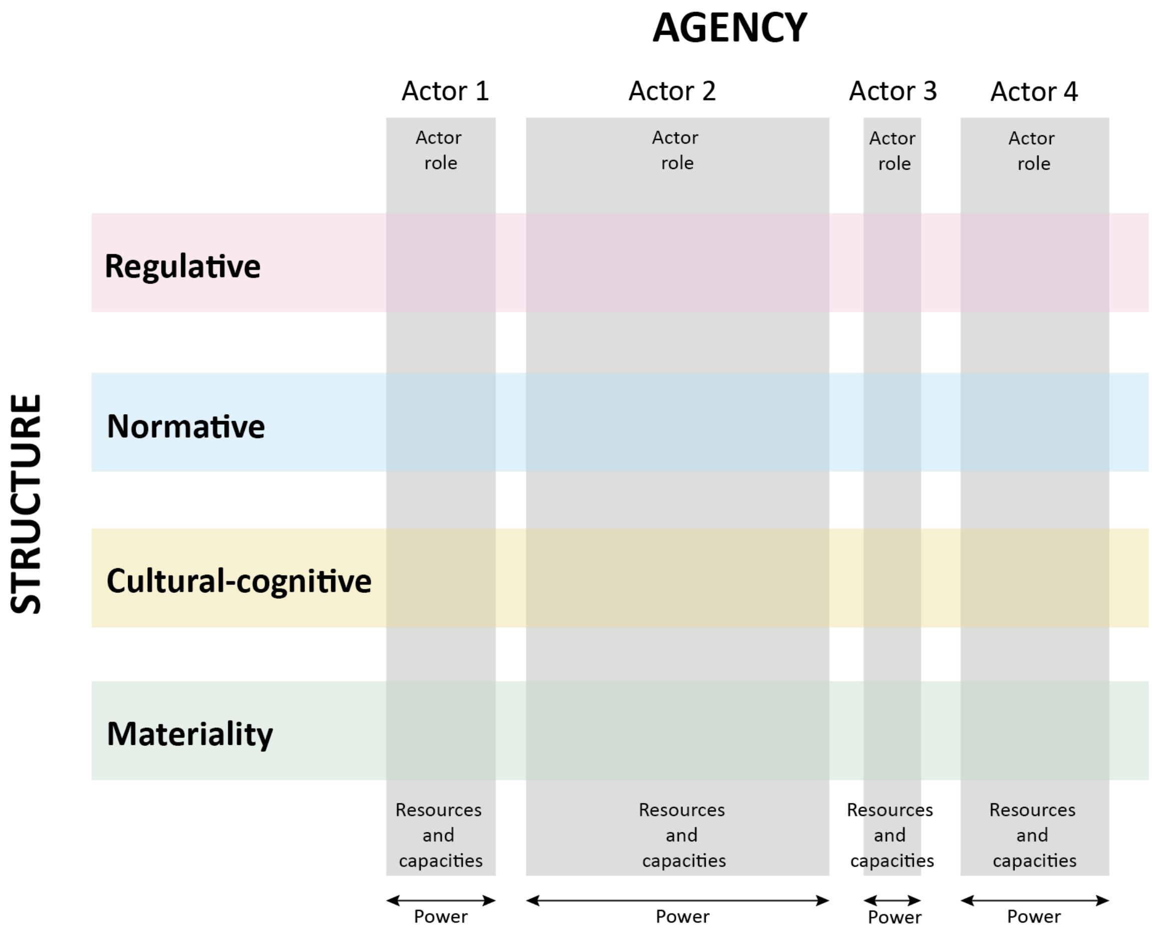

FIGURE 14 Framework for contextualising agency in a structure.

2.4.3 There and back again: directionality of transitions

If questions of transition agency cannot be discussed without also discussing questions of power, then questions of power cannot be discussed without also discussing the politics of transitions. In this sense, our journey in and around the topic of systemic transformations has come a full circle from inspection of regimes as the structural context of social systems to discussions of resilience and transition agency in the food system context, to return to the question of what the system we are tinkering with should eventually look like. This, of course, is a matter of individual perspectives, but also, to a great extent, it is a matter of social power. As transitions involve shifts in power relations (Dentoni et al., 2018; Rotmans & Loorbach, 2010), it is evident that in the course of transition processes, some actor groups are likely to win and others to lose. According to Archer (1995: 217), the success and failure of attempts towards systemic transformations 'is itself conditioned by the relative power of the interacting social groups'. However, the structural power constellations have not been always explicitly addressed in studies of societal transitions and transformations (Feola, 2020; Hatt, 2013). A number of authors have called for greater reflexivity concerning the politics of transitions and specifying the kinds of transitions that are considered sustainable in the first place (Feola, 2020; Meadowcroft, 2011; Patterson et al., 2017). Thus, calls for greater reflexivity of transition agency and power also ask for more explicitly endorsing the normative nature of transition processes, as well as questions of transition justice – whether the impacts of transition processes will exacerbate or even out power imbalances among different groups of actors and regions.

Even though different actor groups might agree on the need for transformative change, they might – and often do – strongly disagree on what counts as sustainable (Smith & Stirling, 2010; van Bers et al., 2019). Many transition policies are contested (Burton, 2019; Kuokkanen et al., 2018): their regional impacts vary greatly (Lehtonen et al., 2022), and different food system actors prioritise different transformational strategies (Dengerink et al., 2021). While there is agreement about the necessity of radical transformation in the food system for both the sake of sustainability and resilience, there is disagreement about its future directions (Béné, 2022; Clapp, 2022a). The concept of sustainability is difficult to measure precisely, and it is subject to interpretation and discursive contests about its ingredients due to which the sustainability concept can be used in a variety of ways (Béné et al., 2019a; Constance, 2018; Janker et al., 2018; Sage, 2022).

Much of the research done in relation to farmers' sustainability agency centres on sustainable farm management practices, typically in relation to the uptake of certain agri-environmental practices, but such an approach no longer remains at the heart of the agrifood transition discourse. Instead, it is more focused on the need to shift diets from animal-based food towards plant-based foods (Garnett, 2013). However, the implications of these shifts have not been widely discussed in relation to farmers' transformative capacities. Another issue around which discursive contests revolve concerns sparing versus sharing, reflecting the question of whether sustainability is best guaranteed by working intensively on land reserved for human use and sparing the rest for other life forms or whether it would be better to work the land in such a way that it can be shared with other lifeforms as well (Constance et al., 2018; Grass et al., 2019; Helenius 2020).

The consequences of transition policies have been explored, for example, in research concerning the geography of transitions as well as the justice of transitions. However, even within the stream of geography of transitions, questions of power, spatial marginalisation and peripheralisation have received less attention (Halonen et al., 2022), which are critical for studying the transformative agency of farmers, who are strongly bound to the material world: the land, climate and growing conditions of their farms. Research on transition justice analyses the distributive, procedural, recognitive, cosmopolitan and restorative dimensions of transition processes (Cadieux & Slocum, 2015; Glennie & Alkon, 2018; Kaljonen et al., 2021; Maluf et al., 2022). Research on just transitions specifically addresses the power dynamics, social inequalities and tensions related to transition processes, asking how the effects are distributed among different actor groups and regions (distributive justice), among different parts of the globe (cosmopolitan justice), whether different actor groups have a say in policy processes (procedural justice), whether the diversity of values is respected in the societal discussion (recognitive justice) and how the harms caused by transition policies should be compensated (restorative justice; Kaljonen et al., 2021). The integration of such insights is important for the analysis of transition agency and power, as it makes the social inequalities and power constellations related to transition policies visible.

3 METHODOLOGICAL APPROACH

3.1 Methodological choices

The research strategy adopted in this research is based on **mixed methods** and theoretical, methodological and data **triangulation**. Critical realism generally supports methodological pluralism, which represents a paradigmatic turn of leaving behind the 'paradigm wars' or the either-or dualism of only relying on quantitative or qualitative research methods and moving towards a both-and type of approach (Danermark et al., 2002; Mingers, 2014; Tashakkori & Teddlie, 1998). The range of phenomena and entities embraced by critical realism – from languages and emotions to material objects – means that their explorations need to be based on quite different research strategies (Mingers, 2014). To be able to appreciate the complexity of the real instead of confining oneself to the domain of empirical or actual, it is necessary to approach the topic of inquiry from multiple angles and lenses. Mingers (2014: 184) aptly describes this philosophy:

> (---) the real world is complex and multi-dimensional, while particular research or intervention methodologies focus only on specific aspects. Using a particular methodology is like viewing the world through a specific instrument such as a telescope, an X-ray machine, or an electron microscope. Each reveals certain aspects but is blind to others.

In this research, my aim is to understand the scope of farmers' agency in the context of a food system facing strong transformation pressures. The research task is thus two-fold: there is a need to capture both the farmers' viewpoint and the changing structural context. Danermark et al. (2002: 39) maintain that 'questions of method should primarily be related to the nature of the object under study and the purpose of the study'. Evidently, such a research task requires triangulation: approaching the topic from multiple viewpoints. Denzin (1978) identifies four types of triangulation: on data, investigator, theory and methodology. Of these, data, theory and methodological triangulation are applied here. In data triangulation, a research problem is analysed using a variety of data sources; in theory triangulation, the results are interpreted on the basis of a variety of theories, and methodological triangulation means using multiple methods (Tashakkori & Teddlie, 1998). In terms of data triangulation, I utilise two sets of farmer survey data and a literature review. In terms of theory triangulation, I draw from two distinct theoretical frameworks: social–ecological resilience theory and socio–technical sustainability transitions. In terms of methodological triangulation, I utilise a set of both quantitative and qualitative methods to analyse the survey data and qualitative methods to analyse the existing literature.

The research strategy I have adopted relies mostly on abduction. It starts with established theories which are then applied to the analysis of cases. However, the application does not happen in a straightforward top-down manner (as in deduction) but through redescription and contextualisation (Danermark et al., 2002). In abduction, an empirical event is related to a rule (theory), which will lead to new assumptions about the event (Danermark et al., 2002). While the abduction strategy can provide new insights, interpretations and explanations, those are fallible, hypothesis-like suggestions – conclusions among a set of many possible conclusions (Danermark et al., 2002).

The research strategies adopted in the articles are presented in Table 3. Article 1 explored the decision strategies of farmers in mainland Finland in terms of choosing certain kinds of agri-environmental practices. It utilised farmer survey data from 2010 (n = 2,124). The methods were based on the qualitative content analysis of open-ended survey questions and quantitative contingency tests. Article 2 utilised the same data set but analysed farm-level resilience as emerging from the interplay between food system structure and farmer agency. The research strategy was quantitative and utilised multinomial logistic regression analysis. Article 3 analysed the adaptive and transformative resilience capacities of peripheral farmers. In this study, farmer survey data from Eastern Finland was utilised. The data were analysed by means of both quantitative (contingency tests and multinomial logistic regression) and qualitative (content analysis) methods. Article 4 analysed the historical regimes and regime shifts of the Finnish agrifood system by means of a qualitative literature review and thematic analysis.

In the remainder of this section, I describe the utilised data sets and analysis methods in more detail. The section ends with an evaluation of the research process.

TABLE 3 Research strategies of the articles.

Article	Data	Approach	Methods
RQ: Why do farmers choose certain agri-environmental practices?			
(1) Kuhmonen, 2017	Farmer survey data from 2010 (mainland Finland, n = 2,124)	Quantitative – mixed	Content analysis + contingency tests
RQ: How does farm-level resilience emerge from the interplay of the structure of the food system and the agency of farmers?			
(2) Kuhmonen, 2020	Farmer survey data from 2010 (mainland Finland, n = 2,124)	Quantitative	Multinomial logistic regression
RQ: What kind of adaptive and transformative capacities farmers hold in a peripheral setting, and which factors contribute to them?			
(3) Kuhmonen & Siltaoja, 2022	Farmer survey data from 2018 (Eastern Finland, n = 577)	Quantitative – mixed	Multinomial logistic regression, content analysis, contingency tables
RQ: What kind of long-term evolution and transition dynamics can be identified within the Finnish agri-food system?			
(4) Kuhmonen & Kuhmonen, 2023	Literature review (n = 96)	Qualitative	Thematic analysis

3.2 Farmer surveys

3.2.1 Survey data

Two sets of farmer survey data were utilised in this research. Both datasets were collected as part of the evaluation process of the Finnish Rural Development Programmes (RDPs). The first data set was collected in 2010 during the mid-term evaluation of the RDP for mainland Finland for the years 2007–2013 (Kuhmonen et al., 2010), and the second data set was collected during the mid-term evaluation of the RDP of Eastern Finland for the years 2014–2020 (Kuhmonen et al., 2018). Data from the first data set from mainland Finland was used for Articles 1 and 2, and data from the second data set from Eastern Finland was used for Article 3. The RDPs are the mechanism through which the funds of the Common Agricultural Policy (CAP) are distributed to farmers and other rural actors. RDPs are crafted both nationally and regionally, even though the regional programmes have the same subsidy measures as the national programme. The programmes address questions related to economic, environmental and social challenges of rural areas in the member states and define the principles and subsidy measures on which the funds will be distributed.

The survey data for both datasets were collected via online surveys. Survey requests were sent to all farmers that had registered email addresses in the Integrated Administration and Control System (IACS) farm register. For the mainland Finland survey conducted in 2010, this resulted in addresses for about

23,000 farmers, and for the Eastern Finland survey conducted in 2018, there were 7,796 farmers in the base population. The response rates for the surveys were about 9% for both, yielding altogether 2,124 (mainland Finland) and 577 (Eastern Finland) responses. In both datasets, large farms were more greatly represented than within the base population, as were garden farms and farms with 'other production' as the main line of production (Table 4). The surveys included questions related to the farm and its characteristics (e.g. line of production, location and farm size), the farmer (age, family relations, education and livelihood), farm management and production (e.g. farm strategy, financial performance, goals and barriers), adoption of subsidised agri-environmental measures and other measures and environmental aspects generally.

The farmer survey datasets were used to analyse farmers' choices of sustainable farm management practices (mainland Finland data; Article 1), resilience trajectories (mainland Finland data; Article 2) and resilience capacities of farmers (Article 3). For a detailed description of the variables used in these studies, see Kuhmonen (2017), Kuhmonen (2020) and Kuhmonen and Siltaoja (2022).

TABLE 4 Representativeness of the utilised data sets. Data source for 'all farms': Natural Resources Institute Finland). MF = Mainland Finland, EF = Eastern Finland.

Variable	Survey farms (MF, 2010)	All farms (MF, 2010)	Survey farms (EF, 2018)	All farms (EF, 2018)
n	2,124		577	
Farm size (MF, 2010; %)				
< 15 ha	19	32		
15–29.99 ha	22	26		
30–9.99 ha	23	19		
50–74.99 ha	17	12		
75–99.99 ha	9	6		
⩾ 100 ha	10	6		
Farm size (EF, 2018; ha)			44	39
Line of production (%)				
- Dairy	18	18	20	29
- Beef	6	6	10	10
- Pork	5	3	1	0
- Poultry	1	1	0	0
- Other cattle	3	5	3	6
- Cereals	43	44	22	9
- Other crops	6	6	29	41
- Horticulture: garden crops	5	3	9	6
- Horticulture: greenhouse production	8	13	0	1
- Other production	5	1	6	2
Total	100	100	100	100

3.2.2 Operationalising resilience

For the needs of the Articles 2 and 3, the resilience concept had to be operationalised in order to quantitatively analyse it. The operationalisation strategies used were different for these two studies. Article 2 analysed resilience in terms of the farms' performance trajectories and thus adopted a conception of resilience as in asking resilience *for what purpose* (Meuwissen et al., 2019). In contrast, Article 3 analysed farm-level resilience in terms of resilience capacities of robustness, adaptability and transformability, thus asking *resilience by which means* (Meuwissen et al., 2019). While both articles explored the question of 'who is resilient in the face of sustainability transformation', they did so from different viewpoints (triangulation).

Agency is central for resilience – both at the higher systemic level, such as those of whole food systems, as well as at smaller scales, such as farm systems. However, many resilience assessments tend to sideline this subjective, agent-centric quality of resilience (Jones, 2019; Perrin et al., 2020), despite the fact that subjective and objective resilience assessments seem to produce highly compatible results (Jones & d'Errico, 2019). My operationalisation strategy for resilience was based on agent-centric processes instead of external indicators of farm performance in both cases. The operationalisation strategy in Article 2 relied on farmers' performance perceptions, whereas in Article 3, it was based on farmers' goal-setting strategies. Perceptual processes are at the midway point of the internal world of the actor and the external context where he or she operates; they transmit information from both sides. Thus, they cannot be used as straightforward indicators of performance per se, but in assessing resilience – the capacity of a system to survive and keep functioning despite stresses and shocks – they work much better. In this vein, in Article 2, I operationalised farm resilience based on the farmers' perceptions of their farms' past performance trajectories in terms of the environmental and economic performance. This conceptualisation addressed the specific resilience of the central farm functions – providing a livelihood to the farmer (economic performance) but doing so without undermining the future prospects of farming (environmental performance). For a farm to be labelled as resilient, the farmer thus had to perceive improvement in both environmental and economic performance over the past three years. The operationalisation process is described in more detail in the original publication.

Farmers' goals are similarly important for the resilience of farm systems. Goals are what ultimately guide our behaviour; they motivate and direct behaviour, as discussed in Section 2.4.1. Their importance is highlighted by considering that the functioning of a complex adaptive system can be traced back to the goals of the systems – what it is that they are 'tuned' to achieve. In Article 3, the farmers' goals were analysed against the backdrop of the three resilience capacities of persistence, adaptability and transformability. In the analysis, other variables depicting the future strategic orientation for the farm and more detailed plans for the future were also utilised. In a nutshell, persistent farmers were farmers that did not have overarching development aspirations for their farm apart from continuing business as usual. If a farmer, in contrast, indicated some kind of development plans – be it in relation to growing the farm, handing it over to a successor or seeking some kind of technological improvements or investments – it was coded as adaptable. The farm was coded as transformable when there was clearly an ongoing search for a new direction. Diversification was coded in this category, due to the recurring finding that diversification as a development strategy is becoming rare on Finnish farms – to such an extent that diversification as such implies going against the tide in many ways within the Finnish food system context. Finally, a non-resilient category was identified, consisting of farmers who intended to quit farming altogether, who had no successors and were planning to retire or move to another business and sell or lease or afforest the fields. Here, it must be noted that while the operationalisation strategy is different in Articles 2 and 3, I have defined resilience consistently in relation to the food system context: for a farm to remain resilient, it has to contribute to the food system functions, even if looking for a new livelihood beyond the food system would be a feasible resilience strategy from the point of view of farmer livelihood. For a detailed description of the coding process, see the original article.

3.2.3 Content analysis

Content analysis was done at several points of the research process for a number of variables in both farmer survey datasets. These variables were originally asked as open-ended questions. Closed questions are efficient and can be analysed more quickly, but they do not allow for individual voices to be heard (Krippendorff, 2004). Open-ended questions are used when there is not a clear, predefined understanding about the phenomenon under study, or when the issue requires the survey respondent to reflect on the matter more deeply than simply choosing an option among a predefined set of answers. The aim of the content analysis was to summarise the data by converting a large number of responses given in open-ended survey questions to a more restricted number of categories (Neuendorf, 2002; Weber, 1990) that could be then used in further statistical operations (cross-tabulations and logistic regression analyses). For these kind of situations, conventional content analysis is a suitable option (Hsieh & Shannon, 2005). In conventional content analysis, the categories arise from the data in an inductive manner (Hsieh & Shannon, 2005) – even though in practice categorisation is affected by a researcher's previous understanding about the subject of the study, which will then feed into the category-building, making the process more abductive in nature (Krippendorff, 2004). This is what is meant by understanding the categories as analytical constructs that 'operationalize what the content analyst knows about the context' (Krippendorff, 2004: 34). Categorisation requires going back and forth with the data, changing and renaming categories along the way, especially in those cases where an initial understanding of the phenomenon is not well developed. Content analysis relies in practice on a mixture of theory, experience, statistical information and intuition (Krippendorff, 2004). The analysis process aims at capturing not just the surface level expressions but also the latent constructs within the data (Neuendorf, 2002) – for example, coding resilience strategies based on farmers' self-stated goals and strategies was an interpretive endeavour that required interpretation and merging information from several variables.

The classes derived from the content analysis were used for understanding farmers' adoption motivations of subsidised agri-environmental measures as well as their perceived effectiveness in Article 1. In practice, each response was oftentimes assigned two categories: a parent category and a subcategory. In Article 3, content analysis was performed for questions concerning farmers' goals, perceived barriers for achieving the stated goals, problems with soil condition and prevention of waterway eutrophication. An overview of the survey questions, number of coded responses and the derived categories are provided in Table 5. During the research process as a whole, the number of open-ended responses categorised in the content analysis was 4,289.

TABLE 5 Content analyses: an overview. 'Relevant respondents' refers to the share of respondents that were eligible to answer the question.

Survey question	**Number of responses**	**% of relevant respondents**
Data: Mainland Finland (n=2,124)		
'Why did you choose these additional measures from the basic-level agri-environmental scheme?'	1,278	70%
Contextual factors: personal factors, farm factors, social networks		
Production-related factors: general fitness, line of production, feasibility, easiness, benefits, familiarity, cost-effectiveness, suitable machinery		
Effectiveness-related factors: economic effects, environmental effects		
'Why did you choose these measures from the special agri-environmental scheme?'	540	69%
Contextual factors: personal factors, farm factors, social networks		
Production-related factors: general fitness, line of production, feasibility, easiness, benefits, familiarity, cost-effectiveness, suitable machinery		
Effectiveness-related factors: economic effects, environmental effects generally, chemical loading, landscape, biodiversity, waterways		
What was the most important environmental benefit from the agri-environmental scheme on your farm?'	1,169	55%
Land use as the causal mechanism: plant and grass cover, nature management fields, filter strips, riparian zones, avoiding abandonment, environmental management		
Productive practices as the causal mechanism: pesticide use, fertilising practices, organic farming, changing the production methods		
Final impact: erosion, air emissions, quality of the farm environment, soil quality, landscape, biodiversity, ground water, surface waters and nutrient emissions, environmental awareness		
Data: Eastern Finland (n=577)		
'What are your most important goals for farming?'	381	66%
Resilience categories: persistence, adaptability, transformability		
Identification of economic, social and personal goals		
'What are the most important barriers on the way of your goals?'	343	90%
Barriers related to the physical environment, markets, politics, social environment, personal characteristics, the farm and the economy		
'If there are problems in the soil condition on your fields, what are they like?'	205	36%
Problems related to hydrology, pH and nutrients, locational factors (e.g., stony fields), other factors		
'Do you seek to reduce the nutrient emissions from the fields to water bodies? How?'	373	65%
Prevention by reducing input use, through farming methods such as tillage practices, through preventing runoffs with riparian zones etc.		

3.2.4 Statistical analysis

The research strategy in relation to the quantitative data was built on contingency tables and logistic regression analyses. First, the choice of variables to be utilised in the statistical models was based on screening the data with various methods based on analysis of variance. As neither of the datasets that were utilised in this research were collected specifically for the purpose of analysing farm-level resilience, the choice of explanatory variables was not based on a theory-driven understanding about the phenomenon of resilience. Instead, the choice of variables to be analysed further was based on an abductive, data-driven process in which the variables included in the original survey data sets were scrutinised one by one by analysing them against the research variables and the theoretical understanding about resilience, to decide on the set of variables to be used in the final statistical models. To avoid multicollinearity, overlapping questions were excluded – thus, it was not possible to include, for example, both a question on farmer age and farming experience in years, as these variables tend to correlate strongly.

For Article 2, tests of variance served as part of the pre-screening process. For Article 3, these methods were also utilised as part of the analysis strategy of profiling the farms with varying resilience capacities. This was because many of the background variables of interest were derived from the content analysis, but as there were so many respondents who had not answered all open-ended questions, including these questions in the regression model would have limited the number of observations too much. For the continuous variables, ANOVA tests were performed, and for categorical and dummy variables, frequency tables with chi-square tests were utilised.

In Articles 2 and 3, multinomial logistic regression analysis was conducted to expose factors that differentiated the resilience categories. This method is feasible for describing the relationships and interdependencies between a (categorical) research variable (the resilience categories) and several explanatory variables, which can be both continuous and categorical. In Article 2, the analysis was performed twice to explore the predictors for both the resilient and vulnerable groups. In Article 3, the reference category was the non-resilient group, and thus, the model predicted memberships for the other resilience categories. Detailed descriptions of the analysis process are provided in the respective articles.

3.3 Literature review

For the analysis of the properties of the agrifood regime and its development dynamics, a literature review was conducted. For this study, approximately 100 items from the literature were reviewed. These items included analyses of the history of the Finnish agrifood system as well as statistics and items documenting developments in specific fields related to the agrifood system. The items were located and retrieved from various sources, digital databases as well as physical libraries by utilising search queries and snowball sampling. The complete list of items is provided in Article 4. From the literature, 'data' was collected in terms of nine dimensions and systemic properties that were deemed essential for understanding the evolution of the agrifood system from the perspective of resilience theory. The data analysis and collection of the literature items occurred simultaneously, and data collection ceased when it appeared that no new themes were emerging from the sources; i.e. saturation was achieved.

The method of the literature review was based on the principles of thematic analysis (Clarke & Braun, 2017), which could be also thought of as directed content analysis (Hsieh & Shannon, 2005). In this approach, existing theory directed the analysis to a larger extent than in the case of conventional content analysis. The analysis aimed at identifying the regime shifts from the history of the Finnish agrifood system based on the concept of adaptive cycle. The process operated on the temporal and content-specific dimensions. In practice, this means that the analysis aimed at dating the major regimes and regime shifts throughout the course of the agrifood system's history and also identifying the properties and rulesets of these regimes. These two research tasks were accomplished side by side. Regimes were first identified at a coarse level, from which the analysis proceeded towards a more fine-tuned understanding about the regimes and their phases in terms of exploitation, conservation, release and reorganisation. The rules of the regimes were identified by analysing the system during each regime in terms of the nine properties of the system: (1) agricultural production, (2) main source of energy and nutrients, (3) technology and production methods, (4) food chains, (5) culture and society, (6) climate and environment, (7) demography, (8) international trade and (9) agricultural policies. The nine dimensions were then described for each regime. To specify the phases of the adaptive cycle, five systemic properties were analysed for each phase and regime: (1) resilience, (2) connectedness, (3) potential, (4) feedback loops and (5) agency. While resilience, connectedness and potential are central features of a social-ecological system and relate in a well-known way to the adaptive cycle, feedback loops and agency have not been analysed similarly in relation to studies on adaptive cycles. However, based on the understanding described in the previous sections, these variables were deemed important for understanding the system dynamics.

3.4 Evaluation of methodological choices

The concepts of reliability and validity are typically used to evaluate the scientific rigor of research. Validity examines the extent to which the chosen indicators actually represent the studied phenomenon, whereas reliability concerns the consistency of measurement, for example; whether the same results would be retrieved in repeated studies (Carmines & Zeller, 1979). In sustainability sciences, the choice of indicators plays a huge role in the results and implications of research projects. This risks the very concept of sustainability becoming 'defined by the parameters that can be measured rather than the other way around' (Bell & Morse, 2008: xvii). The same issue concerns resilience assessments (Rotz & Fraser, 2018). The concepts of sustainability and resilience are both elusive, contextual and subject to interpretations – as was evident in the discussion in Section 2.3.1. Thus, a researcher looking into these phenomena needs to stay attuned to questions of validity when generalising and communicating research results – indicators for sustainability and resilience are neither objective or value-neutral (Rotz & Fraser, 2018), but reflect many underlying assumptions and aspirations.

As discussed in Section 3.2.2, resilience has been operationalised variably in the research articles of this thesis. Resilience, like sustainability, is an overarching theme used to depict system dynamics and its implications for actors operating within the agrifood system, rather than a specific unambiguous conceptual construct. Thus, the validity of the chosen operationalisation strategies needs to be interpreted from the viewpoint of the aims of the focal studies. In relation to Articles 2 and 3, the question to be asked is whether performance perceptions can be used to depict the concept of resilience in the first place, and whether farmers' outspoken goals and intended strategies may be used as proxies for resilience strategies. Given the nature of the concept of resilience as a boundary object that has certain conceptual integrity but that allows interpretation (Soubry & Sherren, 2022), the answer to both questions is probably yes. With respect to Article 2, performance perceptions, if used as sustainability indicators, need to be dealt with cautiously. For example, Moore & Rutherfurd (2020) caution that self-reports of environmental behaviour tend to be less reliable than observed proxy data. However, despite the commonalities, resilience and sustainability performance are not synonymous. For the needs of understanding and identifying farmer groups that are likely to thrive in the face of both environmental and economic pressures, performance perceptions provide a plausible starting point.

Reliability in the case of surveys relates to the consistency of measures: whether the survey respondents answer survey questions consistently and thus provide reliable information about the research topics, but also with regard to the sampling techniques. Both surveys addressed the entire farmer population in the study areas. The response rates of the surveys were rather low, but in line with other farmer surveys conducted in Finland. As a whole, both surveys utilised in this research project yielded a rather large number of respondents, which contributes to the robustness of the statistical techniques used. Bias in relation to the respondents can be derived from the differences between those who responded to the survey and those who did not. Such biases are unavoidable in survey settings. The coverage of the survey data is discussed earlier in this section. Cronbach's alpha, or coefficient alpha, is a popular method for testing internal consistency in survey design (Drost, 2011). Cronbach's alpha was estimated for a set of the explanatory variables in Article 2.

The overall framing of the research as well as the conclusions I present operate at a higher level of abstraction compared to the original articles. The robustness of findings is based on a triangulation technique: inputs to most of the research questions have been derived from more than one article, as well as three sets of data.

4 OVERVIEW OF THE ORIGINAL ARTICLES

4.1 Article 1 – Why do farmers choose agri-environmental practices?

In Article 1 (Kuhmonen, 2017), I set out to understand farmers' motivations for adopting environmentally friendly farming practices, specifically subsidised agri-environmental measures funded as part of CAP in Finland. The study also explored farmers' perceptions of the environmental effectiveness of these practices. It contributed to an empirically informed stream of adoption studies that have explored factors affecting farmers' adoption behaviour of environmentally friendly farming practices. It was not based on a specific theory-led approach but rather was explorative and data-driven in nature. The study contributed to an understanding of farmers' self-stated adoption motivations on a wide range of measures, which allowed a comparison between different types of measures and their adoption rationales. The results of the study build understanding about the role of agri-environmental policies in the sustainability transition, as the agri-environmental scheme is the most important mechanism involving farmers as part of it.

The study was conducted during the 2007–2013 programming period. The agri-environmental measures were divided into two main categories: basic and special schemes (MAF, 2011). Joining a scheme meant that a farmer was compensated for financial losses caused by adopting environmentally friendly farming practices. Those farmers who had opted to join the basic scheme could, depending on their location, choose a set of additional measures. These were 'broad brush' types of measures, which 'tend to include a large number of farmers, cover a wide area, make relatively modest demands for changes in farmers' practices, and pay correspondingly little for the environmental service provided' (Van Herzele et al., 2013). Almost all survey respondents had joined the basic-level scheme (98%). Additionally, the scheme included a set of special measures of a 'deep and narrow' type with higher complexity and greater effectiveness (Van Herzele et al., 2013). These measures were adopted by 37% of the survey respondents (24% of the base population). In Table 6, a general outlook on both the adoption motivations and the perceived effectiveness of measures in the subsidy scheme is offered based on the content analysis of open-ended responses, along with chi-square tests.

TABLE 6 Farmers' adoption motivations and perceived effectiveness of agri-environmental measures in the agri-environmental subsidy scheme in the Rural Development Programme 2007–2013.

	Adoption motives	Perceived effectiveness
Basic-level scheme		
Optimising fertilisation	General fitness; feasibility; economic effects	Changes in fertilisation practices
Reducing fertilisation	Social networks, cost-effectiveness; environmental effects	Avoiding abandonment of the fields; landscape effects
Tillage practices	Farm factors; general fitness; method of production; economic effects	Changes in plant cover; reduced erosion; improved biodiversity
Crop portfolio	Method of production; economic effects	Changes in production methods; improved soil quality; improved biodiversity
Manure management	Social networks; suitable machinery	Changes in production methods; reduced emission to the air
Nature management fields	General fitness; economic effects	Setting up nature management fields; application of filter strips; improved biodiversity
Special-level scheme		
Reducing fertilisation	Environmental effects	Reduced pesticide use; changes in fertilisation practices; protection of groundwater
Manure management	Social networks; benefits; cost-effectiveness; suitable machinery	Changes in production methods; reduced emissions to the air
Protecting the waterways	Farm factors; environmental effects related to waterways	Application of riparian zones; changes in environmental management and fertilisation practices; protection of groundwater
Promoting biodiversity	General fitness; line of production; familiarity; landscape effects	Changes in environmental management; improved quality of the farm environment; landscape and biodiversity effects
Organic farming	Personal factors; method of production; economic effects; environmental effects generally; reduced chemical loading	Changes in environmental management; adopting organic farming; improved soil quality, landscape and biodiversity

In general, I argued that adoption decisions should be understood as manifestations of the fitness between farmers' goals and prescriptions of the measures. Thus, farmers aim at aligning the triad consisting of conditions at the level of the farm system, their own goals for farming and the institutional factors in the form of prescriptions of agri-environmental measures. All of these are mediated through farmers' interpretations about the outcomes of these practices, both in relation to their effects on practical farm management and their perceived environmental effects. Even though the conditions on individual farms and farmers' motivations are highly diverse, there were some specific patterns observable in the data.

First, the basic agri-environmental scheme is a production-oriented scheme that fits the aims of a wide variety of farmers and can thus promote only incremental changes at the farm level. Measures in the basic-level scheme were adopted mostly due to production-related motives: when the measure was perceived to fit the existing farm system and when the measure was perceived as easy to implement. Even though economic motivations were not mentioned very often as the primary adoption motivation, the results reflect the fact that the basic-level agri-environmental scheme is especially perceived in Finland as part of farmers' income streams. The majority of farmers chose measures that represented the smallest effort and smallest possible change to existing practices. Even though a policy of small steps and incremental changes can be critiqued for its inability to trigger transformative change, this approach ensures that the majority of farmers are somehow keeping up with the sustainability transition. However, the agri-environmental scheme and especially the measures in the basic-level scheme act as low-threshold measures that may trigger more lasting changes. In particular, some of the measures related to fertilisation practices were described positively: they were perceived as cost-effective, and a number of farmers stated that they would have implemented such practices anyway. In this sense, fertilisation represents an area where it is possible to achieve win-win situations from the point of view of the farm economy and environmental outcomes. This, of course, requires commitment and knowledge from the farmer's side.

Second, the special agri-environmental scheme offers more opportunities for transformative change at the farm level. While the special agri-environmental scheme was not as widespread as the basic scheme, from an environmental point of view, the most effective practices could be found in this scheme. While many farmers adopted measures in the special scheme because of production-related motives, contextual motives (factors related to the farm, the farmer and the social networks) and effectiveness-related motives were substantially more common in this scheme. Value- or world view -related motives were especially important for measures that promoted biodiversity and organic farming. These measures require commitment from the farmers, as they differ substantially from conventional farming practices. Especially in the case of practices that require skills in their application or that are very complex, economic incentives also play a role – and do not rule out, as such, sustainability-related motivations. In a nutshell, the special measures offer the means for more transformative change at the farm level.

Third, the farmers' perceptions regarding the effectiveness of the measures seemed quite accurate when contrasted with the prescriptions of the measures. For the survey respondents, changes in farming and land-use practices were seen to imply effectiveness per se, as half of the responses concerned changes in practices, and half addressed final environmental impacts. Interestingly, however, especially for those measures that are strongest in promoting agricultural biodiversity, landscape values in their adoption motivations outweigh the importance of direct biodiversity benefits. Thus, from the point of view of farmers, the protection of agricultural landscapes and agricultural biodiversity go hand in hand. In the adoption of measures targeting fertilisation practices and essentially reducing the eutrophication of water bodies, the measure prescriptions were related to farmers' adoption motives and how they attributed the impact of the measures. For example, farmers reported changing fertilisation practices in the case of the basic-level measures of optimising and reducing fertilisation, but not so much in the case of the special measure that reduced the fertilisation levels more drastically. It seems that this measure was seen more as a way to prevent abandonment of the fields than to using them for productive purposes in the first place.

Fourth, the results should be interpreted in the context of the prevailing food regime: How does the structure condition farmers' choices of agri-environmental measures? The importance of production-related motives in relation to all types of measures, at the level of both basic and special schemes, highlights the important role that livelihood issues play in adoption decisions. Thus, questions of farmer livelihoods should not be detached from questions of agri-environmental management. However, the conclusion drawn needs not be that production motives rule out environment- or sustainability-related motives, but rather that for a farmer, the act of farming is supposed to be economically viable and a form of livelihood. The livelihood options, then, are constructed within the possibilities and constraints posed by the contemporary agrifood regime.

4.2 Article 2 – Exploring the factors contributing to farm resilience towards environmental and economic pressures

In this study, I set out to explore farm-level responses to two fundamental and partly incompatible demands they are facing: staying economically viable and environmentally sustainable. I conceptualised farmers' capabilities and strategies in response to these demands in terms of resilience. This operationalisation of resilience builds on the capability to deal with economic shocks and stresses while running farm operations in an environmentally sustainable way. Further, I argued that the resilience of a farm system – whether it continues to function as a farm – is dependent upon farmer agency, and these aspects tend to be often sidelined in resilience studies. Thus, I did not use external indicators of resilience but relied on farmers' perceptions of their economic and environmental performance to study their responses to pressures from the external environment. While such an approach lacks the validity of precise measurements and cannot be used as an indicator of, for example, the overall environmental sustainability of the Finnish farming sector, it does address some of the most fundamental dimensions of the resilience concept, such as agency, adaptation, perceptions and temporality. The continuity of a farm system is based precisely on the interpretations of the farmer: not on how the system looks to an external observer based on a number of abstract values, but rather on how the farmer as the focal decision-maker interprets the situation.

With this setting, I aimed to understand how resilience emerges 'as an outcome of the interplay between farmers as focal agents in the farm systems managed by them and the larger agrifood system representing the structure that constrains and enables farmers' agency' (Kuhmonen, 2020: 361). I operationalised resilience through the farmers' perceptions of their farms' performance trajectories in terms of environment and economy by utilising farmer survey data from mainland Finland from 2010 (see Section 3.2.1). The surveyed farmer population was divided into four groups based on their performance trajectories: a resilient group in which the farmers perceived positive development in both dimensions; an environmentally vulnerable group, where the farmers perceived positive development in the economic dimension but negative in the environmental dimension; an economically vulnerable group, where the farmers perceived positive development in the environmental dimension but negative in the economic dimension; and a vulnerable group, where both performance trajectories were perceived negatively. Using multinomial logistic regression analyses (as described in Section 3.2.4), I explored the factors contributing to these developments.

Generally, farmers' perceptions about the environmental dimension were more positive than their perceptions about the economic dimension. The perceptions were also correlated: when environmental performance was perceived positively, economic performance was also likely to be perceived positively, and vice versa. The largest share of farmers (36%) was situated in the group that was both environmentally and economically vulnerable. Around 40% of the respondents were positioned in both of the mixed groups, in which one of these dimensions was vulnerable. The resilient group consisted of 23% respondents. The basic characteristics of these groups are presented in Table 7 based on the results of the regression analysis.

TABLE 7 Characteristics and key figures of the resilience groups in terms of environmental and economic performance perceptions.

	Resilient	**Environmentally vulnerable**	**Economically vulnerable**	**Non-resilient**
Group size	n = 483, 23%	n = 400, 19%	n = 452, 21%	n = 738, 36%
Production line	-	-	-	Pig and poultry, cereals
Farm size	Large farm size	Average farm size	Small farm size	Small farm size
Farmer age	-	-	Old farmers	Young farmers
Farm strategy	Growth or diversification	Not diversification	Downsizing	Not growth or diversification
Organic	-	-	Not organic	
Adoption of special AEMs	Has adopted	-		Has not adopted
Environmental management	-	-	Perceived needs	-
Social capital	Positive perceptions	Negative perceptions	Negative perceptions	Negative perceptions

The vulnerable and resilient groups were in many respects mirror images of each other. The vulnerable farms were mostly small, whereas the resilient farms were large. The vulnerable farms had not committed to farm development, whereas the resilient farms had either in terms of growth or diversification. Vulnerable farms had not adopted special agri-environmental measures, whereas resilient farms had. Farmers in the vulnerable group held negative perceptions about the socioeconomic developments in the area in which they resided, as well as about administrative processes related to the implementation of agricultural policies, whereas the perceptions the resilient farmers held were positive. Vulnerable farms were likely to consist of cereal farms, as well as pig and poultry farms, but the resilient group was not characterised by any specific production line. The market situation, especially for cereals, was difficult at the time of the study, which may have contributed to the perceptions regarding the economy in the vulnerable group. Farmers in the vulnerable group were also younger.

The farms in the economically vulnerable and environmentally resilient group were maintained by older farmers who had committed to agri-environmental issues in farm management but were downsizing. The farms in this group were small in size and the farmers held negative perceptions about social capital. The farms in the environmentally vulnerable and economically resilient group were heterogenous. They were of average size, committed to business as usual, and held negative perceptions about social capital.

In particular, the role of perceptions concerning social capital was pronounced in separating the resilient group from the vulnerable groups. This raises the question of to what extent operationalising farm-level resilience based on farmers' perceptions indicates first and foremost the perceptual tendencies farmers hold. However, I argue that because the role of perceptual tendencies was so pronounced, evaluations of resilience should necessarily entail the dimension of individual agency. In the end, resilience was not just about perceptions; it was also strongly related to structural factors, such as farm size and farmer age. The connection between farm size and resilience versus vulnerability implies the strong effect that the overall food system structure exerts at the farm level; for a farm to be resilient within the current systemic structure, it usually needs to be relatively large in size. The farms' development orientation was important as well, with a development orientation going hand-in-hand with resilience, implying that resilience is related to an ongoing attempt at adaptation or transformation at the farm level. Interestingly, the environmental orientation took on different manifestations in the various groups. While farmers in the doubly resilient group were more likely adopters of special-level agri-environmental measures, the environmentally resilient and economically vulnerable group was characterised by a concern for the management of environmental issues at the farm level, not so much by action.

The results of the study suggest that resilience in relation to environmental and economic pressures emerges from a farm's adaptation to the dominant regime in terms of both structural prerequisites (farm size) and the farmer utilising the possibilities that the regime offers. In addition, adaptation requires that the farmer possess agency that makes such adaptation possible, which is observable in a future orientation and levels of social capital. Resilient farms aim to develop their operations in various fronts, one of which is environmental sustainability. However, the majority of farms in Finland at the time of the study were labelled as vulnerable in some or both dimensions. The agrifood regime exerts a tightening cost-price squeeze on farmers, and in such a situation, those farms that are initially better off are more likely to survive. This setting emphasises self-reinforcing feedback at the farm level, both for the better and for the worse: farms that are initially better off are able to harvest resources and grow. However, the prerequisites for farm development are not the same for all. Thus, even though it was not possible to study the causalities related to the interplay of agency and structure with this research setting, it is possible that resilience emerges from spiralling effects of agency and structure reinforcing each other – either for the better, as in the case of resilient farms, or for the worse, as in the case of vulnerable farms.

4.3 Article 3 – What kinds of resilience capacities do peripheral farmers hold?

This study addressed farm-level resilience through capacities that build resilience and are manifested as varying adaptive and transformative strategies at the farm level. The double challenge of simultaneous financial pressures, coupled with a heated sustainability debate, calls into question the resilience of farms that are already in a vulnerable position. Eastern Finland is an example of an area that is strong in animal production, has a limited number of alternative production possibilities due to climatic and soil conditions, and in which the general socioeconomic development pattern has been unfavourable.

We adopted a lens of just sustainability transitions to analyse the resilience capacities of farms in this area. Specifically, we asked how the resilience capacities of farms in peripheral areas should be considered in the design of just transition policies. The concept of restorative justice offers an analytical tool to explore this question further. We utilised representative farmer survey data from 2018 in the analysis. We examined the farm-level resilience strategies: whether the farmers indicated persistent, adaptive or transformative types of resilience, or have lost resilience altogether. These strategies shape the direction of the transition processes at the food system level, in which the role played by transformative farms is particularly interesting.

The farms were first classified into four groups based on their resilience strategies. After that, the groups were analysed in relation to a number of background variables, revealing what kind of farms were likely to manifest specific kinds of resilience capacities by using contingency and regression analyses. The largest farm group consisted of persistent farmers (37%), followed by adaptable (34%), non-resilient (24%) and transformable farmers (8%). The basic characteristics and key figures of the resilience groups based on contingency analyses are presented in Table 8.

Persistent farmers aimed to do things largely as they had been done previously. They had small crop farms, and they were not dependent on farming as a source of livelihood. Perhaps partly due to the relatively low expectations of farming income, they were satisfied with the profitability of farming. These farmers were less likely to have opted into any of the subsidy schemes, including agri-environmental schemes. Adaptable farmers, in contrast, aimed at the continuous development of their farms by growth, succession or investment plans. They were dependent on farming as a source of income, and they were also satisfied with the profitability of farming. Their farms were large, typically dairy, cattle or horticultural farms. The farmers were rather young, and often a spouse was also involved in the farming. Their aim was to continuously develop the farming business, and they actively utilised the available subsidy measures.

TABLE 8 Characteristics and key figures of the persistent, adaptable, transformable and non-resilient farm groups in Eastern Finland.

	Persistent	**Adaptive**	**Transformable**	**Non-resilient**
Group size	n = 212, 37%	n = 176, 31%	n = 48, 8%	n = 139, 24%
Description	Satisficing; business as usual	Regime aligners; continuous improvements and development	Looking for new paths, multifunctional strategy, major turn	Quitters that aim at giving up farming
Farm	Smallish farms Cereals, other crops Produce raw materials only	Large farms Dairy and cattle farms, horticulture and other animals Also processing	Large farms Other animal production, special crops and horticulture Also processing	Small farms Horticulture and other crops Produce raw materials only
Farmer and the farming family	Vocational education Living alone No children	Young farmers Higher education Farming couple with children	Young farmers Higher education No children	Old farmers Vocational or basic education Have children
Farming as a livelihood	Farming not that important as source of livelihood, small farming income Business-as-usual in the past Satisfied with profitability	Farming important source of livelihood, relatively high farming income Growth in the past Satisfied with profitability	Farming important source of livelihood, farming incomes both small and large Diversified or changed in the past Not satisfied with profitability	Farming not that important source of livelihood, small farming income Business-as-usual or downsizing in the past Not satisfied with profitability
Goals and barriers	Economic and personal goals, barriers in markets and physical environment	Economic and social goals, barriers related to markets, policies, farm economics	Economic and social goals, barriers in markets and the farm	Economic and personal goals, personal barriers, social barriers
Soil condition	Moderate soil condition	Good soil condition	Good soil condition	Moderate–weak soil condition
Prevention of eutrophication		Runoff prevention and farming methods	Runoff prevention and farming methods	Reducing input use
Biodiversity		Semi-natural habitats	Wetlands and semi-natural habitats	
Agri-environmental measures	Not assigned; when assigned, no effect	Assigned; implemented new practices as a result	High adoption rates of different subsidy schemes; implemented new practices as a result	Not assigned; when assigned, no effect

What distinguished the transformable and non-resilient farms from persistent and adaptable farms was their perception about the profitability of farming. When not satisfied with profitability, the farmers were likely to pursue different pathways, either within the domain of the food system, as in the case of transformable farmers, or beyond it, as in the case of non-resilient farmers. In contrast, the main difference between transformable and non-resilient farms was the resources and capacities they possessed. Non-resilient farmers were older, had a lower level of education and had no successors interested in taking over the farm. Farming typically constituted less than 50% of their income. They also identified problems in the quality of their most important asset, the fields, but did not do much to improve the situation. Their future plan was to sell, lease or afforest the fields. In contrast, the transformable farms – even though evaluating the profitability of farming as weak – were younger, had the highest level of education across all groups, had large farm sizes, and aimed at reconciling the economic and sustainability objectives in their work. The role of farming income in relation to total income varied, but many aimed to increase the role of farming in their income streams. Transformable farmers actively utilised available subsidy measures. These farmers were searching for new pathways and new ways of doing or diversifying the farm business.

The sustainability orientation across these farm groups was considerably different. For the group of persistent farmers, the lack of a development orientation in farming was also present in the lack of a development orientation towards agri-environmental management. Non-resilient farmers did not hold many environmental objectives, but their orientation towards cost reduction led many to reduce input use, typically fertilisers – even when they identified a lack of nutrients as a problem in the soil condition. Adaptable and transformable farmers, who were committed to farming as a source of livelihood, either presently or in the future, were also committed to agri-environmental management. Sustainability goals were present especially in the group of transformable farmers, and farmers in both of these groups had adopted several environmentally beneficial practices, from taking care of the soil condition to managing wetlands and seminatural habitats, as well as opting into agri-environmental schemes.

In sum, we concluded that adaptive and transformative capacities in farming were related to farmers' commitment to farming as a source of livelihood. What follows, then, is that transition policies need to be built upon enabling farming as a livelihood. Individuals committed to farming tend to build their expertise on various fronts, including sustainability issues. From the point of view of farmer agency, sustainability and economic goals need not be exclusive. However, the question of structural constraints remains. Adaptable farmers aim at aligning their practices with the requirements of the regime, which typically means an orientation towards growth or intensification. Transformable farmers, in contrast, are searching for pathways beyond the contemporary regime. This search, however, has been ongoing in the case of these farms in the past as well

– the small number of transformable farms also signals that this strategy is not an easy one.

A sustainability transition implies, among other things, changing the ruleset by which the actors are playing. How this ruleset can change is a core question for just transition. From the point of view of peripheral farmers, the persistent farmers might keep on farming as long as it is a feasible thing to do – but also quit perhaps more easily if the incentives are lost. Transformable farmers who are looking for a new ruleset to play by might benefit from a transition – provided that it allows room for a specific model of farming that is suitable for their conditions. In the face of a sustainability transition, adaptable farms might be vulnerable to drastic changes in the regime's ruleset. Farmers have invested in and aligned their operations according to the regime's current rules, and, for example, disincentivising animal production would probably negatively affect this group of peripheral farmers.

Regime shifts as changes in a system's stability domain mean that the previous state of an entity operating in a system cannot be restored as such. Accordingly, restorative justice cannot be built upon the idea of compensations or transition periods. These ideas stem from linear approach to systems. To build resilience of farm systems in the context of a just sustainability transition, there is a need to proactively build alternative pathways suitable for a rich variety of farms. As the contemporary regime has worked towards squeezing out this diversity from the point of view of resilience building and just transitions, there is a need for a completely different future direction.

4.4 Article 4 – Dynamics of adaptive cycles during the history of the Finnish agrifood system

While the previous articles in this project explored farmers' choices, trajectories and strategies within the constraints and possibilities offered by the contemporary agrifood regime, this study aimed at (1) unpacking the ingredients of this very regime, along with (2) identifying the evolutionary dynamics that led to its emergence, and (3) analysing the conditions of regime shifts that have occurred previously in the Finnish agrifood system. We did this by examining the history of the Finnish agrifood system in the context of one of the central concepts of resilience theory: the adaptive cycle. The adaptive cycle (as outlined in Section 2.2.4) can be used to analyse the cyclical nature of evolution in social–ecological systems. We set out to explore whether and to what extent the adaptive cycle serves as a heuristic model to unearth periods of transformations in the past, as well as the drivers behind them in the context of the Finnish agrifood system. To do this, we utilised a variety of literature discussing the history of the Finnish agrifood system, as described in Section 3.3.

The findings indicate that the adaptive cycle serves as a good heuristic model of the transition dynamics in the food system context. We identified six consecutive regimes from the 14th century to the present day and labelled them as follows: Expansion (1334–1721), Progressive (1722–1868), Cattle (1869–1918), Premodern (1919–1944), Modernisation (1945–1994) and Globalisation (1995–present) regimes (Figure 15). The dynamics during these regimes followed periods of release, reorganisation, exploitation and conservation of the adaptive cycle. Regime shifts could be observed as a consequence of a release phase in which an old systemic constellation breaks apart, followed by a reorganisation phase during which the system has the possibility to embark on a new trajectory. During each cycle, the system always took on a somewhat different development trajectory, but to what extent this was a shift in relation to the previous regime remains open to debate. The regime shifts took place on a continuum rather than on a clear-cut incremental versus radical divide. The regime shifts were more transformative in nature when the metabolism of energy and nutrients in the system changed profoundly.

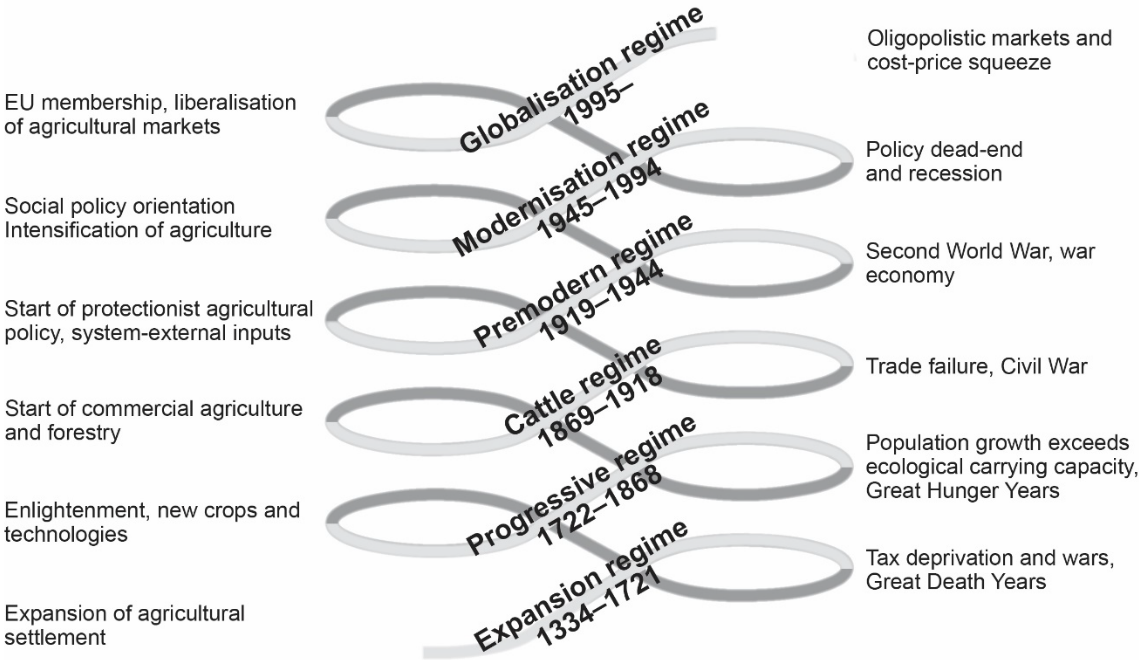

FIGURE 15 Adaptive cycles in the Finnish agrifood system since the 14th century (original: Kuhmonen & Kuhmonen, 2023; reproduced under the CC BY licence).

The first two regimes – Expansion and Progressive - which lasted up until the late 19th century, were built on predominantly local flows of nutrients and energy. Wood was the most important source of energy, and nutrients were harvested from the surrounding natural environment – the role of cattle was pronounced as being the most important vector of collecting nutrients from wood pastures and meadows and producing manure to be spread on fields on which food crops were grown. In the eastern parts of the country, nutrient metabolism relied on fire: slash-and-burn agriculture was based on releasing nutrients bound to tree mass to be harvested by agricultural crops. Both regimes had extensive land-use patterns: they required a great deal of land area to provide for the nutritional needs of the growing population. Both regimes also came to an end in deadly famines, in which there were several mutually reinforcing factors at play: the social side of the system was rigid, and the ecological side was vulnerable due to the exhaustion of natural resources. When harsh weather conditions coincided with such system states, the system crossed its resilience threshold.

The Cattle regime (1869–1918) represents a watershed in terms of the metabolism of the Finnish agrifood system. During this regime, technological development, especially in dairy production, was strong. However, while the productivity and efficiency of dairy production grew markedly, the food supply of the growing urban population increasingly relied on imported grains. This also turned out to be a major vulnerability of the Cattle regime, as the choking up of import routes contributed to unrest that eventually led to the Finnish Civil War shortly after the country gained its independence in 1917. The growth of the role of extra-local resources in the food system did not, however, end here – quite the contrary. Even though both the Premodern and Modernisation regimes that followed the Cattle regime were built on the idea of self-sufficiency at the product level, the role of system-external inputs – energy, nutrients, agrochemicals and animal feed – required in producing food grew constantly.

From the Cattle regime onwards, the foreign trade orientation in the Finnish food system has fluctuated markedly. While the Cattle regime was based on a free-trade orientation, both the Premodern and Modernisation regimes were protectionistic. This changed in the 1990s, when Finland joined the European Union, which marked the beginning of the Globalisation regime. During this regime, the agrifood system oriented towards free trade, and an extensive subsidy system was introduced to sustain agricultural production in disadvantaged regions. This subsidy system has also worked to halt the negative environmental externalities of food production practices that are still based on the extensive use of external inputs. The metabolism of the Globalisation regime has been largely based on importing large volumes of external inputs to be fed into the system (both energy and nutrients). Even though efficient farm management practices and agri-environmental policies have cut the excesses of input use, the system still operates on the principles of a linear, fossil-driven economy, which continuously increases the volumes of various forms of wastes in the biosphere – from nutrients in the waterways to GHG emissions in the atmosphere.

Despite the largely varying contexts during the food system history explored here, the phases of the adaptive cycle acted similarly with respect to the indicators of connectedness, potential, resilience, feedback and agency. For the system to embark on an exploitation phase, it needed resources – both physical resources and assets as well as human capital. The growth of the system has always created unintended consequences. These consequences were visible on the social side of the system in growing rigidity and centralisation and decreasing room for diversity, but also on the ecological side as growing sustainability problems – indeed, the sustainability problems we are currently facing are by no means a new phenomenon in the history of the Finnish agrifood system. These unintended consequences made the system vulnerable to external shocks and stresses, which then contributed to the system crossing the resilience threshold during the release phase. No regime shift took place without resilience effects, which varied in severity from emergence of food lines, as in the turn from the Modernisation to Globalisation regime in the 1990s, to famines killing 20%–30% of the population, as in the turn from the Expansion to the Progressive regime in the 17th century.

The systemic growth and its manifestations are of central importance to understanding not only the sustainability and resilience of the system, but also the role of agency in the system dynamics. Growth has taken various forms: population, production, consumption and material welfare. Growth tends to be a central aim for system managers, but it has systemic effects that are not only positive. Economic growth has not been decoupled from material and energy consumption, which means that growth brings a system closer to its ecological carrying capacity. In addition, and as suggested by theorising on adaptive cycles, growth creates rigidities in the system that are ultimately observable as decreasing agentic leeway, especially on the grassroots level. Under such conditions, embarking on new pathways is difficult. In the conservation phase, the resources needed for reorientation may be plentiful but tightly bound to the hands of existing (centralised) operators. The source of growth (co-)determines the nature of the path dependency of the regime and, consequently, the nature of the unintended consequences in the conservation phase. For example, growth in the Modernisation period was related to the excessive use of inputs that were relatively quickly visible in the impaired ecological status of especially waterways, while growth in the Globalisation phase has been related to the subsidy system, which has created systemic problems, such as a dependence on subsidies, outsourcing public funds to intermediaries (instead of farmers) and bureaucratisation.

The indicators from the phase of the current regime suggest that we are currently living in a conservation phase in which the pressures for transformation are mounting. These pressures are visible both in the material sphere as increasing sustainability problems as well as the social sphere as a quickly declining number of farmers, increasing economic hardships of farms and increasingly heated societal debate about the future direction of the system. In such a situation, there is a need to urgently build adaptive and transformative capacities at the farm level, allocate resources for transformational adaptation and build visions of a desired future pathway.

5 DISCUSSION

In this section, I discuss the findings of the articles in light of the research questions, interpreted against the overall framing of structure and agency, as laid out in the theoretical section. My aim is to elaborate on the unfolding of processes of societal transformation in the agrifood context from a farmer's viewpoint. In doing so, I have adopted the lenses of critical realism and systems thinking, arguing that while structural changes are the outcome of agents' endeavours, the structure has causal, independent powers on the actors operating in it. The findings shed light on the extent to which farmers can be the source of transformative change in the context of the food system's sustainability transformation. With this overarching motivation, the discussion section elaborates on what drives farmers' choices, what the contemporary agrifood regime is like, who is resilient in the face of the sustainability transition, and whether farmers reproduce or transform the contemporary food system structure.

5.1 What drives farmers' choices?

Farmers do not, like any other group of actors, merely react to changes taking place in their operational environment, such as policy incentives or market push. Instead, changes in the external environment are mediated through perception and interpretation in relation to the ultimate goals the actor is pursuing as a sense-making activity. These goals and interpretations are the result of complex interactions between individual characteristics and socialisation to a certain structural context (de Haan & Rotmans, 2018). Thus, in order to promote sustainability transformation in the agrifood system, it is of utmost importance to understand farmers' values, aspirations, perceptions and decision-making tendencies – their agency as manifest in the 'ability to act with intention' (de Haan & Rotmans, 2018: 4). Transformative sustainability agency in the farming context has been frequently reported to arise from farmers' positive values and aspirations towards sustainability – for example, Sorvali (2023) reports that 30%

of pro-environmental behaviours can be explained by farmers' value orientations. Indeed, values are often cited as the 'deep leverage point' of systemic changes (Abson et al., 2017; Chan et al., 2020; Dorninger et al., 2020). My findings indicate that transformative farmers were motivated by social and sustainability goals, which are likely to arise from their distinctive value bases (Article 3). Value-related motivations were especially important in relation to the adoption of biodiversity-promoting farming practices and organic farming (Article 1). At the same time, the overwhelming majority of farmers' self-stated goals were related to profitability, and most did not mention sustainability-related goals at all (Article 3). The most frequently mentioned adoption motivations for agri-environmental measures were related to productive reasons (Article 1). A plethora of research has indicated that farmers adopt agri-environmental measures based on a variety of motivations, above and beyond the sustainability effects of the practices (Brown et al., 2021; Coyne et al., 2021; Farstad et al., 2022).

However, farming is first and foremost a business practice; it is supposed to provide a living for the farmer and the farmer's family (see also Huttunen, 2019; Padel et al., 2020). It is thus presumable that productive and economic reasons guide farmers' decision-making. This, as such, cannot be taken as an indication of the absence of other motivations and values guiding farmer agency. Quite the contrary, in a similar vein as Manyise and Dentoni (2021) who argue that entrepreneurial orientation is related to ecological resilience, my findings from Articles 2 and 3 indicate that a development orientation – that could as well be labelled as an entrepreneurial orientation – and a sustainability orientation can, and often do, co-exist. This means that farmers who were committed to developing a farm in one way or another were also likely to develop it in terms of sustainability. These entrepreneurially oriented farmers were dependent on farming as a livelihood or intended to increase the role of farm-based income streams. Those farmers who were less dependent on farming as a source of income or were about to exit the food system were less conscious of many sustainability issues. However, there were also farmers on the road of downsizing their farms, for example, through extensification, who were also mindful about environmental aspects in farming – landscape maintenance in particular played a role in their decision-making.

The coexistence of an entrepreneurial orientation and sustainability commitments can be credited to three main factors. First, many environmentally friendly farming practices are eco-efficient as such and beneficial for the bottom line as well: for example, improving the soil condition contributes to increased atmospheric carbon capture, decreased nutrient runoff and improved yields. Second, when farmers are dependent on farming as a source of livelihood, they are likely to commit to active farm development, which makes them look for ways to improve efficiency but also act as 'a good farmer', which increasingly nowadays encompasses various sustainability commitments (Birge & Herzon, 2019; Huttunen & Peltomaa, 2016; Riley, 2016). An entrepreneurial orientation thus spills over to domains other than the economy. Third, the search for sustainable, transformative pathways is related to a search for viable business models (Article 3). Thus, transformative farmers are trying to find ways to combine their sustainability-related orientations and values with profitable business opportunities rather than stressing one at the expense of the other. Whether transformative farmers are successful in these aspirations is central to the success of such bottom-up transformation pathways in the food system.

Farmer agency can be seen as moulded by three nested spheres or layers that all are causally active with respect to the range of farming practices and their sustainability: the farmer, the farm and the agrifood system. The farmer strives for his or her goals within the constraints set by and possibilities afforded by the (local) farming context and the larger food system context (see also Eakin et al., 2017; Farstad et al., 2022; Huttunen, 2019). Thus, while farmers' choices are driven by the quest for economic profitability, the value base and motivations are important guides in this quest. The structural context that consists of the farm and the food system places strong preconditions on the farmers' endeavours. The range of production possibilities at a given farm may be very limited, especially if the farm income is supposed to provide the majority of income streams for the farm family. Diversification has often been seen as a central means of achieving farm-based livelihoods while adhering to sustainability targets (de Roest et al., 2018; Rantamäki-Lahtinen, 2009). However, in the Finnish context, there are indications that a diversification strategy is becoming less important for farmers actively developing their farms (Saukkonen et al., 2019), and the share of diversified farms has been slowly decreasing (Natural Resources Institute Finland, 2023b). The food system is largely characterised by a concentration of activities, not by diversification. These aspects that concern the food system as the arena within which farmers' agency materialises are discussed in more detail in the next section.

5.2 What is the regime like?

In the pursuit of transformational change, it is useful to distinguish it from incremental, non-transformational changes – systemic transformations have become the buzzword of sustainability science and policymaking to the extent that any kind of change is easily labelled as 'transformational' (Feola, 2015). To this end, understanding not only change, but also the source of stability – the regime as the structural context for farmers' agency – is essential (Erbaugh et al., 2021). Identifying the rules and logics of the contemporary regime as the root causes of the problems it has created is a precondition for promoting an alternative ruleset. These aspects were explored in particular in Article 4, which concentrated on the regimes and regime shifts throughout the 700-year history of the Finnish agrifood system. The Finnish agrifood system is embedded in the global food system; thus, the rules and logics on which the food system operates globally (as described in Section 2.2.5) strongly affect the behaviour and dynamics of the Finnish food system as well (Fuenfschilling & Binz, 2018; Wesseling et al., 2022). For the Finnish agrifood regime, a number of characteristics are of special importance. These concern (1) the nature of the metabolic flows and the relationship with growth, (2) the life cycle phase of the regime and (3) the tensions and contradictions present in the system.

The contemporary agrifood regime is fuelled by fossil metabolism and nutrients derived from system-external sources. These resources enable the striving for continuous growth, which is the most important paradigmatic quality of the socio-economic system that encompasses the food system. Fossil fuels and nutrients manufactured from fossil fuels and extracted from virgin deposits are available on demand; their extraction and utilisation are not limited by natural variation or seasonality. Striving for continuous economic growth means seeking increasing efficiency, which drives concentration, centralisation and specialisation in food systems and beyond (Burns & Rudel, 2015; Clapp, 2022; FAO, 2022; Kuhmonen et al., 2022). The idea of green growth is built on the premise of decoupling environmental impacts from economic growth, but concrete and widespread evidence of decoupling is missing (Haberl et al., 2020; Vadén et al., 2020). Quite the contrary, there is manifold evidence about how economic growth eventually increases the pressure on natural resources, for example, in the case of nutrient use transgressing planetary boundaries (Sandström et al., 2023). Our analysis of the Finnish food system's history indicates that systemic growth has repeatedly led the food system to cross ecological carrying capacities, which has led to the system losing its resilience. A focus on efficiency, whether framed as resource efficiency or eco-efficiency, does not solve the problem either: the burning question is to reduce the sustainability impacts in absolute, not relative, terms and thus far, increasing efficiency has been found to increase pressures on resource use (Berner et al., 2022; Parrique et al., 2019).

Increasing pressures on resource use are strongly felt by farmers who act at the very interface between the resource base and the economic system. Economic growth requires increasing consumption opportunities. These opportunities will not increase if meeting basic needs, such as food, requires most of the income of consumers. The share of agriculture in the value added by food products declines along with economic growth as well as the share of food production in the gross domestic product (FAO, 2022). A concentrated retail sector pressures suppliers to lower purchasing prices (Björkroth et al., 2013; Nordisk Ministerråd, 2005). As a result, producer price margins are steadily declining (Kuosmanen & Niemi, 2009), the gap between retail and producer prices is widening (Niemi & Liu, 2016), and the share of retail from the consumer prices of food is increasing (Peltoniemi & Niemi, 2016). The cost-price squeeze that farmers face is the consequence of these dynamics: increases in costs of production are higher than increases in prices paid for products, as described in Section 1.3. The outcomes – a decreasing number of farms, increasing farm size, specialisation and a relentless search for efficiency – are taken as healthy signals of the food system functioning as it should. However, the very same root causes that can be observed as structural development in the farming sector are also manifest in persistent sustainability problems.

The extent of a regime's lock-in depends on the availability of alternative logics and rulesets to play by. Indeed, agrifood regimes often accommodate alternative rule systems beyond the hegemony of the dominant rule system. Such heterogeneity acts as a source of diversity, innovations and systemic renewal. However, the Finnish food system seems to be strictly dominated by only one kind of logic: 'one rule to rule them all'. While the system obviously accommodates alternative – albeit very niche – ways of operating, such as local food networks or agroecological symbioses, the dominance of the mainstream regime rules is outstanding, which is manifested by, for example, the extremely concentrated structure of trade and retail and large farm sizes, in comparison with many European counterparts (European Commission, 2014).[3] What follows is that farmers may find it difficult to adopt alternative business models in the farming sector. This was evident in the observation made in Article 3 about the difficulties the (small group of) transformative farmers were enduring – especially the fact that these same farmers had also previously been on a quest to find alternative pathways. This tendency may be attributed to the paradigmatic mindsets and discourses prevailing among Finnish food system actors and a tendency to outsource the trouble of thinking to 'the system' (Korhonen-Smith & Rantala, 2023). At the same time, the life-cycle phase of the food regime also plays a role.

Systems in the conservation phase of the adaptive cycle grow rigid and centralised. All kinds of diversity become marginalised, while resources – which might be plentiful as such – are concentrated in the hands of fewer actors. Growth becomes harder to achieve, and due to internal complexity, the system has to invest growing amounts of its resources just to maintain its integrity. Embarking on pathways that diverge from mainstream logic becomes difficult for a wide range of actors. New innovations find it difficult to make a breakthrough. Just as food systems globally are locked in unsustainable trajectories (Béné, 2022), I argue that the Finnish food system is currently in a conservation phase and a state of lock-in or even a rigidity trap. The system is characterised by negative, stabilising feedback loops that aim to restore its previous position in the face of disturbances. For example, attempts to divert funds in the form of additional subsidy payments to resource-deprived farmers and improve their ability to deal with sudden price shocks have resulted in value chains either downstream or upstream raising prices of inputs or decreasing prices paid for raw materials.

Transformations build on tensions that begin to pile up within the system – in this way, the very presence of contradictions in social systems indicates opportunities for structural changes (Svensson & Nikoleris, 2018). Tensions can be attributed to conflicting goals among the actors operating in the system. Transformative regime shifts imply changes in the goals and functions of the systems (Dorninger et al., 2020; Hodbod & Eakin, 2015). While food systems as a whole are organised around systemic goals and functions, the grand systemic goal does not direct the behaviour of all the agents operating in the system, but

[3] Despite the fact that farms in Finland are already relatively large, the often cited solution for the profitability crisis in the farming sector is… the growth of farm sizes.

they all have their own goals, some of which may develop to be in an ever-increasing contrast with the food system's main functions. Examples of such goals include maximising productivity and/or efficiency, maximising profits, making a living, delivering on food security, conserving and promoting biological diversity, and mitigating climate change. These goals and functions do not act in accordance, but they feature inherent trade-offs, tensions and contradictions. If actors' goals within the same system conflict, the goals of the party that holds more power than others start to dominate the behaviour of the whole system (Meadows, 2008). As dominant actors within the food system operate according to the logic of cost reduction and profit maximisation, these goals dominate the choices of other actors in the system as well (Glover et al., 2014; Hodbod & Eakin, 2015; Rimhanen et al., 2023).

Tensions can also be the result of the sheer growth of the system. Our analysis of the Finnish food system's historical trajectories indicated that many things that were initially deemed desirable and good in the system turned into sources of vulnerability along with the growth and maturation in the regime, which then contributed to the collapse of the system. Indeed, a recurring finding from the literature is that large-scale systemic transformations mostly take place as a result of crises (Friedmann, 2005; Herrfahrdt-Pähle et al., 2020; van Bers et al., 2019). The vulnerabilities that eventually lead to resilience losses have been linked to both the social and ecological sustainability of the system. For example, while the fossil metabolism adopted in the first half of the 20th century initially relieved the burden of extensive land use on ecosystems, along with the growth of the system, it also created unintended consequences, such as climate change, and then turned out to be the ultimate cause of sustainability problems. The history of the Finnish food system also provides multiple examples about the relatedness of social inequalities to losses of resilience – in a similar vein, Davidson (2010) argues that a concentration of privilege can act as a trigger for social collapses. Essentially, it might be impossible to find an unproblematic mode of organisation for the agrifood system as long as the system focuses on growth. To this end, exploring the possibilities for non-growing modes of social organisation, including food systems, should be at the top of the priority list to guarantee staying within a safe operating space of planetary boundaries (see also FAO, 2022; Guerrero Lara et al., 2023; Tschersich & Kok, 2022).

5.3 Who is resilient in the face of a sustainability transition?

I operationalised resilience in the farming context in two ways: as combined environmental-economic performance trajectories (Article 2) and through farmers' goals and strategies for the future (Article 3). The results from these analyses can be seen as indicating the farm-level responses to a range of economic and environmental pressures and the adaptive and transformative capacities that the farmers hold. The results inform the research question regarding what kinds of farmers are resilient in the face of a sustainability transition, given the *current* stresses and pressures. However, the future outlook in terms of the direction that a prospective sustainability transition might take remains hazy. As indicated in Article 3, persistent farmers, to whom farming is not an important source of income, may continue for long times precisely because of the negligible impact of farming for income, but at the same time, these farmers might easily lose the incentives to continue farming. Adaptable farmers operate by the rules of the regime and actively aim to adapt to its requirements: they increase their farm sizes and aim at continuously developing the farm; they are the ‘perfect students’ aligning to the rules of the regime. At the same time, these are the exact farmers who may be vulnerable to drastic changes to the rules of the current regime, such as disincentivising animal production. Transformable farmers try new ways of doing and place emphasis on sustainability issues. They were facing economic hardships, but clearly had capacities that allowed them to embark on new pathways. Non-resilient farmers are merely holding on before quitting altogether, often because of a high age, poor health or lack of successors.

In general, those farmers that are able to meet the demands of the cost-price squeeze and increasing demands for centralisation and growing efficiency can be labelled resilient. While it is not possible to make a straightforward comparison between the utilised datasets and studies, the shares of the desirable types of resilience (positive performance trajectories in Article 2, adaptive or transformative capacities in Article 3) varied between 23% and 39%. Resilience capacities arose from both structural factors and individual capabilities. In Section 5.1, the role of farmers’ entrepreneurial orientation was discussed in relation to their ability to accommodate both economic and sustainability demands. An entrepreneurial orientation is related to the role of farming as a source of income, which is either pronounced or the farmer is striving to increase its role. Relatedly, for example, Knickel et al. (2018) highlight the importance of livelihood for farm-level adaptive capacity. When farming played a rather modest role in total income, a business-as-usual orientation without special concern for sustainability issues was more likely. As a whole, farmers’ adaptive and transformative capacities stem from investment and commitments to farming. The investments could take various forms; in addition to investing in physical capital, such as farm equipment, fields and their good growing condition, farmers with adaptive and transformative capacities had high education levels, manifesting investments in human capital (Article 3).

Together with a favourable structural context, agentic capacities could create an upward spiralling effect based on the interaction between various forms of capital (Emery & Flora, 2006). Such an upward spiral is based on positive, self-reinforcing feedback that allows different assets to build upon each other. Here, the farmers’ perceptual tendencies also played a role: in Article 2, entrepreneurial orientation, sustainability commitments and perceptions regarding social capital were all intertwined. However, it is important to note that the structural context needs to align with agentic capabilities. For example, Eakin et al. (2016: 801) argue that

> the components of transformational capacity will necessarily need to go beyond the objective resources and cognitive capacities of individuals to incorporate 'linking' capacities: the political and social attributes necessary for collective strategy formation to shape choice and opportunity in the future.

Within the structural factors, the role of farm size was especially important for farm-level resilience; large farm size predicted membership in the resilient farm categories in Articles 2 and 3. Growth in farm sizes is related to the general tendency of centralisation and concentration; resilient farmers are able to meet the demands of the regime. Farm size matters in many domains; it allows achieving economies of scale, and for small farms, it is more difficult to find successors than for already large ones.

Acknowledging the role of structural factors in resilience is central, as resilience is far too often used for the purpose of shifting the burden of transformation from the system level to the individual level (Eakin et al., 2016; Soubry & Sherren, 2022). While individual inclinations and characteristics obviously played a role in farm-level resilience, the importance of farm size, along with other structural factors, such as the line of production, indicates that resilience is strongly a structural property. Those farms that are able to meet the demands of the regime and adapt to its rules are resilient. The regime rules favour especially centralisation and concentration, which makes a large farm size an important precondition for meeting the demands of the regime. Resilience arises from adaptation to the existing regime and fitness with it and should not be treated as something that a farmer can achieve just by learning the right skills. The right skills will obviously help, but resilience is much more than a management strategy.

Resilience research has identified diversity, redundancy and slack as important preconditions of resilience. Specialisation, homogenisation and a relentless strive towards efficiency have been argued to weaken the resilience of farms and food systems (de Roest et al., 2018; Khoury et al., 2014; Sundstrom et al., 2023). From this point of view, the findings indicate a paradox: while those farmers that depend on economies of scale and specialisation have adaptive capacities, they are also vulnerable to market fluctuations due to the strong path dependency of their own operations. In particular, adaptively resilient farmers had invested considerable resources and capital into farming in order to become (financially) resilient; however, achieving this required committing to a single line of production and seeking effectiveness and productivity within it, which at the same time increased their vulnerability.

The question of which farmers are resilient in the face of a sustainability transition may be trivial in the end when the conditions for farm-level resilience are strongly constrained by food system resilience, as seems to be the case in Finland. The food system is showing signs of vulnerability that go far beyond the farm level and are related to factors such as supply chains and market disruptions, extreme weather events, loss of biodiversity and natural resources, plant and animal diseases, pollution, availability of foreign labour, social inequality, energy supply, terrorism and wars and conflicts (Paloviita et al., 2016; Rimhanen et al., 2023). Farmers' possibilities in building resilience to such threats are limited, but instead require large-scale detachment from the linear, fossil-driven economy, which could then open up new avenues for farm-based livelihoods in building resilience.

Who is resilient in the face of a sustainability transition essentially depends upon how the transition will unveil and how the fitness landscape changes. Transformative regime shifts have implied a changing metabolic basis of societies, and in such a shift, the role of farmers as producing and circulating energy and nutrients will presumably grow in importance. However, as indicated by resilience theory, transformations take resources (Darnhofer, 2014; Nicholas-Davies et al., 2021; Reidsma et al., 2020; van Bers et al., 2019), which are largely deprived from the farm level. For example, Meuwissen et al. (2020: 8) argue that structural constraints 'reinforce a focus on maintaining the status quo' and despite the expressed needs for transformation, the transformative capacities at the farm level are low. In effect, resources are fed into the farm systems, but those resources are needed to keep up with the cost-price squeeze and the growth demands imposed on the farms by higher levels of the system. Thus, the system needs a growing amount of resources just to continue functioning (which is typical of a conservation phase), and at the same time, those resources cannot be used for building something new. Reasonable profitability is often seen as a precondition for transformational capacity (Fleming et al., 2015; Reidsma et al., 2020). From this point of view, the struggles of transformative farmers are understandable. Transformational capacity is also linked to the outlook of the regions: if it is unclear and outmigration prevails, embarking on new, risky and innovative pathways may not be a likely choice (Meuwissen et al., 2020). The processes of regional marginalisation result from the same sources that contribute to the processes of centralisation and specialisation (Knickel et al., 2018). Considering that crises often give rise to regime shifts but also tend to compromise resilience, the position of resource-deprived farms upon such systemic transformations is worrisome. When regime developments – such as specialisation and economies of scale – have led to a loss of capacities that contribute to food system resilience (de Roest et al., 2018; Knickel et al., 2018; Piters et al., 2021), the resource-deprived actors in the system are in the most vulnerable positions.

5.4 Do farmers reproduce or transform the contemporary food system structure?

The question of structure and agency is pertinent for a student of societal transformations, which calls for simultaneous observation of stability and change. de Haan and Rotmans (2018) call for explicit theorising on agency within sustainability transitions instead of implicitly assuming that agency is present in all instances of transition processes and dynamics. In the food system context, for example, van Bers et al. (2019) argue that the conditions of transformative agency need scrutiny to foster transformative change. I believe that the approach of critical realism to agency, integrated with insights from resilience theory and socio-technical sustainability transition research, can shed light on precisely the conditions in which intentional and devoted agency can be a force for transformative change. Treated in this manner, it is possible to draw conclusions about the scope of farmers' agency in relation to food system transformation.

Even though the majority of sustainability impacts in the food system take place as a result of farmers' decision-making, I argue that the scope of farmers' agency in addressing these problems is limited. So far, sustainability at the farm level has meant, for the most part, adopting eco-efficient farming practices, many of which are cost-efficient and good for their bottom line. However, sustainability problems in the agrifood system extend beyond the choice set of an average farmer. This is due to the systemic nature of the sustainability problems: A highly specialised, centralised and homogeneous agrifood system is the result of fossil metabolism and linear resource flows (Kuhmonen et al., 2022). To turn the linear model into a circular model, to be able to harvest energy from renewable and local sources and to allow nutrients to circulate within the system rather than through it requires more localised and diversified modes of organising the system (Koppelmäki, 2022). Protecting biodiversity within agroecosystems would require more mixed systems, more heterogeneous landscape patterns and grazing cattle – all features that have been slowly eliminated or diminished in the system for the sake of efficient and profitable production (Béné et al., 2019b; Herzon et al., 2014). Reducing the scope of animal production to mitigate climate change would require rural and agricultural livelihood options beyond those of animal production also in areas constrained by climatic and growing conditions, as well as possibilities for reasonable profitability with smaller herd sizes. All of these issues effectively revolve around questions of profitability.

The food system context pushes farmers for economies of scale, which again limits the range of livelihood options at the farm level. The threshold of profitability on Finnish farms settles at the economic size of a half-million euros, which means that only a small minority of Finnish farms receive entrepreneurial profit (Economydoctor, 2023a). The weak economic situation of farms is sometimes attributed to farmers' lack of adaptive capacities and entrepreneurial skills, but I argue that a systemic tendency speaks more about the system itself than the actors operating in it. In contrast, Himanen et al. (2016) maintain that farmers are reaching the limits of their adaptive capacities. Manyise and Dentoni (2021) argue that adaptive capacities reflect the scope of farmer agency: when squeezed, adaptive entrepreneurial behaviours tend to become suppressed. Squeezed agency not only arises from weak profitability; for example, Lonkila (2022) illustrates how developments in breeding technology led to farmers losing their sense of expertise, which translates to diminishing agency.

Farmer agency needs to be understood as an interplay between intentionality and the tendencies brought about by structural conditions. While intentionality clearly plays a role in farmers' agency, it is not the main vehicle for bringing about transformative changes in the food system. Instead, farmer agency should be seen as taking place within certain trajectories – a farmer cannot keep all the options open at all times. While in a certain development path, the contingencies and path dependencies start to delimit the options available for farms – the mechanism is essentially the same at the level of farm systems as at the level of food systems. Weituschat et al. (2022: 2206) elaborate on this matter:

> When barriers in the institutional context are stronger than drivers promoting change, the current focal goal of decision-makers will be strengthened, their actions will gravitate around the status quo, and the institutional setting will be reproduced, creating a lock-in (---).

In effect, when farmers' goals are related to financial survival and the only way to survive is through reproducing the status quo, farmers have little leeway to act as transformative change agents. The logics of adaptive cycles (as discussed in Section 2.2.4) apply to all systemic levels: increasing returns from adopting a certain development path creates path dependency, which can lead to lock-in, which makes the system vulnerable. In a conservation phase of the adaptive cycle, the agency of actors tends to become squeezed – the structure dominates over agency and creates stability in terms of a locked-in pathway within the system. This has been the case throughout the history of the Finnish agrifood system. In such a system state, it is difficult to mobilise grassroots actors to create lasting changes within the system from the bottom up. Instead, changes in such a system state tend to happen in a top-down manner – which again tends to squeeze the agency of the system actors even further. Essentially, it takes a release and reorganisation, a breakdown of the existing regime, a regime shift, radical transformation or creative destruction (as it is said, a dear child has many names) for the bottom-up type of transformative agency to have leeway.

However, the argument that farmers' agency is squeezed to reproducing the status quo due to the current regime life cycle phase and lock-in state does not mean that transformative capacities and aspirations do not exist among farmers. Despite the difficult context, in Article 3, a group of transformative farmers motivated by, among others, sustainability-related goals actively searched for alternative pathways. The aspirations of the transformative farmers were related to building a new set of rules to play by. Regimes often accommodate not just one, but also alternative rulesets, but as discussed earlier, such alternative rulesets are largely missing or marginalised in the contemporary Finnish agrifood regime. Once the structural context is favourable to their aspirations following the adoption curve, it is presumable that others will follow. However, I argue that structural changes do not happen just because of farmers' changing value base, but such changes require a window of opportunity.

The morphogenetic approach, coupled with understanding from transition theories, suggests that structural changes are initiated by committed groups of actors who will get the system on the move. Movement begins when tensions within the system grow unbearable and when an external shock cracks the structure of the regime. Whether such movements will be initiated by the farmers depends on the future outlook: as long as they believe that the contemporary regime is all there can be – that no other alternatives exist – the answer is probably not. Currently, farmers have responsibility for the food system's sustainability, but they lack resources and direction. However, truly lasting change comes through farmers' commitment, as has been shown by previous regime shifts. Such a shift requires a window of opportunity and a clear vision of the future direction, which is currently missing (see also Kuokkanen et al., 2016; Vermunt et al., 2022). Sustainability transition in the food system context is currently a buzzword that lacks a vision and shape, but that is nevertheless imposed on food system actors in a top-down manner. Top-down policies tend to be characterised by a one-size-fits-all type of solutions that however do not fit ecological and place-specific realities of agrifood systems very well (Vermunt et al., 2020).

As the environmental impacts in food systems are created at the field level, incorporating farmers into the transition is of utmost importance. However, when this happens by the logic of cheap food, economies of scale and centralisation, the push and incentives for intensification and scale enlargement remain felt by farmers. As a result, farmers are torn in two directions: complying with the economic rules of the regime and addressing sustainability concerns. Such a setting is likely to exacerbate the existing power relations in the food system: those who are already well positioned within the system are likely to survive difficult times, whereas less resourceful actors are likely to drop off. Unfortunately, these less resourceful actors are likely to entail farmers that have the potential to contribute to the food system's sustainability transformation. However, if centralisation and economies of scale are at the heart of the sustainability problems of the food system, deepening the current power structure is an unlikely solution. Regime shifts involve inevitable shifts in power relations (Svensson & Nikoleris, 2018). However, Dentoni et al. (2018) have observed that power relations in food systems are unlikely to change when transformative changes are pursued through market-based actors. To this end, the food system's sustainability transformation should address not just the sustainability impacts of the food system activities but also the very power relations and actor roles in the system.

6 CONCLUSIONS

6.1 Theoretical contributions of the research

The literature on sustainability transformations has been recurrently criticised for vague conceptualisations of human agency in relation to the processes of social change. In the recent years however, the volume of research covering various aspects of human agency in transformation and transition research has grown substantially. Much of this scholarship draws—implicitly or explicitly—from structuration theory, wherein agency and structure are seen to form an intricate bond, where one conditions and moulds the other in an inseparable process of interaction. In this research however, I have argued for an ontologically different approach to the relationship between agency and structure in processes of social change towards sustainability. The essence of my argument rests on an analytical separation between agency and structure, which I deem as necessary to both understand and effectively promote transformations towards sustainability. This approach draws from the stratified model of reality as proposed in critical realism and from the quantum model of change as in systems thinking.

The stratified model of reality in the context of transformations towards sustainability requires understanding the subject of change—in this case, the food system—as consisting of three nested domains: the system, the regime as its temporal mode of organisation, and agency as the driving force of the structural changes that result in regime shifts. The food system operates in the domain of the real: it has certain causal (albeit partly latent) powers that are related to how the system delivers on its key function: feeding people. Which of these powers are actualised depends on the effective rule set of the system that prevails during a specific time period, that is, the regime. Sustainability transitions or transformations are structural changes by nature: they require a system-wide reorganisation of social activities, technologies, infrastructures and interaction with nature and natural resources. This systemic reorganisation equates with a regime shift when the concept of regime is used in the sense of a stability domain of a complex adaptive system. Evidently, such radical transformations require agency to take place; they will not happen without dedicated action, envisioning, leadership, committed entrepreneurs and a great deal of hard work. However, guided by the morphogenetic approach and the concept of adaptive cycles from resilience theory, I argue that the window of opportunity for such transformative agency is open in only specific time periods. When the internal tensions and contradictions within the regime start to pile up during the conservation phase of the adaptive cycle, the regime becomes internally fragile and unstable. These internal contradictions are the consequence of centralisation of resources and power within the regime, which work to diminish the scope of agency especially for those actors within the regime who are not in the position of power. When such vulnerability is coupled with an external crisis, the momentum for radical transformation—quantum change—is at hand. Indeed, analysis of the history of the Finnish agrifood system evidenced that radical reorientations only took place through crises of some sort. However, the seeds for a reorientation are sown well in advance before the crisis through the contestation of the dominant paradigm and its discourses.

From the point of view of farmers as the subjects of this research, their agency and role in the transformation process, this kind of a conceptualisation of transformative agency means that the farmers' scope of transforming the system is limited. In this work, I have approached the types of transformative agency through the concept of resilience. While the resilience concept does not open up avenues for understanding the lived worlds of farmers, their perceptual processes or intricacies of their decision-making, resilience serves as a boundary object between agency and structure. Through the concept of resilience, I have been able to analyse farm-level trajectories in relation to sustainability transformations, while addressing both aspects stemming from their agency and the structural conditions surrounding them. Such an analysis indicates—perhaps expectedly—that both agency and structure matter for the farm-level resilience. That said, the structural constraints that farmers are facing are strong. They are manifested by the importance of large farm size for farm-level resilience, which can be seen as the indication of centralisation within the food system and the consequent cost-price squeeze. Many farmers obviously possess transformative capacities stemming from their commitment towards sustainability and alternative ways of farming, but I argue that the efforts to initiate a food system transformation must go beyond the idea of promoting alternative values or ways of doing among farmers.

Structuration theory considers the social structure as the flip side of agency—its developments, such as sustainability transformations, included. In this view, structure is 'the sum' of agency; people have created the structure, so they hold all the power in eventually changing it. However, if the analytical dualism between agency and structure is accepted—as I have argued for throughout this manuscript—then structure must precede agency: a contemporary structure is not the result of choices made by people currently inhabiting it; it is the inheritance of choices made by their predecessors. Transformations consume a lot of energy, in other words, they require resources. Many growth-oriented farmers are locked in their specific trajectories through investments as in the case of adaptive farmers I identified in this research. If the farm is constrained by a small size, the easiest option might be the path of the least trouble, as in the case of persistent farmers. And even when the farmer has both the skills and material resources necessary for a transformation, if the regime is tuned around only one way of operating, the transformation efforts are hindered, as in the case of transformative farmers. In all these cases, resources required by the radical transformation are either missing or ineffective. At the same time, analyses concerning the distribution of value added in the food system reveal that farmers are in effect getting a diminishing share of those resources. Thus, even though the sustainability impacts of the food systems are born at the farmgate, farmers' possibilities to change this setting are limited. They operate in a structural setting that is given—they can be argued to be imprisoned by the regime.

The contribution of this research regarding theory development falls upon the scholarship on socio-technical sustainability transitions and social-ecological sustainability transformations. The basic arguments I have presented concerning systems, regimes and agency apply similarly to both branches of literature. The essence of my argument – that the scope of transformative agency is dependent upon the life cycle phase of the regime – similarly applies to both fields. I have also shown that these two fields have more commonalities than discrepancies, and these commonalities and synergies should be the starting point for deeper understanding of sustainability transformations.

6.2 Policy recommendations

The ontological approach concerning agency and structure in sustainability transformations that I have promoted here takes as its starting point that structure and agency both have causal forces on each other that are also to some extent independent of each other. Such an approach is critical especially from the viewpoint of promoting just transitions: the structural constraints and imbalanced power relations need to be acknowledged in order to design just transition policies. This approach matters also from the viewpoint of recognising the difficulties farmers may be enduring in the crossfire of conflicting demands imposed on them instead of building a discourse of blame, guilt and victimisation.

If the scope of farmer agency varies according to the life cycle phase of the regime, successful transformation policies need to take such variability into account. While there is clearly a need to conduct more research in relation to what kind of policy mixes are suitable for different life cycle stages, considering the possibilities offered by the regime and the nature of (farmer) agency, some preliminary suggestions can be presented here based on the insights of this research project. The early life cycle stages of regimes entail new possibilities for actors to exploit; at such phase experimenting with new options should be encouraged, as well as incentivising the preferred options (for example in relation to specific farming styles or techniques). When the regime matures and certain—expectedly preferred and sustainable—farming styles have established, the value chain business actors could take more responsibility for incentivising and promoting sustainable practices as part of their supply chain management and sustainable procurement practices. However, as so far all regimes in the Finnish food system have come to an end at some point, preparing for the sometimes chaotic transformation phase is critical during the (late) conservation phase. In this phase, it is necessary to nurture the resilience of the system in terms of retaining sufficient diversity and redundancy in the system, which are easily overrun in the search for efficiency typical for the conservation phase. In the late conservation phase, the system should also prepare for the reorganisation phase by exploring suitable future options, attractors and pathways to embark on. This is where the food system actors can contribute to ideating alternative future visions for the system, visible in the societal debates and even paradigm wars.

Currently, the farmers in Finland are subjected with pressures that, on the one hand, cause many of them to either enlarge their farms or quit farming—or continue farming on a part-time basis—and on the other hand, require greater farmer involvement in the efforts of building a more sustainable food system. These pressures are linked to the life cycle phase of the regime, which is currently in the conservation phase characterised by a search for efficiency and a centralisation of activities, resources and power. The contemporary regime, with its metabolism relying on fossil fuels and logics built on an endless strive for more growth, is the structure that has given rise to the variety of sustainability problems we are currently witnessing, especially the looming climate catastrophe and extinction wave. This regime operates on a rule set that not only encourages but also effectively forces farmers to cut costs, enlarge their farms and specialise. Even though some farmers adopt also other kinds of strategies, the economic viability of these options has not decisively improved in the recent years, quite the contrary. While part-time farming is important for the supply security at the food system level, commitment to farming as a livelihood is important for the promotion of sustainability goals, as evidenced by the findings of this research. A model focused on efficiency can bring some sustainability benefits, but at the same time, efficiency is closely related to the logic of centralisation, linear resource flows and regional segregation of food production activities that drive the sustainability problems in the food system. The regime rules are beyond farmers' powers; from a farmer viewpoint, they are given. If the regime rules are the reason for the sustainability problems of the food system, it is unreasonable to assume that farmers' choices could have a key role in resolving those problems—despite the fact that farmers keep reproducing these problems in their day-to-day farm management.

To enable greater farmer commitment to sustainability transformation, it is critically important to consider strategies to build possibilities for viable and sustainable business models at the farm level, also those beyond growth, efficiency and intensification. Alternative pathways do not simply emerge from within a locked-in regime but require both goal-oriented construction of new opportunities along with unravelling the old system structures. However, if and when such actions are imposed on a food system without considering the prevailing power relations, the first 'victims' of destabilisation policies will be those actors with the least power and resources—the farmers. A transition policy can hardly be labelled as just if its subjects have no alternative but to face its consequences. Thus, for farmers to have a choice of acting otherwise, transformation policies should aim at building possibilities for choice—for example, through detaching from the fossil economy, striving for increased self-sufficiency in energy and nutrients, creating local agroecological symbioses and promoting farming practices beneficial for biodiversity. Here, the procurement practices of retail, trade and catering can play a focal role.

At the same time, the focus on structural development—in other words, continuously increasing farm size—in the food system should be critically reviewed. Currently, the touching unanimity among food system actors concerns the consensus that more efficiency, more competitiveness and more structural development are all good goals for the Finnish food system. These aims will automatically exclude other kinds of goals such as farmers receiving a fair share of profits generated within the system or halting the biodiversity loss. These trade-offs and contradictions need to be acknowledged—if we still want to prioritise growth and efficiency over other aims, so be it, but this choice should be based on consciousness about the impacts of the choices rather than on pious and ungrounded hopes.

6.3 Limitations and further research needs

With this research, I have laid out a picture of the current situation in the Finnish agrifood system from a point of view of sustainability transformation and farmer agency. I believe, in line with Geels (2022), Sorrell (2018), Svensson and Nikoleris (2018) and Trosper (2005), that critical realism provides a suitable ontological framework for understanding societal sustainability transformations and transitions. To develop the frameworks and concepts of the multi-level perspective, adaptive cycle and morphogenesis further in line with the ontology of critical realism, much work remains to be done. This concerns especially the processes of transformations: how is collective agency mobilised to give rise to radical transformations in the food system context? How should individual vs. collective agency be approached in this context? What roles do the various groups operating in the food system play? Which of them has the most power? Throughout this research process, I have argued for the importance of power relations in food system transformation, yet this is clearly an area to which the empirical farmer survey data provide at best indirect evidence. Thus, applying the preliminary conceptualisation of power and agency in food system transformation remains the topic for further research. The survey datasets employed are snapshots of how farmers perceive their situation at a specific moment. They offer insights into how farmers, by and large, operate in the face of the contradictory demands imposed on them by the food regime. With this approach, I have been able to explore the interface between agency and structure, but not so much the processes of agency per se. To dive deeper into farmers' perceptual world, explorations of specific constraints and possibilities, goal-setting strategies and decision-making styles, a more qualitative research approach would likely provide important lessons.

While the historical literature review contrasted the present-day dynamics with those that took place in history, it would be interesting to apply the theories of societal transformations in more detailed analysis of the food system history, especially in analyses of the past transformation periods. Relatedly, shifting the approach from the history towards the future would be an important area of enquiry. What could be the contents of a prospective food regime of the future: what could it look like, what kind of tensions would it give rise to, and with what kind of pathways could it be reached? Similarly, this research as such does not say specifically much about what one should do as a policymaker, a supply chain specialist or a farmer. What are the prospective points of intervention to transform a food system, remains the topic for future research. Explorations concerning the pathways towards a more sustainable food system should be accompanied by more detailed analysis concerning the roles that could be assigned to different food system actors. Such an analysis could be a critically important complement to the analysis presented here about the role of farmers as actors in the transformation process. Furthermore, as the power relations are not static across time and place, comparative analysis regarding the regime rules, life cycle stages of regimes, power relations and scope of farmers' agency could provide important insights in relation to the arguments I have presented about the Finnish case in this research.

YHTEENVETO (SUMMARY IN FINNISH)

Ruokajärjestelmät ovat kestävyyskysymysten polttopisteessä. Sillä, miten ruokaa tuotetaan, on merkittäviä vaikutuksia luontokatoon, ilmastonmuutokseen, ravinteiden kiertoon ja elinympäristöjen saastumiseen. Ruokajärjestelmän ympäristövaikutusten vähentäminen edellyttää koko tuotanto- ja kulutusjärjestelmän lävistävää kestävyyssiirtymää. Maanviljelijät ovat kestävyyssiirtymän portinvartijoita: heidän päivittäiset valintansa ratkaisevat ruokajärjestelmän kestävyyskehityksen suunnan. Maanviljelijöiden keskeinen rooli onkin laajasti tunnistettu: maatalouden ympäristöpolitiikka rakentuu pitkälti viljelijöiden valintojen ympärille; ruokaketjussa toimivat yritykset ovat alkaneet kasvavassa määrin seurata ja jäljittää maataloustuotannon ympäristövaikutuksia, ja tutkimuskirjallisuudessa viljelijöiden kestäviä valintoja on tutkittu runsaasti.

Huolimatta pyrkimyksistä ymmärtää ja kannustaa viljelijöitä kohti kestäviä valintoja, vaikutukset ovat olleet parhaillaankin kaksijakoisia. Vaikka monet viljelykäytännöt esim. lannoituksen osalta ovat kehittyneet selvästi aiempaa kestävämpään suuntaan, kehityskulut ovat yhä isossa kuvassa negatiivisia: vesistöjen ekologinen tila on heikentynyt, maatalousympäristön monimuotoisuus vähentynyt, eikä kasvihuonekaasupäästöjen määrää ole saatu lasku-uralle. Nämä kehityskulut saavat monet kysymään, pitäisikö maatalouden ympäristövaikutuksia suitsia aivan toisenlaisin keinoin kuin tähän asti on tehty.

Samalla kuitenkin myös viljelijöiden heikkoon asemaan ruokaketjussa on alettu kiinnittää enemmän huomiota. Ruokajärjestelmän valtasuhteet ovat epäsuhtaisia: kauppa hallitsee ruokamarkkinoita, ja viljelijöiden saama osuus ruoan hinnasta on ollut pitkään laskusuuntainen. Sopeutumispaineet viljelijän toimintaympäristössä lisääntyvät jatkuvasti, kun maatalouden kustannukset kasvavat nopeammin kuin maataloustuotteiden hinnat, ja ruokaketjun muut toimijat odottavat viljelijöiden samalla ottavan vastuun ympäristövaatimuksiin vastaamisesta. Maanviljelijöiden roolia kestävyyssiirtymän tekijöinä voidaankin perustellusti tarkastella kahdesta hyvin erilaisesta näkökulmasta: ensimmäisessä viljelijöillä on kaikki valta vaikuttaa tuotantopäätöksiinsä ja tarvittaessa toimia toisin; toisessa he näyttäytyvät ruokajärjestelmän vähävaltaisimpana toimijaryhmänä, jotka rimpuilevat markkinoilta välittyvien kustannuspaineiden ja politiikan ristiaallokossa.

Tässä tutkimuksessa tarkastelen viljelijöiden roolia ruokajärjestelmän kestävyyssiirtymän tekijöinä. Kysyn, mitkä tekijät ajavat viljelijöiden valintoja, millaisilla viljelijöillä on resilienssiä kestävyyssiirtymän kynnyksellä, millaiset systeemiset säännöt ohjaavat viljelijöiden toimijuutta, ja missä määrin viljelijät pystyvät muuttamaan ruokajärjestelmää. Näihin kysymyksiin vastaaminen edellyttää rakenteen ja toimijuuden purkamista analyyttisesti erillisiksi kokonaisuuksiksi, joilla on molemmilla kausaalista voimaa suhteessa toisiinsa. Tarkastelen ruokajärjestelmän rakennetta regiimin käsitteen kautta, ja viljelijöiden muutostoimijuutta resilienssiteorian avulla. Regiimin käsitteellä viittaan järjestelmän tiettynä ajankohtana vallitsevaan, dynaamisesti vakaaseen organisoitumistapaan, joka ankkuroituu tietynlaisen sääntökehikon, yhteiskunnallisen energia- ja ravinneaineenvaihdunnan, teknologian, infrastruktuurin, valtasuhteiden ja arvoperustan ympärille. Resilienssiteorian avulla taas pyrin ymmärtämään niitä tekijöitä, jotka mahdollistavat viljelijöiden luovimisen erilaisten ristiriitaistenkin vaatimusten seassa, sopeutumaan toimintaympäristön muutoksiin sekä muuttumaan perustavanlaatuisesti.

Tutkimuksen empiiriset aineistot perustuvat kahteen, vuosina 2010 ja 2018 tehtyyn viljelijäkyselyyn sekä Suomen ruokajärjestelmän historiaa kartoittavaan kirjallisuuskatsaukseen. Tutkimuksen tulokset osoittavat, että viljelijät pyrkivät valinnoissaan yhteensovittamaan laajemman toimintaympäristön (esim. tukipolitiikan) tarjoamia mahdollisuuksia sekä sen asettamia rajoitteita (esim. markkinatilanne) omiin tavoitteisiinsa ja viljelemänsä tilan ja tuotantosuunnan todellisuuteen. Pyrkimys taloudelliseen kannattavuuteen ohjaa viljelijöiden valintoja vahvasti. Toisaalta muutoshakuisia viljelijöitä motivoivat myös sosiaaliset ja kestävyystavoitteet. Kestävyysorientaatio kytkeytyy vahvasti kehittämispyrkimyksiin, jotka puolestaan liittyvät maatalouden merkitykseen kokonaistoimeentulossa. Sellaiset viljelijät, joille maatalous on toimeentulon kannalta tärkeä, kehittävät tilaa kokonaisvaltaisesti, myös ympäristökestävyyden osalta.

Ruokajärjestelmän hintapaineet kuitenkin kaventavat kannattavien liiketoimintamallien kirjoa maataloudessa ja ohjaavat maatiloja kohti erikoistumista ja yksikkökokojen kasvua. Erikoistuneista ja voimakkaasti investoineista tiloista tulee samalla haavoittuvia politiikan suunnanmuutoksille ja kustannusten kasvulle. Erikoistumiseen ja kasvuun kannustava ja pakottava järjestelmä marginalisoi monimuotoisuutta. Suomalaisessa ruokajärjestelmässä on vain vähän tilaa ”toisin toimimiselle”; ruokajärjestelmä perustuu lähes yksinomaan suuruuden ekonomiaan, jolloin viljelijöiden tosiasialliset mahdollisuudet valita tai toimia toisin jäävät vähäisiksi.

Siinä missä kasvu ja erikoistuminen kaventavat viljelijän toimintatilaa, juuri kasvu ja erikoistumisesta seuraava keskittyminen ovat myös ruokajärjestelmän kestävyysongelmien tärkeimpiä juurisyitä. Nämä kehityskulut kytkeytyvät fossiilienergiaan pohjautuvaan yhteiskunnalliseen aineenvaihduntaan sekä pyrkimykseen kohti jatkuvaa talouskasvua, jotka välittyvät hintapaineiden kautta maatilatasolle. Monimuotoisuuden vaaliminen nähdään tärkeänä maatilojen resilienssiä ylläpitävänä tekijänä, mutta tosiasiassa maatiloilla on erittäin vaikea toimia vastoin koko ruokaregiimin keskeisimpiä toimintaperusteita, jotka nimenomaan vähentävät monimuotoisuutta kautta koko järjestelmän.

Ruokajärjestelmän kestävyyssiirtymä ei voi tapahtua reilusti ilman, että maatiloille pyritään aktiivisesti ja tietoisesti rakentamaan vaihtoehtoisia kehityssuuntia. Muutokset vaativat resursseja, jotka tällä hetkellä valuvat maatiloilla miltei kokonaan kustannuspaineisiin vastaamiseen. Fossiilimetaboliasta irtaantuminen on kestävyyssiirtymän kannalta keskeistä, ja tarjoaa myös maatiloille uusia mahdollisuuksia. Kestävyyssiirtymä vaatii myös ruokajärjestelmän valtarakenteiden ja jatkuvan kasvun tavoitteen kriittistä tarkastelua ja ravistelua. Maanviljelijöiden keskuudessa on kykyä ja halua muutosvoimana toimimiseen, mutta sen valjastaminen edellyttää kestävien ja kannattavien liiketoimintamahdollisuuksien olemassaoloa.

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ORIGINAL PAPERS

I

ADOPTION OF THE AGRI-ENVIRONMENTAL MEASURES: THE ROLE OF MOTIVATIONS AND PERCEIVED EFFECTIVENESS

by

Irene Kuhmonen, 2017

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Adoption of the agri-environmental measures: The role of motivations and perceived effectiveness

Abstract

This paper investigated farmers' self-stated adoption motives and the perceived effectiveness of agri-environmental measures in Finland. The measures were classified into ten distinct categories according to their prescriptions. The adoption motives were related to contextual factors, production factors and perceived effectiveness of the measures, while effectiveness was further related to land use, input use and the final impacts. The results indicate that the adoption motivations and the perceived effectiveness of the measures are related to their prescriptions: measures targeting the same problem with different prescriptions fit the aims and farming strategies of different farmers.

Keywords:

Agri-environmental measures, adoption, farmer perceptions, fitness, effectiveness

1 Introduction

The intensification and restructuring of agricultural production throughout the world has contributed to several environmental problems: water eutrophication, soil degradation, pesticide contamination, air quality problems, climate change effects and biodiversity losses (OECD 2008). Farmers' choices regarding the farming practices have a crucial role for the development of the environmental effects of agriculture. Within the European Union, these practices are promoted as part of nationally implemented agri-environmental schemes (AES) that include financial incentives to compensate the additional costs and economic losses caused by their adoption (European Commission 2005). Understanding decision-making concerning participation in these schemes is a focal foundation for eliciting behavioural change. The decision-making of individuals is based on personal beliefs, perceptions and constructions of the reality, which are combined with the goals, values and attitudes of the decision-maker (Baron 2008). All of these constructs are formed in interaction with the external environment, which also constrains individuals' choice sets (Burton 2004). The internal environment may also set such constraints in the form of, for example, capability deficiencies (Burton 2004). Farmers' decision-making is typically motivated by some fundamental premises, such as seeking viability and ensuring continuity over generations (Ingram et al. 2013, Sutherland 2010, Vanclay 2004).

Researchers have long sought to understand the structural and behavioural antecedents related to adoption of agri-environmental practices. The meta-analytical reviews have revealed that few factors explain adoption decisions universally (Knowler and Bradshaw 2007). Based on research conducted so far, the adoption decisions may be seen to be contingent upon several factors, all of which are not within the sphere of farmers' decision-making – decision-making is highly contextual (Siebert et al. 2006, Wilson and Hart 2000). Positive attitudes towards environment and pro-environmental practices typically precede adoption, but the relationships between attitudes, contexts and behaviours are complex (Ahnström et al. 2008). Farmers are actors within wider systems and networks, and the system properties may limit the choice possibilities of farmers significantly (Carlisle 2016). Adequate resources in the form of knowledge and information and also financial resources enhance adoption (Grammatikopoulou et al. 2016, Pavlis et al. 2016, Wilson and Hart 2000). Support from social networks and the conception of environmentally-friendly practices as culturally accepted farming practices similarly enhance their adoption (Huttunen and Oosterveer

2016, Burton et al. 2008). Findings concerning structural factors such as age of the farmer, farm size and dependency on farming as a source of livelihood are mixed and sometimes contradictory (Lastra-Bravo et al. 2015). The antecedents of adoption are contingent upon the characteristics of the subject of choice – different factors precede the choice of different practices (Pannell et al. 2006, Van Herzele et al. 2013). Generally, adoption is more likely to occur, when the farming system fits well with the prescriptions of the scheme and the specific measures (Lobley and Potter 1998, Zimmermann & Britz 2016), and when the adoption is considered to enhance the adopters' goals (Pannell et al. 2006).

The aim of this study is to increase understanding of farmers' adoption behaviour of agri-environmental practices in the context of agri-environmental schemes within the European Union. For that end, this study surveys the adoption motivations of Finnish farmers with a representative dataset covering 20 distinct agri-environmental measures (AEM), treated in bundles based on the practice characteristics. In addition, farmers' perceptions of the environmental effectiveness of these measures are also described. The study makes three contributions: first, it brings forth farmers' self-stated motivations related to adoption. Farmers' choices are fuelled by the very diverse motivations and constrained by the resources and the external environment, which suggests that motivations should be observed explicitly. Second, the study takes into account the practice characteristics. Concomitantly, it becomes possible to observe relationships with the specific practices and farmers' self-stated motivations. Farmers' self-stated adoption motivations have been previously explored on a scheme level (e.g. Morris and Potter 1995, Pavlis et al. 2016, Wilson and Hart 2000) or for targeted practices, such as fertilization or nutrient management practices (Macgregor and Warren 2006, Söderqvist 2003). Accounts of farmers' self-stated motivations concerning all the measures within an AES have been rarely conducted, with the notable exception of Van Herzele et al. (2013), who studied the adoption motivations of simple, medium and complex agri-environmental measures. The approach chosen here resembles that of Van Herzele et al.'s, but the practices are defined by their environmental effectiveness potential instead of implementation complexity. Third, the study links the farmers' perceptions of the environmental effectiveness of the agri-environmental scheme with the adoption of specific practices. Decision-making is not a linear process with a beginning and an end, but rather, it is an evolving cycle with feedback loops informing the decision-maker about the consequences of previous choices (Meyfroidt 2012, Pannell et al. 2006, Schlüter et al. 2017). Thus, the observed or perceived effectiveness of the measures is likely to affect future choices (Reimer et al. 2012, Villanueva et al. 20150).

The research falls within the behavioural tradition of research on farmer decision-making regarding adoption of agri-environmental practices. It explores the factors that farmers themselves perceive to condition the adoption of agri-environmental practices. Through this extensive contextual understanding of the decision-making heterogeneity it is possible to inform policy makers, administrators, advisers and researchers about feasible ways to design and target agri-environmental measures. The paper is organized as follows: chapter 2 presents the materials and methods used, chapter 3 presents the results, and chapter 4 concludes with a discussion.

2 Materials and methods

This research is based on data collected in the mid-term evaluation of the Rural Development Programme for Mainland Finland 2007-2013 in 2010 (Kuhmonen et al. 2010). The programme addresses a wide range of economic and environmental issues of the farms and rural areas. The Finnish agri-environmental scheme is conducted as a part of this rural development programme (MAF 2014). A survey request was sent to all farmers having an email address in the farm register (IACS), altogether about 23,000 farmers. The data consists of 2,124 farmer responses, resulting in a response rate of 9.2 %. The amount of farms in Finland is approximately 60,000, meaning that roughly one third of the farmers had stored their email addresses in the system. In terms of representativeness, slight biases were present towards overrepresentation of large farms, young farmers and farms with other livestock and crops than the most conventional ones (table 1). Despite these biases, the data can be considered as a valid sample of the Finnish farm population. The survey covered all types of farm production and the whole mainland area. The topics addressed by the survey and analysed in this paper included the adoption of the agri-environmental measures, self-stated motives for the adoption of the measures and the perceived effectiveness of the agri-environmental scheme.

Table 1. Representativeness of the data.

Line of production	Survey farms %	All farms %	Farm size	Survey farms %	All farms %	Age	Survey farms %	All farms %
Dairy	18 %	18 %	- 14.99	19 %	32 %	- 29	4 %	3 %
Beef	6 %	6 %	15 – 29.99	22 %	26 %	30 – 49	54 %	42 %
Pig husbandry	5 %	3 %	30 – 49.99	23 %	19 %	50 -	42 %	55 %
Poultry	1 %	1 %	50 – 74.99	17 %	12 %	*Total*	*100 %*	*100 %*
Other animal husbandry	3 %	5 %	75 – 99.99	9 %	6 %			
Cereals	43 %	44 %	100 -	10 %	6 %			
Other special crops	6 %	6 %	*Total*	*100 %*	*100 %*			
Garden crops	5 %	3 %						
Other crops	8 %	13 %						
Other production	5 %	1 %						
Total	*100 %*	*100 %*						

The Finnish agri-environmental scheme in 2007-2013 was divided into two subsets: the basic-level scheme with basic and additional measures, and the special agri-environmental scheme with targeted measures. The additional measures may or have to be adopted by those who have opted into the basic-level scheme, depending on the location of the farm. The basic scheme includes 'broad brush' type of measures, whereas the special measures are more demanding and complex to implement, but also more effective in environmental terms, thus representing 'deep and narrow' type of agri-environmental measures. One farmer may opt into both the basic and special schemes, and he or she may also adopt several measures from the schemes. The adoption rate of the basic agri-environmental scheme was very high with 98% of the respondents having opted into the basic-level scheme. The rate in the sample is higher than among the base population, where 89% of farmers had opted in the basic-level scheme (MAF 2011). The adoption rate of the special measures within the dataset was 37%, while the adoption rate among the base population was 24% (MAF 2011).

The 20 measures offered within the scheme and inspected here (three additional measures for garden farms were excluded due to their specific targeting) were further categorized into nine distinct classes based on the measure prescriptions. The categories were labelled as follows. '*Optimizing fertilization*' includes two types of additional measures that aim at reducing the fertilization based on nutritional computations and analyses. The measures within the '*Reducing fertilization*' category promote extensification of the farming system. The category includes two additional measures and three special measures with fixed fertilization levels. The measures within the basic level and special level schemes were analysed separately. The category '*Tillage practices*' includes basic-level measures enhancing winter-time plant cover and reduced or no-tillage. '*Crop portfolio*' category includes two basic-level measures which promote diversification of the cropping system and cultivation of catch plants to reduce nutrient emissions. '*Manure management'* category includes one measure from the basic-level scheme and one from the special scheme which enhance manure spreading during the growing season and incorporation of liquid manure into the soil to reduce emissions caused from spreading the manure. '*Protecting the waterways*' includes three special measures aiming at decreasing nutrient flows to water bodies using riparian zones, wetlands and runoff water treatment methods. '*Nature management fields'* includes one measure from the basic scheme with the same name as the category, which enhance setting aside farmland. '*Promoting biodiversity*' includes three special measures related to farmland nature conservation and breeding of local breeds. '*Organic farming*' includes the special measure of organic production. The measures and the adoption rates of the measures and categories are presented in table 2.

Table 2. Classification of the agri-environmental measures and adoption rates of the specific measures and measure categories within the data (n of all respondents 1567). B refers to basic-level scheme, S refers to special scheme.

Category	Measures	Adoption (measures, n, %)	Adoption (category, n, %)
Optimizing fertilization (B)	Calibrated fertilization	374, 23.9%	685, 43.7%
	Nutrient balances	336, 21.4%	
Reducing fertilization (B)	Reduced fertilization	262, 16.7%	310, 19.8%
	Extensive grassland production	60, 3.8%	
Reducing fertilization (S)	Intensified reduction of nutrient loading	25, 1.6%	59, 3.8%
	Long-term grass cultivation of organic lands	19, 1.2%	
	Arable farming in groundwater areas	19, 1.2%	
Tillage practices (B)	Plant cover during winter and reduced tillage	1044, 66.6%	1044, 66.6%
Crop portfolio (B)	Crop diversification	205, 13.1%	221, 14.1%
	Cultivation of catch plants	31; 2.0%	
Manure management (B+S)	Spreading manure during the growing season (B)	144, 9.2%	222, 14.2%
	Incorporation of liquid manure into the soil (S)	88, 5.6%	
Protecting the waterways (S)	Runoff water treatment methods	22, 1.4%	230, 14.7%
	Riparian zones	209, 13.3%	
	Multifunctional wetlands	14, 0.9%	
Nature management fields (B)	Nature management fields	605, 38.6%	605, 38.6%
Promoting biodiversity (S)	Traditional rural biotopes	104, 6.6%	266, 17.0%
	Enhancing the biological and landscape diversity	165, 10.5%	
	Local breeds and crops	53, 3.4%	
Organic farming (S)	Organic production	168, 10.7%	168, 10.7%

In the survey, the respondents were asked to freely express motives for the adoption of additional measures and special measures. The respondents were also asked to identify the environmental effects of the agri-environmental scheme on their own farm. For the additional measures, 1,278 responses were given and 540 responses for the special measures. Further, out of the 1,827 farmers who chose additional measures, 70% stated their motives for the adoption. For the special measures, with 784 farmers in the sample having adopted them, 69% of these respondents stated their motives for the adoption. For the perceived effectiveness of the scheme, 1,169 responses were given, resulting in a response rate of 55% among all respondents.

The responses to all open-ended questions were analysed by means of *conventional content analysis*, in which the coding categories were derived from the data (Hsieh and Shannon 2005). Content analysis allows to qualitatively organise large amounts of text into a restricted number of categories (Weber 1990), which may then be analysed using quantitative methods. The self-stated motives for the adoption of additional and special measures were identified as referring either to contextual factors, production-related factors or effectiveness-related factors. The same response could be coded in multiple categories. First, *the contextual factors* identified were related to the farmer-specific factors (preferences, characteristics, attitudes), farm-specific factors (such as presence of suitable land for specific purposes) and the farmers' networks including other farmers and advisors. Second, *the production-related factors* were related to the fit of the measure with the agricultural production either generally or specifically (fit with the line of production, production methods, existing machinery and other infrastructure), easiness of the prescriptions, benefits related to the measure, cost-effectiveness, familiarity and feasibility. Third, the *effectiveness-related factors* referred to either environmental or economic effects. For the special measures, additional categories for the environmental effectiveness were used, when the respondent specified e.g. landscape, biodiversity or water quality as the most important environmental benefit delivered by the measure.

The perceived effectiveness of the agri-environmental scheme was coded into three categories according to the two different causal mechanisms and the final impact. The causal mechanisms identified by the respondents referred to *changes in land use patterns* and *changes in the productive practices*. The subcategories within the land use category were grass-cover, nature management fields, filter strips, riparian zones, avoiding abandonment of arable land and environmental management. Within the productive practices category, the subcategories were the use of pesticides, fertilizing practices, organic farming, and changes in the production system. *The final impact category* included erosion, air emissions, quality of the farm environment, soil quality, landscapes, biodiversity, ground waters, nutrient emissions to surface waters and environmental awareness. Additionally a class labelled "no significant effect" was identified.

The responses were analysed by contingency tables with the Chi square test for statistical significance. The analyses were conducted for those cases that had responded to the corresponding question, i.e. excluding cases with missing data. Thus, the analysis of the motives for adopting the basic-level scheme included 1,278 cases, analysis of the motives for adopting the special scheme included 540 cases and analysis of the scheme's effectiveness included 1,169 cases.

3 Results

The results of the analysis are presented in Tables 3–5. In these tables, the average frequencies of the adoption motives and perceived effectiveness of all the measures are given first. The frequencies are then presented separately for each measure category. The exact significance value (p) depicting either positive or negative association profiling the measure categories is given when the association is statistically significant ($p < 0.05$, in cases of small group sizes also p values < 0.1 are given in parentheses). In the following presentation of the results, the positive profilers as compared to negative profilers of the measure categories are of special interest.

The most common motives to adopt basic-level measures were production-related motives (88%), while effectiveness-related motives accounted for 13% of responses and contextual motives 3%. The single most frequently mentioned adoption motive was the general fitness of the measure with the production system of the farm, followed by the easiness of the measure (table 3). Consistently, Wynne-Jones (2013) noted that farmers welcomed such agri-environmental management practices that were considered primarily productive. For the more environmentally effective special measures, the adoption motives were somewhat different, with context factors accounting for 36%, production factors 51% and effectiveness factors 26% of the motives, respectively (table 4). Within the special measures, the single most common motive was the farm-related factors within the contextual factors followed by environmental effectiveness in total.

The *contextual factors* were mentioned as adoption motivations by 3% of basic scheme adopters and 36% of special scheme adopters. *Farm factors* were important adoption motivations for the special measures, especially waterway protection, promoting biodiversity and reducing fertilization, while they only played a minor role for the basic measures. This implies that especially special measures were adopted because of the existence of suitable areas, such as waterways and seminatural cultural habitats. Similar results have been presented by Murphy et al. (2011) concerning the presence of wetlands and adoption of water quality maintaining practices and by Home et al. (2014) and Van Herzele et al. (2013), among others, concerning the presence of farmland with lower productivity and the adoption of extensive agricultural practices. Those farmers who were motivated by *personal factors* in adoption decisions stated that the specific practice was important or it agreed with their worldview in general. Personal factors were seldom mentioned to motivate the adoption of the basic-level measures, but were particularly pronounced in adoption of organic farming and biodiversity promoting practices among the special measures. The effect of various personal factors, including environmental concern, attitudes and orientation has been widely explored in the adoption literature, with a general positive effect on adoption, although the impact is moderated by several context-specific factors. The management of traditional rural biotopes in Finland has been associated with farmers' personal goals (Birge and Herzon 2014), while meadow bird protection has been associated with farmers' self identity (van Dijk et al. 2015). In the adoption of organic farming, the environmental attitudes (Läpple and Kelley 2013) and orientations (Micha et al. 2015) play a role. *Social networks* mattered as adoption motives especially when the implementation of the practice required use of special machinery as in the case of practices related to manure management. These were in some cases available through subcontractors or neighbouring farmers. Also the influence of family and extension services counted within the category. Use of contractors has been linked to adoption decisions also by Grammatikopoulou et al. (2016) and Huttunen (2015), both in Finland.

Regarding the *production-related adoption motivations*, the *fitness* of the measure with the farming system in general, or more specifically with the line or method of production was mentioned altogether in 42% of the responses for the basic-level scheme and in 28% for the special scheme. In the adoption literature, compatibility or fitness with the existing system has often been cited among the most important factors affecting adoption (Lobley & Potter 1998, Van Herzele et al. 2013) – especially regarding adoption of simple practices such as the basic level practices (Wilson & Hart 2000). *Feasibility* was a similar fitness-related motivation mentioned by 13 % of the basic-level measure adopters and 3 % of the special scheme adopters. The difference compared to the other fitness motivations was, however, the perception that enrolment into the scheme was a necessity for income reasons, and the farmer chose the one compulsory additional measure he or she thought was possible to implement on the farm – thus the difference in frequencies of this motivation between the basic and special schemes. *Easiness* of the measure was the second most common motivator after general fitness with one fifth of respondents mentioning it for basic-level measures, while only 5 % indicated easiness as a motivating factor for special scheme measures. In the adoption literature, the perceived complexity and difficulty of the practices usually affect adoption negatively (Sattler and Nagel 2010, Wauters et al. 2010), while easiness has a positive effect (Defrancesco et al. 2008, Van Herzele et al. 2013).

Generally, the perceived *benefits* are important for adoption of agri-environmental measures (e.g. Villanueva et al. 2015). The benefits derived from the adopted measures were cited as motivating factors in 5 % of the responses concerning the basic-level measures and 2 % of the special measures. Perceived benefits profiled especially manure management within the special scheme; similar results concerning the benefits of manure management practices have been reported by Huttunen (2015) and McCann et al. (2015). *Familiarity* was a more important motivator within the special measures (9 % of respondents cited this motivation) than in basic measures (5 %). Previous experience of the practice typically enhances adoption, as indicated by e.g. Defrancesco et al. (2008) and Micha et al. (2015). In this case, familiarity also referred to cases in which a farmer would have implemented the practice even without financial incentives as he or she was accustomed with the measure; this was typically the case in biodiversity promoting measures. *Cost-effectiveness* refers to the cases in which a farmer perceives benefits related to cost savings arising from implementing the practice. Within the adoption literature, cost-effectiveness has often been cited as an important factor motivating adoption (e.g. Huttunen 2015, Macgregor and Warren 2006). It was mentioned as an adoption motivation in 6 % of responses concerning the basic-level measures and 5 % concerning the special measures, and it was related to especially reducing fertilization within the basic scheme and manure management within the special scheme. Existence of *suitable machinery* was related to especially manure management measures. This motivation reflects the need for specific infrastructure for the farmers to be able to apply the measures (Vanclay

2004), and has been found to affect adoption similarly by Huttunen and Oosterveer (2016) and Reimer et al. (2012).

Effectiveness-related factors were mentioned as adoption motivations in 13 % of the responses concerning the basic-level measures and in 26 % of responses concerning the special measures. Thus, the perceived effectiveness of the measures played a larger role for the special scheme, and especially the role of perceived positive environmental effects was more significant for the special scheme than for the basic scheme (19 % in the special scheme vs. 5 % in the basic scheme). However, the role of economic incentives as an adoption motivator was similar in both of the schemes (8 % in the basic scheme vs. 9 % in the special scheme). The role of economic motivations was highlighted in the case of crop portfolio practices and organic farming. Van Herzele et al. (2013) found that economic incentives matter especially for the measures with high complexity, a finding that applies to the results presented here as well.

Regarding the perceived *environmental effectiveness* of the agri-environmental scheme, almost half of the respondents (47 %) identified positive environmental impacts induced by the scheme (table 5). Changes in the productive practices were identified as the major impact by 38 % of the respondents and effects on land use by 24 % of the respondents. 10 % of the respondents identified no impacts. Most frequently cited effects were related to the surface waters and nutrient emissions (28 %), followed by fertilizing practices (27 %). Changes in the fertilization practices were identified especially by adopters of the measures related to optimizing fertilization, which suggests that even though these measures do not include detailed prescriptions about the amount of fertilization, they do affect farmers' behaviour. Many respondents identified the practice they had adopted as the positive environmental effect born as a result of implementing the scheme. Within the land use practices, plant and grass cover was mentioned as the positive environmental effect especially by adopters of measures related to tillage practices, nature management fields were mentioned by those farmers who had applied the measure, and riparian zones were mentioned by adopters of riparian zones. Infrequently mentioned but interesting effectiveness categories within the land use effects were related to avoiding abandonment of farmland and environmental management. Environmental management may be related to final impact categories of quality of the farm environment and landscape. They characterize the landscape, aesthetics and appearance issues related to adoption of agri-environmental measures, and profiled especially adoption of practices related to waterway protection, promoting biodiversity and organic farming. These issues may also impede adoption, as noted by Burton et al. (2008), but may also act as motivators (Home et al. 2014). Avoiding abandonment profiled the basic level practices of reducing fertilization, and suggests that these AEMs are important for those (likely part-time) farmers who are evaluating the pros and cons of keeping the fields cultivated. Adopters of the special measures did not differ from all respondents based on frequencies of land use effects, productive practices or environmental effects identified, although some differences in the subgroups were present that could be related to the nature of the measures, such as setting up riparian zones, practicing organic farming or protecting ground waters. Relatively few adopters of the special measures also perceived that the scheme had no environmental effects whatsoever. The perception of no environmental impacts induced by the scheme may be related to either the awareness and attitudes of the respondents or selectivity of the measures. The difference between the special scheme adopters and all adopters implies differences in awareness factors, but the slightly higher frequencies within reduced fertilization adopters imply that the effective changes induced by the practices may be limited among these respondents.

Table 3. Adoption motives for the categories of measures within the basic-level agri-environmental scheme. For each category, the frequencies (% of adopters) and p-values depicting statistically significant associations are given. n=1278.

	All categories	**Optimizing fertilization**		**Reducing fertilization**		**Tillage practices**		**Crop portfolio**		**Manure management**		**Nature mngt. fields**	
Share of adopters:		*48,0 %*		*21,1 %*		73,6 %		15,5 %		10,3 %		38,8 %	
Adoption motives:	***%***	***%***	***p***	***%***	***p***	***%***	***p***	***%***	***p***	***%***	***p***	***%***	***p***
Contextual factors													
Personal factors	0.8 %	1.0 %		1.1 %		0.9 %		1.5 %		0.8 %		1.2 %	
Farm factors	1.7 %	1.3 %		2.6 %		2.1 %	0.044	1.5 %		0.0 %		2.4 %	
Social networks	0.5 %	0.3 %		1.5 %	0.040	0.3 %		1.0 %		2.3 %	0.027	0.4 %	
All contextual factors	*3.1 %*	*2.6 %*		*5.2 %*	*0.022*	*3.3 %*		*4.0 %*		*3.1 %*		*4.0 %*	
Production-related factors													
General fitness	24.4 %	28.1 %	0.002	24.1 %		26.1 %	0.012	27.8 %		29.0 %		27.8 %	0.014
Line of production	6.7 %	4.6 %	0.003	8.5 %		7.0 %		3.5 %	0.003	8.4 %		5.2 %	
Method of production	10.8 %	9.6 %		7.8 %	0.042	12.4 %	0.001	18.7 %	0.000	9.2 %		11.7 %	
Feasibility	12.7 %	16.5 %	0.000	8.1 %	0.006	11.5 %	0.023	11.6 %		9.9 %		11.1 %	
Easiness	20.5 %	19.1 %		15.9 %	0.020	21.1 %		9.6 %	0.000	18.3 %		16.9 %	0.007
Benefits	5.2 %	6.2 %		4.8 %		3.4 %	0.000	1.0 %		5.3 %		4.6 %	
Familiarity	4.7 %	3.3 %	0.014	4.8 %		4.5 %		4.5 %		6.1 %		4.8 %	
Cost-effectiveness	5.9 %	6.2 %		11.1 %	0.000	5.9 %		6.1 %		4.6 %		6.3 %	
Suitable machinery	2.7 %	2.3 %		0.4 %	0.002	2.4 %		6.1 %		5.3 %	(0.059)	2.8 %	
All production-related factors	*8.8 %*	*88.3 %*		*81.1 %*	*0.000*	*88.3 %*		*84.3 %*		*90.1 %*		*86.7 %*	
Effectiveness-related factors													
Economic effects	8.1 %	11.1 %	0.000	8.9 %		9.0 %	0.029	18.7 %	0.000	9.9 %		11.5 %	0.000
Environmental effects	5.2 %	4.4 %		9.6 %	0.000	5.7 %		7.1 %		4.6 %		4.6 %	
All effectiveness-related factors	*12.9 %*	*14.7 %*	*0.042*	*18.5 %*	*0.002*	*14.4 %*	*0.005*	*24.7 %*	*0.000*	*13.7 %*		*15.7 %*	*0.011*

Table 4. Adoption motives for the categories of measures within the special agri-environmental scheme. For each category, the frequencies and p-values depicting statistically significant associations are given. n=540.

	All categories	**Reducing fertilization**		**Manure management**		**Protecting the waterways**		**Promoting biodiversity**		**Organic farming**	
Share of adopters:		9,6 %		14,6 %		35,4 %		44,4 %		27,8 %	
Adoption motives:	***%***	***%***	***p***	***%***	***p***	***%***	***p***	***%***	***p***	***%***	***p***
Contextual factors											
Personal factors	8.3 %	0.0 %	0.009	3.8 %		3.1 %	0.001	10.4 %		20.7 %	0.000
Farm factors	26.3 %	26.9 %		5.1 %	0.000	41.9 %	0.000	27.1 %		7.3 %	0.000
Social networks	2.4 %	0.0 %		11.4 %	0.000	1.6 %		0.8 %	0.028	0.0 %	0.014
All contextual factors	*36.1 %*	*26.9 %*		*19.0 %*	*0.000*	*45.5 %*	*0.001*	*37.1 %*		*26.7 %*	*0.000*
Production-related factors											
General fitness	16.5 %	21.2 %		22.8 %		17.3 %		20.4 %	0.019	20.0 %	
Line of production	4.1 %	1.9 %		1.3 %		0.5 %	0.001	6.7 %	0.006	4.7 %	
Method of production	7.6 %	5.8 %		3.8 %		1.0 %	*0.000*	7.9 %		18.7 %	0.000
Feasibility	3.0 %	5.8 %		6.3 %		2.6 %		1.7 %		1.3 %	
Easiness	5.0 %	7.7 %		2.5 %		5.2 %		6.3 %		2.0 %	0.032
Benefits	2.0 %	1.9 %		8.9 %	0.000	1.6 %		0.4 %	0.014	0.0 %	0.027
Familiarity	8.9 %	3.8 %		7.6 %		5.2 %	0.018	11.7 %	0.031	12.0 %	
Cost-effectiveness	5.0 %	7.7 %		13.9 %	0.001	4.2 %		2.5 %	0.013	6.0 %	
Suitable machinery	1.3 %	1.9 %		7.6 %	0.000	0.0 %	0.046	0.0 %	0.016	0.0 %	
All production-related factors	*50.9 %*	*57.7 %*		*70.9 %*	*0.000*	*37.2 %*	*0.000*	*54.2 %*		*62.0 %*	*0.001*
Effectiveness-related factors											
Economic effects	9.1 %	9.6 %		11.4 %		6.8 %		6.7 %		16.0 %	0.001
Environmental effects generally	7.6 %	17.3 %	0.011	8.9 %		8.9 %		6.3 %		14.0 %	0.001
Chemical loading	1.1 %	0.0 %		0.0 %		0.5 %		0.8 %		4.0 %	0.000
Landscape	4.8 %	5.8 %		0.0 %	0.015	3.1 %		10.4 %	0.000	2.7 %	
Biodiversity	1.5 %	3.8 %		0.0 %		2.1 %		2.1 %		2.7 %	
Waterways	5.4 %	3.8 %		2.5 %		14.1 %	0.000	2.5 %	0.006	1.3 %	0.005
Environmental effects, total	*19.3 %*	*26.9 %*		11.4 %	0.034	26.7 %	0.001	20.8 %		23.3 %	
All effectiveness-related factors	*25.7 %*	*30.8 %*		*17.7 %*	*0.049*	*31.4 %*	*0.017*	*25.0 %*		*34.7 %*	*0.003*

Table 5. The perceived effectiveness of the categories of agri-environmental measures. For each category, the frequencies and p-values depicting statistically significant associations are given. n=1169.

B=basic scheme, S=special scheme	**All**	**Special scheme**		**Optimizing fertilization (B)**		**Reducing fertilization (B)**		**Reducing fertilization (S)**		**Tillage practices (B)**	
Share of adopters:		39,3 %		45,5 %		19,1 %		4,0 %		66,5 %	
Perceived effectiveness:		**%**	***p***	**%**	***p***	**%**	***p***	**%**	***p***	**%**	***p***
Causal mechanism: land use											
Plant and grass cover	11.2 %	8.0 %	0.003	10.8 %		11.1 %		11.1 %		14.9 %	0.000
Nature management fields	4.0 %	2.9 %		4.1 %		5.1 %		2.2 %		4,5 %	
Filter strips	3.3 %	2.9 %		3.3 %		2.3 %		6.7 %		3.4 %	
Riparian zones	3.2 %	6.5 %	0.000	3.1 %		1.4 %		0.0 %		3.6 %	
Avoiding abandonment	1.7 %	1.6 %		0.6 %	0.007	3.7 %	0.017	0.0 %		1.8 %	
Environmental management	1.6 %	3.6 %	0.000	2.1 %		0.9 %		0.0 %		1.5 %	
Land use effects, total	*24.4 %*	*24.8 %*		*22.8 %*		*23.5 %*		*20.0 %*		*28.9 %*	*0.000*
Causal mechanism: productive practices											
Pesticide use	3.3 %	4.2 %		2.5 %		2.3 %		8.9 %	(0.059)	3.0 %	
Fertilizing practices	26.7 %	20.5 %	0.000	32.0 %	0.000	31.3 %		13.3 %	0.024	23.2 %	0.000
Organic farming	3.2 %	7.8 %	0.000	3.3 %		2.8 %		4.4 %		3.6 %	
Changing the production methods	6.4 %	6.9 %		6.8 %		3.2 %	0.019	4.4 %		7.0 %	
Productive practices effects, total	*37.6 %*	*37.1 %*		*42.7 %*	*0.001*	*38.7 %*		*28.9 %*		*34.3 %*	*0.001*
Final impact											
Erosion	5.1 %	4.5 %		6.9 %	0.007	3.2 %		4.4 %		6.5 %	0.001
Air emissions	1.4 %	2.0 %		1.4 %		1.4 %		4.4 %		1.2 %	
Quality of the farm environment	1.1 %	2.0 %	0.013	0.6 %		0.9 %		2.2 %		1.1 %	
Soil quality	2.9 %	3.8 %		4.1 %	0.026	0.5 %	0.008	4.4 %		3.3 %	
Landscape	7.6 %	11.4 %	0.000	6.0 %	0.035	12.4 %	0.004	4.4 %		6.5 %	0.026
Biodiversity	9.4 %	10.5 %		8.1 %		8.8 %		6.7 %		10.7 %	0.020
Ground water	0.9 %	1.6 %	0.049	0.4 %		0.9 %		6.7 %	0.006	0.9 %	
Surface waters and nutrient emissions	27.6 %	25.0 %		28.4 %		28.1 %		28.9 %		28.1 %	
Environmental awareness	1.7 %	1.6 %		1.7 %		0.9 %		4.4 %		1.5 %	
Positive environmental effects, total	*49.5 %*	*52.5 %*		*49.0 %*		*47.5 %*		*60.0 %*		*51.7 %*	*0.025*
No impact	9.7 %	6.9 %	0.007	8.1 %		12.0 %		11.1 %		8.5 %	0.035

	Crop portfolio		**Manure mngt. (B+S)**		**Protecting the waterways (S)**		**Nature mngt. fields (B)**		**Promoting biodiversity (S)**		**Organic farming (S)**	
Share of adopters:	17,4 %		11,5 %		14,9 %		41,4 %		16,4 %		11,1 %	
Perceived effectiveness:	**%**	***p***	**%**	***p***	**%**	***p***	**%**	***p***	**%**	***p***	**%**	***p***
Causal mechanism: land use												
Plant and grass cover	10.6 %		12.2 %		8.2 %		12.9 %		4.8 %	0.001	5.6 %	0.017
Nature management fields	5.6 %		3.1 %		2.4 %		8.3 %	0.000	3.2 %		1.6 %	
Filter strips	2.0 %		0.8 %	0.016	5.3 %		4.7 %	0.028	1.6 %		1.6 %	
Riparian zones	5.1 %	0.039	4.6 %		15.3 %	0.000	4.2 %		2.7 %		2.4 %	
Avoiding abandonment	0.0 %	0.044	3,1 %		1.2 %		1.3 %		2.7 %		2.4 %	
Environmental management	1.5 %		2.3 %		4.1 %	0.011	1.9 %		7.5 %	0.000	4.0 %	0.040
Land use effects, total	*24.7 %*		*26.0 %*		*35.3 %*	*0.000*	*32.0 %*	*0.000*	*21.9 %*		*16.7 %*	*0.018*
Causal mechanism: productive practices												
Pesticide use	2.5 %		4.6 %		2.4 %		4.0 %		3.2 %		5.6 %	
Fertilizing practices	15.7 %	0.003	36.6 %		20.0 %	0.019	26.1 %		21.4 %	0.043	13.5 %	0.000
Organic farming	4.5 %		6.1 %		2.9 %		3.0 %		3.7 %		27.0 %	0.000
Changing the production methods	12.1 %	0.000	15.3 %	0.003	5.3 %		7.0 %		3.7 %		4.8 %	
Productive practices effects, total	*30.8 %*		*61.1 %*	*0.003*	*27.6 %*	*0.002*	*36.7 %*		*30.5 %*	*0.017*	*46.0 %*	*0.000*
Final impact												
Erosion	5.6 %		3.8 %		4.7 %		5.7 %		2.1 %	0.026	4.8 %	
Air emissions	1.5 %		6.9 %	0.000	0.0 %		1.1 %		1.6 %		0.0 %	
Quality of the farm environment	0.5 %		1.5 %		1.2 %		0.8 %		2.7 %	0.033	0.8 %	
Soil quality	4.5 %	0.047	5.3 %		4.1 %		3.0 %		1.1 %		6.3 %	0.023
Landscape	5.1 %		9.2 %		7.6 %		7.4 %		20.3 %	0.000	15.1 %	0.002
Biodiversity	13.6 %	0.003	9.9 %		9.4 %		11.4 %	0.030	15.0 %	0.005	15.1 %	0.020
Ground water	0.5 %		2.3 %		2.9 %	0.009	1.3 %		1.1 %		0.8 %	
Surface waters and nutrient emissions	25.3 %		23.7 %	0.002	31.8 %		27.8 %		25.7 %		20.6 %	0.038
Environmental awareness	1.0 %		1.5 %		2.4 %		1.1 %		2.7 %		1.6 %	
Positive environmental effects, total	*46.5 %*		*58.8 %*		*55.9 %*	*0.043*	*48.9 %*		*59.4 %*	*0.002*	*52.4 %*	
No impact	5.6 %		7.6 %	0.047	5.9 %	0.042	7.2 %	0.011	7.5 %		4.8 %	0.028

4 Discussion

This study has offered insights into the factors that the farmers themselves regard as important in the adoption process of agri-environmental measures and their perceptions of the scheme's effectiveness. It is presumable that farmers have reported those reasons that they personally consider to have had the primary effect on their adoption decisions. Based on the adoption behaviour and the motivations given for it, there are differences between the agri-environmental schemes. The measures within the basic-level scheme, the so-called 'broad-brush' measures, are adopted mainly because of production-related factors, while measures within the special scheme, the 'deep and narrow' type of measures, are chosen more equally because of contextual, productive and effectiveness reasons. The differences between the complexity and additionality of the schemes and the adoption motives have been illustrated also by e.g. Lobley and Potter (1998) and Van Herzele et al. (2013). The pronounced role of the productive factors especially in the case of the basic-level measures echoes findings from studies exploring farmer decision-making in general. These studies suggest that retaining the economic viability of farms is an overarching motivation for most of the farmers (Siebert et al. 2006). Thus, especially on the part of broad-brush measures, adoption decisions are judged first and foremost against the effect they have on the productive practices of farms. Other factors such as the environmental effectiveness of the practices also play a role, but this role is complementary to productive reasons. The role of farmers' environmental attitudes in the decision-making has been widely discussed (Burton 2004), but the results of this study suggest that for most of the measures, other factors than personal orientations have a decisive role in the adoption decisions. However, especially organic farming and biodiversity-promoting measures are examples of practices in which some of the adopters may pursue the practices even without any economic incentives. In the adoption literature, these practices have been linked to self-identity issues (Van Dijk et al. 2015) suggesting that the linkages of different practices to different decision-making elements are highly variable.

The pronounced role of the economic incentives in motivating farmers' adoption decisions has sometimes been interpreted to demonstrate farmers' unchanging productivist attitudes and the failure of farmers to engage with more environmentally motivated orientations (de Snoo et al. 2012). The productivist attitudes tend to prevail among farmers, as farming is first and foremost a source of income (Howley et al. 2015). However, the productivist orientation does not necessarily rule out environmental orientations or practicing environmentally friendly agriculture. Based on the results of this study, the environmental and economic factors are not mutually exclusive as adoption motivations. The economic incentives were equally important for the adopters of the special scheme as for the adopters of the basic scheme, although in other dimensions (production-related factors and environmental effectiveness –related factors) the adoption motivations of these schemes were different. The interplay of environmental and economic considerations was especially pronounced in the case of organic farming. Organic farmers often expressed intrinsic environmental motivations for the adoption and considered their way of production as environmentally superior in itself. However, the economic incentives were equally important for the adoption decision. A similar interplay of economic considerations and environmental philosophy in the case of organic farming has been previously reported by e.g. Darnhofer et al. (2005).

The differences in the associations between adoption motivations and practice characteristics were highlighted in the results of this study, as the adoption motivations for the distinct measure categories diverged. For example, the adoption profiles of the measure categories 'optimizing fertilization' and 'reducing fertilization' are divergent, even though all these measures ultimately target the same aims of reducing fertilization and improving water quality. The adoption of practices the fertilization limits of which were based on calculations of the plants' nutrient needs and nutrient balances was motivated by fitness and feasibility perceptions and economic incentives, while adoption of practices with imposed fertilization limits was related to environmental effects, cost-effectiveness, avoiding abandonment and maintaining the agricultural landscapes. These differences suggest that schemes and measures with distinct characteristics recruit different farmers with different strategies (Lobley and Potter 1998). Defrancesco et al. (2008) indicated that an extensification-oriented agri-environmental scheme was more appealing to those farmers who saw the future of their farming uncertain compared to the future- and investment-oriented farmers. The adopters of reduced fertilization measures expressed a similar view on uncertainty by seeing the abandonment of fields as an alternative to continuing their cultivation extensively. Farmers look for fitness between the scheme prescriptions and the existing practices, but achieving the fit depends on various issues – for some farmers strict fertilizer restrictions impede achieving fitness, but optimizing fertilization based on measurements does not – and yet, the target of reducing fertilization may be achieved both ways. For such environmental aims that require as inclusive adoption behaviour as possible it is essential to offer a portfolio of practices that farmers with differing aims find it possible to incorporate the environmental practices into their existing productive practices. The same targets can be strived for with a heterogeneous set of practices. The differences in the motivations imply that farmers adopting different measures have differing strategies and aims concerning farming, but yet the data used here does not reveal the differences in the characteristics of the farmers adopting various measures. This calls for further research paying pronounced attention to the measure prescriptions, farmers' motivations and the structural factors characterising adopter groups.

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II

THE RESILIENCE OF FINNISH FARMS: EXPLORING THE INTERPLAY BETWEEN AGENCY AND STRUCTURE

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The resilience of Finnish farms: Exploring the interplay between agency and structure

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ABSTRACT

Resilience implies, in its essence, the capacity of a system to tolerate disturbances while retaining its essential functions. In the context of agriculture, resilience thinking calls for considering the ability of farms to thrive in turbulent times along with the ability of the ecological system – in which the agricultural production is embedded – to retain its function and integrity. Resilience is a relevant conceptual tool to analyse the contradictory management demands that farms are facing within the current neoliberal market regime: being economically viable and environmentally sustainable. In this study, the resilience of farms was operationalised through farmers' perceptions concerning their farms' development trajectories in these two dimensions. The operationalisation strategy applied to farm survey data from Finland suggested that the majority of Finnish farms were vulnerable in either or both of these dimensions. The resilient farms were characterised by large size, development orientation, possession of social capital and adoption of targeted agri-environmental measures. The agrifood system was characterised by increasing level of centralisation and connectedness affecting all systemic levels, including the farm systems. Resilience can be seen as a manifestation of a self-reinforcing virtuous cycle, in which both the farm structure and the farmer's agency are well aligned with the contemporary context, whereas vulnerability is the result of a similar, but vicious cycle.

1. Introduction

Agricultural farms and farmers in the context of the current neoliberal paradigm of industrial agriculture, the 'corporate food regime', are facing a two-fold challenge: retaining their competitiveness in order to stay in business while responding to the environmental challenges caused as externalities of current agricultural production practices (Darnhofer et al., 2016; Knickel et al., 2018; Milestad et al., 2012; Rizzo 2017). The terms of trade of agricultural production are, from the farmers' viewpoint, deteriorating along with increasing input prices and decreasing prices of agricultural products, which asks for more efficient farm management and pushes towards economies of scale – the farmers either have to "get big or get out" (Fletcher 2013). At the same time, farmers are expected to take on a stronger role regarding the management of environmental problems caused in the course of agricultural production, from biodiversity loss and water eutrophication to mitigating climate change and nurturing the fertility of soils (EEA 2017). From the outset, these two demands are partly incompatible, which highlights the role of farmers' capabilities and strategies in responding and adapting to them.

The responses of farmers to the challenges arising from these contradictory demands can be conceptualised in terms of resilience. The concept of resilience, relying upon the seminal work by Holling (1973), implies the capacity of a social-ecological system to tolerate disturbances while staying within the same domain of attraction, and thus retaining the essential functions, systemic feedbacks and structures (Walker et al., 2004). In the agrifood system context, resilience has been conceptualised variably (Ashkenazy et al., 2018), from perseverance of farms to maintaining food security, demonstrating the context-dependency of the concept (resilience of what to what; Carpenter et al., 2001). Because a social-ecological system consists of two dimensions – the social and the ecological – a resilient system should sustain both features (Folke et al., 2010). Consequently, the most essential function of resilience in an agrifood system can be defined as its ability to provide food for the human population within the limits of the local environmental carrying capacity (Meuwissen et al., 2019). Following this line of argumentation, I conceptualise resilience in terms of the system functions: a resilient farm provides food for the citizens, but does not do so at the expense of the environment – it provides both public and private goods and thus addresses the social and ecological

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function of the system (Meuwissen et al., 2019). Resilience is thus a relevant framework for analysing farms and farmers facing contradictory management demands.

A resilient system is not a stable system, but one that retains its essential functions through enduring stresses and transient shocks (Ashkenazy et al., 2018; Darnhofer et al., 2016). These stresses and shocks are imposed on the system within the dynamics of adaptive renewal cycles. The heuristics of the concept is based on an understanding of systems developing through repetitive phases of growth and saturation, and crisis and renewal. The phases of growth and saturation are called exploitation and conservation, respectively, and they form the relatively stable 'front-loop', the dominant regime, in which systems spend majority of their time (Gunderson and Holling 2002). The exploitation phase is marked by self-reinforcing feedback loops that boost the system's growth, while in the conservation phase, balancing elements are added to these feedbacks through e.g. increasing internal complexity of the system (Walker and Salt 2006). The endogenous contradictions of the system and/or exogenous disturbances can trip the system over a threshold and precipitate the release phase, where the old structures and connections of the system are broken (Holling 2001). A new systemic configuration emerges in the reorganisation phase, which together with the release phase form the 'back-loop', implying the renewal of the system (Gunderson and Holling 2002; Walker and Salt 2006).

The social-ecological resilience scholarship has been criticised for the cursory conceptualisation of the "social" within the social-ecological systems. This criticism calls for resilience research to more explicitly address the human agency in its various forms: in possessing goal-oriented, transformative capacity, being driven by conflicting interests and varying power positions, and in manifesting understanding and knowledge about the focal system (e.g. Cote and Nightingale 2012, Davidson 2010, Dwiartama and Rosin 2014, Fabinyi et al., 2014, Hatt 2013, Herman et al., 2018, Olsson et al., 2015, Stojanovich et al., 2016, Šūmane et al., 2017). Lyon and Parkins (2013) argue that resilience research should bring the social, actor-oriented processes that are manifest in systemic adaptation and transformation to the centre stage, instead of relying on structural indicators that dismiss the varied perceptions of agents within the system. Whether a farm continues to operate and function as a farm system – that is, by producing food and public goods – is dependent upon the decisions made by the farmer (Darnhofer et al., 2010a; Raatikainen and Barron 2017), and these decisions stem from the perceptions and mental models the farmer holds (Beratan 2007; Meyfroidt 2012; Schlüter et al., 2017) – in short, how they perceive the possibilities and constraints and the viable choices available within their operational environment (Darnhofer et al., 2016). Thus, in this study the operationalisation strategy for resilience builds on farmers' perceptions rather than on external indicators.

Agency in social-ecological systems takes place within the possibilities and constraints defined by the external structure – according to how the system actors perceive and act on those possibilities and constraints. By referring to the systemic scales, it is possible to separate distinct layers of interaction: the actor possessing variable amounts of agency – in this case, the farmer, the immediate systemic context within which the interaction between agency and structure takes place – the farm system, and the external systemic context conditioning these interactions – the agrifood system. For this end, reference to the adaptive cycle can provide important insights. The adaptive cycle can be interpreted to represent a dynamically changing interplay between structure and agency, where the structure – i.e., the state of social-ecological system – serves as both enabling and constraining individual agency, depending on the development phase of the system. The conservation phase is typically marked by increasing systemic contradictions and trade-off situations due to the mounting connectedness within the system (Darnhofer et al., 2016). Such rigidity would suggest strengthening structural constraints on agency. The two-fold challenge – producing cheap food with minimal environmental impacts – faced by farmers can be interpreted as an implication of the constraining forces of the dominant agrifood regime growing stronger towards the conservation period. To understand the emergence of resilience at the farm level, I aim at characterising the resilience of farm systems as an interplay between agency and structure.

In this paper, my aim is to understand the emergence of resilience as an outcome of the interplay between farmers as focal agents in the farm systems managed by them and the larger agrifood system representing the structure that constrains and enables farmers' agency. Further, this interplay takes place in a context where the agrifood system is in the front-loop, arguably growing more rigid and connected. My empirical case comes from Finland, which offers an interesting vantage point to understanding these dynamics. In recent years, the Finnish agrifood system has experienced several developments that have had a profound impact especially on the farm systems: the centralisation process in the food chain has been strong, and farm income is falling despite increasing farm size. The developments were accentuated by trade bans to Russia since 2014 that hit hard especially the Finnish dairy sector. As a result, the profitability of agriculture has been described being in a state of crisis (Karhinen 2019). These developments have been accompanied by a heated public debate about the major role of farming in the eutrophication of surface waters and especially the Baltic Sea. Should these developments be understood as an oddity or outlier; a number of bad years passing by, or can they be seen as a manifestation of a stagnated agrifood system stuck in a conservation phase, downplaying the possibility for farmers to exercise their individual agency in shaping the future of this system? A possibility to understand the emergence of the situation in the present day is offered by taking a look at a cross-sectional farmer survey data dating back to 2010, a time characterised by relative stability within the agrifood system. Could the farmers be characterised as resilient at that time? What factors contributed to farmers being resilient or not? What can be said about the role of structural vs. individual factors in contributing to the observed resilience of farms, and based on this information, can we make conclusions about the developments observable in the present day?

In the rest of the paper, I first discuss the concept of resilience in relation to the agency–structure nexus within the framework of adaptive renewal cycles in section 2. To be able to interpret the case in the relevant context, I also discuss the development dynamics of the Finnish agrifood system in terms of the adaptive renewal cycles. In section 3, I present the data and methodology used in the study, and in section 4, the results of the statistical model. In section 5, I discuss the structuration process of farm-level resilience. I conclude by discussing the agency of farmers in striving for resilience within the current agrifood regime.

2. Background

2.1. The resilience of farm systems

The concept of resilience has been originally used in the field of ecology to depict the persistence of the main relationships within an ecological system to external disturbances, as in the case of predator-prey-relationships (Holling 1973). In its current usage in the context of social-ecological systems, the definitions for resilience stress on one hand the persistence of the functions, structures and essential feedbacks within a system (bounce-back type of resilience or persistence), and on the other, the capacity of a system to self-organise, learn and adapt to changing external circumstances while retaining those features (bounce-forward type of resilience or adaptation and transformation) (Davidson et al., 2016; Walker et al., 2004). While definitions for resilience stress the perseverance of functions, structures and feedbacks, the latter two must be subordinate to the former; the systemic function. By definition, complex adaptive systems such as social-ecological systems do no behave randomly, but emergence in these systems takes place to fulfil the systemic goals (Meadows 2008). In the case of agrifood systems, questions of resilience revolve around food provisioning and food security as the main function of the system to be preserved (Hodbod and Eakin 2015).

The agrifood system is not a single system, but an open, fuzzy, multi-scalar entity constructed of numerous subsystems embedded in each other both vertically and horizontally. The agrifood system at a national level contains regional food provisioning systems and local farm systems, while being itself a part of transnational food systems. At the same time, all these systems are also part of other social-ecological and socio-technical systems, such as rural and urban community systems, transportation systems and energy systems that all have their own adaptive cyclical dynamics (Holling 2001). Resilience does not thus take place in isolation. The changes in one systemic level may cascade through other levels, affecting the systemic assemblage as a whole (Holling 2001) – the resilience of the system in inspection is in its essence about how tolerant the focal system is towards these changes relative to its function.

When a farm system goes through the periods of exploitation, conservation, release and reorganisation within the adaptive renewal cycle, some of the structures of the system, its feedback mechanisms and even some of its functions may change. Farms may grow or shrink, they may change the line and type of production, they may choose to sell their products through different channels or give up production and convert to for example tourism. From the viewpoint of the farmer's livelihood, all these options may indicate resilience – the farm may either persist, adapt as in the case of growing, or transform as in the case of changing line of production or converting to non-agricultural activities. However, from the viewpoint of agrifood resilience, giving up agricultural production altogether at a farm means a loss of resilience. When a farm gives up production, the system switches attractors and moves into a new stability domain outside of agricultural production. The switch may indeed indicate resilience, but it is resilience from the viewpoint of the farmer or the rural community, not from the viewpoint of the agrifood system, as the farm ceases to contribute to the central function of food provision within the agrifood system. The agrifood system and rural community system are adjacent and embedded systems, but yet they are also different systems with distinct systemic functions, structures and feedback mechanisms. In this sense, resilience indeed lays in the eye of the beholder.

In the farming system context, resilience can mean in its simplest terms survival of the productive function of the farm despite the changing conditions (Puupponen et al., 2017). However, besides the ultimate goal of food provisioning, the farm system has to do this within the ecological carrying capacity of the focal system. Moreover, the farm system is both dependent upon and contributes to ecosystem services (such as pollination and water regulation). When assessing the resilience of farm systems, these aspects call for equal consideration (Allen et al., 2018). Meuwissen et al. (2019) define agrifood resilience as the ability of the system to deliver on the system functions, which they label as producing both public and private goods. Thus, a resilient farm is able to acquire a sufficient and sustained income for the farming family as well as providing public goods in the form of e.g. ecosystem services and mitigating the environmental harm.

Lyon and Parkins (2013, 532) argue that the social-ecological resilience literature has succeeded in providing an '"indicator-heavy" scholarship about the structural dynamics of resilience', and call for more understanding about the actor-oriented processes contributing to resilience. This 'indicator-heavy scholarship' is what Darnhofer et al. (2016) refer to as the structural approach to resilience. While such an approach to resilience may 'get the facts right' (Cote and Nightingale 2012, 482), it may fail to capture the process that essentially leads to emergence of resilience, if concentration upon indicators leaves the farmers' mindsets – indeed, their very agency – untouched. To address the agentic dimension of resilience, farmers' decision-making, perceptions and meaning making need to be accounted for, which is addressed in the agentic approach to resilience (Darnhofer et al., 2016). These conceptually differing approaches to resilience may also reflect differences in the methodological approaches: qualitative approaches typically address the dimensions of farmer meaning-making, perceptions and judgment, goal-seeking behaviour and practices, while the quantitative approach tends to aim at operationalising some central dimensions of the resilience concept, such as economic or environmental performance or multifunctionality. Bridging the gap between these approaches is a challenging task and will inevitably lead to further limitations, as capturing both processes related to agency and the material manifestations of resilience at the same time implies compromising either depth or breadth of the phenomenon. Quantitative indicators will always be able to capture only slices of the phenomenon they attempt to depict (Quandt 2016), and with qualitative approaches, it is difficult to evaluate the relevance of findings in relation to the whole population of farmers. Nevertheless, despite these challenges, such an approach can provide insights that neither strand could deliver in isolation.

In this study, instead of simply searching for evidence of farm performance in the domains of delivering public and private goods, I address farmers' perceptions of performance. In this approach, resilience does not simply depend upon the resources and potentials present at the farm, but rather upon the way the farmer perceives them (Darnhofer et al., 2016). Such an operationalisation strategy also resonates with the call for more explicitly accounting for the role of local knowledge in reorienting the agrifood systems towards more resilient paths, as prompted by Šūmane et al. (2017). Farmers have been found to have a profound and versatile understanding of the ecological interactions related to agricultural practices (Bernués et al., 2016; Kelemen et al., 2013; Smith and Sullivan 2014; Soini and Aakkula 2007). However, by tracing performance perceptions, it is not possible to infer the agri-environmental status or economic viability of the Finnish agrifood system per se. What the performance perceptions do reveal, however, is the farmers' relational position: if a farmer perceives good or bad performance, there must be conscious, reflexive reasoning grounded in the material reality behind these perceptions (Giddens 1984). Further, these reflections are likely to echo the adaptive capacity of farmers (Berkes and Ross 2013): perception in itself indicates how the individual farmers relate the issue to their own past experiences as well as their future expectations and goals (Giddens 1984). Such an understanding of resilience resonates with the third approach for conceptualising resilience as suggested by Darnhofer et al. (2016); the relational approach. Within this approach, resilience is seen to take place in emergent and unfolding sequences rather than one moment in time (Darnhofer et al., 2010a). These sequences are constituted by the material reality of the past, as in the path-dependent farm trajectory and farming practices, as well as by farmers' perceptions of causes and effects in the past, and by the future in how it reflects the goals and expectations of the farmer (Darnhofer et al., 2016). Both of these temporal dimensions are mingled in the present, in manifestations of farmers' agency in e.g. evaluating past experiences against future prospects for decision-making in the present (Darnhofer et al., 2016).

When having come to terms with how to interpret resilience in the case of farm systems, the question that yet needs addressing is what contributes to this resilience. Frequently discussed factors include social capital as manifested in, for example, cooperation with different social groups and engagement with governance institutions, utilisation of support mechanisms, adoption of innovations, entrepreneurial mindset, value-led decision-making, the approach of nurturing diversity and avoiding locked-in pathways, and management practices aiming for efficient use of resources (Ashkenazy et al., 2018; Darnhofer 2010; Herman et al., 2018; Knickel et al., 2018). Social capital is one of the most frequently mentioned factors enhancing resilience of farm systems (Ashkenazy et al., 2018; Cabell and Oelofse 2012; Herman et al., 2018; Sinclair et al., 2014) through mobilising collective agency and building adaptive capacity of the system within the networks and social relations of actors (Berkes and Ross 2013; Dwiartama and Rosin 2014). These factors represent mostly the agentic dimension in the agency-structure continuum but shed less light on what kind of alignments with the prevailing structure are required for the resilience of farm systems – are there structural prerequisites for farm-level resilience? Do the factors facilitating resilience play different roles in different contexts? Are all farms similarly positioned to strive for resilience? Hence, in this paper, my aim is to explicitly explore both factors reflecting farmers' agency (such as strategic decision-making and possession of social capital) as well as the factors tying the farms to specific structural configurations (such as farm size and line of production) in analysing the emergence of farm-level resilience.

Navigating through the qualitatively different phases of the adaptive cycle requires different kinds of capabilities and management orientation from the farmer, as discussed by Darnhofer et al. (2016). They note that the exploitation period is typically about searching for efficiency within the current agricultural regime, while conservation period in the larger agricultural system means less possibilities for choice and increased leverage from farm- and farmer-external forces. Conversely, the phases of release and reorganisation leave room for innovation and searching as a result of breakage of the systemic connections and freeing of the resources previously bound in the hands of few in the conservation phase (Darnhofer et al., 2016). The feasible strategies to strive for resilience in different phases of the adaptive renewal cycle may contradict each other as the needed capacities during times of incremental change do not equal those relevant in times of radical, transformative change (Ashkenazy et al., 2018; Cabell and Oelofse 2012; Darnhofer 2010; Holling 2001). This configuration implies that farmers' agency is attuned differently depending on the phase of the adaptive cycle both the farm and the agrifood systems are at. This is why the context in terms of the development of the agrifood system in Finland deserves further scrutiny and will be discussed next.

2.2. Development of the Finnish agricultural regime

Finland was a strongly agrarian society up until the aftermath of the Second World War. The industrialisation and intensification period started in the 1950s and was marked by increasing productivity of the agricultural sector along with the introduction of fossil-fuelled machinery as well as synthetic fertilisers and pesticides and protectionist subsidy and price policies (Kuhmonen and Niittykangas 2008). The regime based on intensification coupled with protectionism was transformed profoundly due to market liberalisation, which resulted from accession to the European Union in 1995. The liberalisation marked a swift release and reorganisation period of the Finnish agricultural regime as producer prices were cut by 40%–60% immediately upon accession (Kuhmonen 1998). Approximately 30% of active farms in 1995 were closed by 2005 (Niemi and Ahlstedt 2005). The structural development of the Finnish farming sector has followed the same trends as the rest of Europe and the western world, resulting in a reduced number of farms, increased average farm size and concentration of land ownership (van der Ploeg 2017). Despite the increase in farm size and agricultural output per farm, the average income per farm has fallen 33% from 2000 to 2018 (Natural Resources Institute Finland Statistics).

Joining the EU meant not only the liberalisation of the agricultural markets, but also the introduction of agri-environmental policies. These policies exposed farmers to new management demands to take into account the environmental effects of agriculture more explicitly (Aakkula et al., 2006; Kröger 2009). Such a development, observable around the industrialised world, has been described by Lamine (2014) as the takeover by the corporate environmental food regime. The agri-environmental policies were widely adopted by Finnish farmers from the very beginning. Around the time the survey for this study was conducted in 2010, the dominant themes for agri-environmental management were nutrient management and biodiversity protection. The need for environmental management within agriculture has been addressed with rural development programmes that encourage farmers to adopt both general and targeted environmental management practices. The survey was conducted during the third programming period in 2007–2013.

In terms of the adaptive renewal cycle, accession to the EU in 1995 meant a period of release and reorganisation in the Finnish agrifood system. The survey was conducted during the front-loop of adaptive cycle with exploitation phase progressing towards conservation, within a regime characterised by globalised markets, rising neoliberal market ideologies, corporate power and environmental concerns. For farms, this has meant an enduring stress of improving both economic competitiveness and environmental management and a need to adapt to the price shocks of the global, neoliberal agricultural regime. In terms of resilience, the period of exploitation means incremental rather than radical change and highlights the role of continuous improvement of efficiency of farm management (Darnhofer et al., 2016). The recent years have witnessed deepening hardships for Finnish farms with an economic situation characterised being in a state of crisis (Karhinen 2019). The resources within the agrifood system are seen to accumulate in the hands of few, especially manifest in the oligopolistic market situation in trade and retail (Karhinen 2019; Paloviita et al., 2017). The wide-scale agricultural support system has been criticised for not delivering the environmental benefits expected of it, and for the support money ending up in unintended places, such as unreasonably high prices of agricultural land or to the input suppliers and even trade and retail actors. These developments seem to indicate a conservation phase, where the trade-offs between the various dimensions of the system have become visible, growth has stagnated, resources have become tightly bound and connectedness increased the internal complexity of the system (Holling 2001). Referring to a survey data from 2010 offers a unique opportunity to understanding the roots of these developments. While many of these developments have culminated in the recent years, how early is it possible to observe signs of them from the farmer viewpoint? In this study, I seek to contribute to understanding the effect that the phase of adaptive renewal cycle in the agrifood system has on its subsystems, the individual farms, and how these effects spread within the farm population – what factors enhance the resilience of farms and which factors cause vulnerability.

3. Research design

In the following, I will offer a general description of the research process aimed at 1) describing the resilience of Finnish farms from the farmer perspective in terms of a farm typology, 2) exploring factors characterising resilient and vulnerable farms and 3) discussing the implications of the findings in relation to the development dynamics of the Finnish agrifood system. In subchapters 3.1–3.4, I will offer a more detailed description of the research design. The data that the study is based on is a quantitative, cross-sectional farmer survey data dating back to 2010. Resilience was operationalised by forming a typology based on farmers' perceptions of their farms' performance in environmental and economic domains. The typology resulted with four groups: the resilient group and three groups that were vulnerable in both or either of the dimensions of economy and environment. To explore the factors that contributed to the positioning of the farms in each of these groups, the statistical method of logistic regression was utilised.

3.1. Data

This research is based on the data collected during the mid-term evaluation of the Rural Development Programme for Mainland Finland 2007–2013 in 2010 (Kuhmonen et al., 2010). A survey request was sent to all farmers having email addresses in the farm register (IACS), altogether about 23,000 farmers. The data consist of 2124 responses, for a response rate of 9.2%. The number of farms in Finland at the time of the survey was approximately 60,000, meaning that roughly one third of farmers had stored their email address in the system. In the data, larger farms and younger farmers are slightly overrepresented (Table 1), partly due to younger farmers and owners of large farms having registered their email addresses in the farm register more

Table 1
Representativeness of the data (comparison data source: Natural Resources Institute Finland).

Line of production	Survey farms %	All farms (2010) %	Farm size (ha)	Survey farms %	All farms (2010) %	Age	Survey farms %	All farms (2010) %
Dairy	18	18	14.99 or less	19	32	29 or less	4	3
Beef	6	6	15–29.99	22	26	30–49	54	42
Pig husbandry	5	3	30–49.99	23	19	50 or more	42	55
Poultry	1	1	50–74.99	17	12	*Total*	*100*	*100*
Other animal husbandry	3	5	75–99.99	9	6			
Cereals	43	44	100 or more	10	6			
Other special crops	6	6	*Total*	*100*	*100*			
Garden crops	5	3						
Other crops	8	13						
Other production	5	1						
Total	*100*	*100*						

frequently than older farmers and small farm owners did. Despite this slight bias, the data can be considered valid to represent the Finnish farm population. The survey covered all lines of production and the whole mainland area.

The survey addressed topics related to the characteristics of the farm (location, line of production, share of different activities from the total turnover, farm size) and the farmer (farmer age), management factors (farm strategy, perceived needs for environmental management), adoption of farm subsidy measures, perceptions concerning the development of the farm performance and perceptions concerning development of the area as well activities in which the farm resides. In addition to the variables derived from survey data, an additional variable describing the biophysical environment of the farm was extracted from public statistics sources based on the farms' location.

3.2. *Operationalisation strategy*

The operationalisation strategy for resilience was based on two variables, which capture the farm development trajectories over the past three years (2007–2009) before the survey: the perceptions of environmental and economic performance. The statements were formulated accordingly: 'the activity has developed to be more environmentally-friendly', and 'the competitiveness of the activity has improved'. The response options were based on a five-point Likert scale with options ranging from 'does not represent at all' to 'represents very well'. The resilience of farms was captured by forming a typology of farms based on these two variables. The farms were divided into four distinct groups: the resilient farms, in which both the environmental and economic performance had evolved positively; the vulnerable farms, in which both types of performance had evolved negatively; and two types of partially vulnerable farms: the economically vulnerable farms, in which the environmental performance had evolved positively but economic performance negatively, and finally the environmentally vulnerable group in which economic performance had developed positively but environmental performance negatively.

As a whole, the operationalisation strategy accounts for four aspects of resilience, as discussed by Darnhofer et al. (2016) and Meuwissen et al. (2019): (1) the environmental dimension, as in accounting for the public goods the farm provides; (2) the economic dimension, as in accounting for the private goods of farming (*the structural approach to resilience*); (3) the mental model through which these constructs are filtered (*the agentic approach to resilience*); and finally (4) the temporal aspect accounting for the adaptability of the farm in time (*the relational approach to resilience*). Out of these, the two survey statements capture points (1) and (2), the reference to farmer's own judgement captures point (3) and the evaluation of the development trend captures point (4).

3.3. *Independent variables*

Given the exploratory nature of the initial survey, the variables the role of which in contributing to farm resilience was analysed were not strictly derived from a theoretical resilience framework, but rather reflected the factors that centrally contribute to farms' performance at a general level. Thus, the process of selecting the variables for the statistical model did not follow a line of deductive reasoning within a theoretical framework, but rather a data-driven, inductive approach was utilised in determining the relevance of those factors. The independent variables included in the statistical model were thus chosen in a pre-screening process based on cross-tabulations and analyses of covariance. To avoid multicollinearity, those variables that correlated with other explanatory variables were excluded from the analysis. Among the remaining independent variables to be included in the statistical models, no significant correlations were observed.

The independent variables that were used in the final models as predictors for farms' position within the resilience typology are described in more detail in the following section. The variables were grouped into two main categories: variables reflecting the external structure and variables reflecting farmers' agency. The rationale behind this categorisation is based on an interpretation of the factors that act mostly as conditioning farmers' decisions, and the factors that reflect farmers' interaction with and interpretation of the external structure (see Archer 1995). The descriptives of the studied variables are presented in Table 2.

3.3.1. *Structure as conditioning farmers' agency*

The factors that were interpreted as structural factors that condition farmers' agency included the main line of production, farm size and the biophysical environment of the farm. *Main line of production* included originally 10 categories (see Table 1), which were condensed into six categories in the stage of analysis: dairy and beef, pig and poultry, cereals, horticulture, other crops, and other cattle and other production. Within these, the most common main line of production was production of cereals (43%), followed by dairy and beef (25%). *Farm size* was measured by a categorical variable with six classes, the most common size category being 30–49 ha. The *biophysical production conditions* of the farm's location were described by the share of farmland of the total land area in the municipality where the farm is located. The larger the share of farmland, the more favourable the conditions are for agricultural production. Data for the agricultural area in each municipality was derived from the Economy Doctor service produced by the National Resources Institute Finland and the information concerning the total land area in each municipality was obtained from Statistics Finland. The farm's line of production and its size are in principle subject to farmers' decision-making, in that they could be changed (unlike the farm's location). However, they are also manifestations of strongly path-dependent farm development trajectories, transformation of which requires lots of activation energy, and in this sense, they serve as good

Table 2
Research variables and their descriptives.

Variable	%	Average	Std. dev.
Farm resilience			
Improvement of environmental performance (scale 1–5)		3.41	0.83
Improvement of economic performance (scale 1–5)		2.38	1.03
Structural factors			
Main line of production (% of farms)			
Dairy and beef	24.6		
Pig and poultry	6.1		
Cereals	43.0		
Horticulture	10.5		
Other crops	8.2		
Other cattle and other production	7.5		
Farm size (ha, % of farms)			
14.99 or less	19.0		
15–29.99	21.7		
30–49.99	22.9		
50–74.99	17.3		
75–99.99	8.7		
100 or over	10.3		
Average share of agricultural land in the municipality area (%)		18.49	10.90
Agency factors			
Age of the farmer (years; % of farms)			
29 or younger	4.4		
30–49	53.9		
50 or older	41.7		
Strategy (% of farms)			
Growth	19.5		
Diversification	10.3		
No change	59.7		
Downsizing	10.0		
Closure	0.6		
Organic farmers (% of farms)	9.1		
Adoption of special AEMs (% of farms)	36.9		
Perceived needs for environmental management (scale 1–5)			
Soil		1.92	0.94
Waterways		2.53	1.06
Biodiversity		2.52	1.04
Air quality		1.79	0.89
Landscape		2.54	1.09
Combined indicator value		2.26	0.79
Social capital: Perception of socioeconomic development (scale 1–5)			
Diversification of the economy in the area		2.37	0.85
Sense of solidarity among the local residents		2.35	0.80
Regional development activities		2.38	0.80
Marginalisation present in the area		2.27	0.80
Improvement of the attractiveness of the area		2.44	0.90
Improvement of the atmosphere of the area		2.40	0.80
Combined indicator value		2.37	0.65
Social capital: Perception of the administrative process (scale 1–5)			
Administrative burden		2.96	1.14
Comprehension of the administrative process		3.15	1.10
Partnership with the administration		2.85	1.07
Trust with the administration		2.97	1.09
Interest of administration in the effectiveness of the subsidies		2.82	1.00
Combined indicator value		2.95	0.81

examples of structuration processes (Giddens 1984) – what is the result of active agency at some point of time turns out as structure conditioning agency at a later point in time (Archer 1995).

3.3.2. Interaction and interpretation as manifesting farmers' agency

Interaction with the external structure and interpretation of it against the backdrop of the farmer's experiences, expectations and worldviews is reflected in factors manifesting farmers' agency. Factors depicting the interaction of farmers with the external structure include the management strategy of the farm, type of farming (organic/conventional) and adoption of special agri-environmental measures. *The farm strategy* was operationalised by asking the respondents to choose one of the five options describing best the development of their farm between 2007 and 2009: growth, diversification, no change, downsizing or closure. Business as usual ("no change") was the most common strategy (60%), followed by a growth strategy (19%). *Special AEMs* included measures related to the protection of waterways (riparian zones, multifunctional wetlands), extensification (arable farming in groundwater areas, focused reduction of nutrient loading, permanent grasslands on organic lands), changes in production techniques (incorporation of liquid manure into the soil, runoff water treatment methods) and promotion of biodiversity (traditional rural biotopes, enhancing the biological and landscape diversity of agricultural environments, local breeds and crops) (MAF 2011a). The adoption rate of special AEMs was 37%, and they were considered as a single dummy variable (adopted/not adopted). *Organic farming* also classifies as a special agri-environmental measure within the reviewed agri-environmental scheme, but it was treated as a separate variable in this study. Organic producers had a share of 9% in the dataset. Both organic farming and other special AEMs were adopted slightly more often in the survey sample than among the base population (MAF 2011b). Less Favored Area (LFA) payments and basic AEMs were not considered in this analysis because of their high adoption rates among respondents (96% of respondents received LFA payments and 97% received basic agri-environmental payments). The high adoption rates derive from the LFA status of the whole Finland and from the exceptionally high level of popularity of the AEMs in Finland. That is why in the Finnish context the special AEMs with more targeted goals and limited adoption are of special interest, as compared with the basic measures.

Factors depicting interpretation of the external structure include farmers' age, perceived environmental vulnerability of the farm environment and perceptions of social capital. The *farmers' age* was measured by a categorical variable with three classes, the most common age group being 30–49 years. The *perceived environmental vulnerability* was measured separately for five items: soils, waterways, biodiversity, air quality and landscapes. For each of these items, the respondents were asked to evaluate the need for environmental management or the level of environmental risks on their own farm, depending on the topic. The responses were given on a categorical scale ranging from 1 (no need for environmental management or no risks) to 5 (very significant need for environmental management or high risk). The five farm-specific needs for the environmental management were all statistically significantly intercorrelated (0.420–0.663). For the analysis, the needs for environmental management were therefore converted into a single variable by taking the average of all five items (Cronbach's alpha 0.837). The impact of *social capital* was captured by two separate variables. The first variable described the socioeconomic development of the farm's location municipality. This socioeconomic development was captured by six statements, the response options of which were based on a five-point Likert scale ranging from 'does not represent at all' to 'represents very well'. The topics of the statements are presented in Table 2. The second variable described the farmers' perceptions regarding the implementation of the administrative process of agricultural policies. These views were captured by five statements concerning partnership, trust, mutual interest and administrative burden. The response options were given on a five-point Likert scale ranging from 'completely disagree' to 'completely agree'. For both constructs, an average value of the statements was used as an independent variable (Cronbach's alpha value for the sociocultural development was 0.897 and for the perception of the administrative process 0.806).

3.4. Statistical model

To study the factors that differentiated the farms in terms of their resilience, multinomial logistic regression was utilised. The methodology of regression analysis is 'concerned with describing the relationships between a response variable and one or more explanatory variables' (Hosmer and Lemeshow 2000, 1). Thus, the method allows to depict the relationships of several independent, explanatory variables with one dependent variable (farms' resilience) in one model. Logistic regression instead of linear regression is plausible when the dependent variable is categorical and the independent variables are categorical or continuous. The analysis was carried out in two phases: first, comparing the vulnerable farm groups with the resilient farm group (model 1), and second, comparing the resilient farm group with all the other farms (model 2). This made it possible to determine the characteristics of each farm group in the data. In the first phase of the analysis, the resilient farm group was used as a reference category. In this phase, the analysis identified those factors that distinguished the vulnerable groups from the resilient group. In the second phase, the reference group was all the other farms within the data against the resilient group.

The regression function to be fitted in the data can be written in the following form:

$$\log it(p) = \log(p / 1 - p)) = \beta_0 + \beta_i X_i;\ i = 1 \ldots n,$$

where p is the probability of a certain state of the dependent variable, β_0 is the constant term (intercept), and β_i is the set of parameters (regression coefficients) for the set of the independent variables (X_i) (Hosmer and Lemeshow 2000). The model was estimated using the maximum likelihood method and the statistical significance of the coefficients was evaluated using Wald statistics. The results are given as regression coefficients (β). In determining the reference groups for the categorical variables in the analysis (i.e. the factors), cross-tabulations were conducted before running the models. The analyses were conducted using IBM SPSS Statistics software.

4. Results

In this chapter, I will first present the results of the resilience typology in chapter 4.1, and second, the results of the statistical models detailing the factors that characterize the farms in the resilience typology in chapter 4.2.

4.1. The resilience of Finnish farms

The resilience of farms was operationalised along two dimensions: the development of economic and environmental performances of the farm. The environmental performance was generally perceived to have improved more often than the economic performance was, with the average value of 3.41 (corresponding with 'represents moderately') for environmental performance and 2.38 (corresponding with 'represents poorly') for economic performance, respectively. Environmental performance was perceived positively (moderate or good performance) by 90% of the respondents, whereas economic performance was perceived positively by 43% of the respondents. The distribution of the responses within these studied variables is presented in Table 3. There was a positive and statistically significant correlation between farmers' perceptions of the development of environmental and economic performance, indicated by a Spearman correlation coefficient of 0.199 (significant at $p < 0.001$ level). The better the environmental performance was, the better the economic performance, and vice versa.

Table 3
Frequencies of the responses to the statements describing the development of the environmental and economic performance of the farms.

Responses to statements	Development of environmental performance		Development of economic performance	
	n	%	n	%
Does not represent at all	46	2	452	22
Represents poorly	165	8	741	36
Represents moderately	937	45	585	28
Represents well	771	37	256	12
Represents very well	172	8	48	2
Total	*2091*	*100*	*2082*	*100*

The respondents perceived the development of the environmental performance significantly more positively than they did economic performance, with a difference of one Likert category response unit in the average values of the performance perceptions. Accordingly, the category limits for the resilience typology were set differently for environmental and economic performance. In the case of environmental performance, poor performance (Likert categories 1–2) was merged with moderate performance (Likert category 3) to form the vulnerable group, and the positive performance (Likert categories 4–5) formed the resilient group. However, in the case of economic performance, the middle category was combined with the resilient group (Likert categories 3–5) and the poor performers (Likert categories 1–2) formed the vulnerable group. The resulting balanced typology depicting the resilience of farm systems is presented in Table 4. Drawing from this typology, minority of farms (23%) were classified as resilient, with good environmental performance and moderate to good economic performance. The largest share of farmers (36%) were situated in the vulnerable group with poor to moderate environmental performance and poor economic performance. Around 20% of farmers were in both of the partly vulnerable groups.

4.2. Factors contributing to the resilience of Finnish farms

The results of the regression analyses are presented in Table 5, including the regression coefficients (B) and significance levels. The sign of the regression coefficient identifies the direction of the effect the variable has in relation to the reference group. The results of the first model identify the variables that characterize the vulnerable groups in relation to the resilient group, while the results from the second model identify the characteristics of the resilient group in relation to all the other farms. Both models are statistically significant.

The *vulnerable farm group* was the largest group with 738 farms (36%). Vulnerable farms were likely to be small. Regarding the line of production, this group was characterised by cereal production and pig and poultry production ($p < 0.1$). The market situation of cereals was difficult around the time the survey was conducted (Niemi and Ahlstedt, 2010), thus, the effect of line of production may reflect the volatility of these farms towards price shocks. These farms were typically farmed by young farmers. The farmers in the vulnerable group had not committed to farm development and they had not adopted special agri-environmental measures. They also had negative perceptions of both the local socioeconomic development and the administrative processes related to the implementation of agricultural policies and the agricultural support system.

The *economically vulnerable farm group* consisted of 452 farms (21%). The farms in this group were likely small in size and farmed by old farmers. Regarding the line of production, other cattle and other production was the least likely to rank within this group, with the only statistically significant relationship found in this variable. These farmers had not committed to developing the farm but were the most likely to downsize their farming business. They were not likely to be organic farmers but paid attention to environmental issues manifested by farm-level needs for environmental management, which they perceived higher than others ($p < 0.1$). These economically vulnerable but environmentally resilient farms thus indicated a concern for environmental issues at the farm, while the economic aspects suggest that these farms were about to leave the stage, indicated by the intentions related to downsizing and older age of the farmers. Farmers in this group also held negative perceptions of the local socioeconomic development and administrative processes.

The *environmentally vulnerable farm group* included 400 farms (19%). This environmentally vulnerable but economically resilient group was the smallest group within the typology, and in this group, the smallest number of statistically significant relationships was found. These farms were most likely of average size, thus neither large nor small. The

Table 4
Typology of farm system resilience and number of farms in each group.

Economic performance	Environmental performance: 1 – Very poor performance	2 – Poor performance	3 – Moderate performance	4 – Good performance	5 – Very good performance
1 – Very poor performance 2 – Poor performance	**Vulnerable group** n = 738 36%			**Economically vulnerable group** with good environmental and poor economic performance n = 452 21%	
3 – Moderate performance 4 – Good performance 5 – Very good performance	**Environmentally vulnerable group** with poor/moderate environmental and good economic performance n = 400 19%			**Resilient group** n = 483 23%	

Table 5
Results of the regression models.

	Model 1						Model 2	
	Vulnerable farms		Economically vulnerable farms		Environmentally vulnerable farms		Resilient farms	
	B	Sig.	B	Sig.	B	Sig.	B	Sig.
Intercept	4.266	0.000	2.149	0.000	1.541	0.005	−3.857	0.000
STRUCTURAL FACTORS								
Main line of production (reference: horticulture)								
Dairy and beef	−0.123	0.637	−0.446	0.100	−0.373	0.141	0.309	0.148
Pig and poultry	0.643	0.077	−0.189	0.647	0.285	0.418	−0.328	0.287
Cereals	0.614	0.012	0.303	0.221	−0.294	0.231	−0.209	0.299
Other crops	−0.383	0.238	−0.193	0.546	−0.526	0.120	0.385	0.145
Other cattle and other production	−0.262	0.438	−0.78	0.031	0.062	0.840	0.269	0.311
Farm size (reference: largest size group, > 100 ha)								
<15 ha	0.638	0.029	0.564	0.071	−0.179	0.556	−0.348	0.148
15–29 ha	0.673	0.012	0.584	0.045	0.356	0.182	−0.528	0.017
30–49 ha	0.783	0.002	0.711	0.011	0.509	0.038	−0.660	0.002
50–74 ha	0.359	0.173	0.587	0.037	−0.019	0.941	−0.273	0.191
75–99 ha	−0.091	0.759	−0.251	0.453	−0.284	0.328	0.223	0.346
Share of agricultural land	−0.003	0.687	−0.003	0.719	−0.004	0.618	0.002	0.671
AGENCY FACTORS								
Farmer age (reference: farmers aged 30–49)								
Under 30	0.717	0.034	0.043	0.918	0.038	0.909	−0.291	0.300
50 or older	0.213	0.146	0.329	0.033	−0.201	0.210	−0.116	0.358
Farm strategy (reference: business as usual)								
Growth	−1.528	0.000	−1.193	0.000	−0.168	0.335	0.909	0.000
Diversification	−2.278	0.000	−1.375	0,000	−0.48	0.022	1.306	0.000
Downsizing	0.260	0.337	0.792	0.004	−0.677	0.091	−0.362	0.147
Organic farming (reference: conventional)								
Organic farmers	−0.331	0.155	−0.518	0.039	−0.107	0.643	0.294	0.120
Special AEMs (reference: no adoption)								
Adopted special AEMs	−0.363	0.014	0.055	0.721	−0.246	0.109	0.213	0.084
Perceived needs for environmental management	−0.107	0.232	0.162	0.081	−0.081	0.387	0.019	0.796
Social capital								
Perception of local socioeconomic development	−1.142	0.000	−0.769	0.000	−0.362	0.002	0.751	0.000
Perception of the administrative process	−0.346	0.000	−0.275	0.003	−0.057	0.539	0.224	0.003
n	665		425		371		467	
Reference category	Resilient farms, n = 467						Vulnerable farms, n = 1461	
- 2 log likelihood	4639.977						1869.793	
Likelihood ratio	608.200, $p < 0.000$						264.987, $p < 0.000$	
Cox and Snell R^2	0.271						0.128	
Nagelkerke R^2	0.290						0.192	
McFadden R^2	0.116						0.124	

farmers had not committed to farm development (but were not downsizing either; $p < 0.1$), and thus held a business-as-usual orientation. These farmers held negative perceptions of the local socio-economic development.

The *resilient farm group* consisted of 483 farms (23%). This was the only group characterised by large farm size, while the other variable indicating the conditioning effect of external structure, line of production, did not play a major role. The resilient group was also the only group characterised by commitment to farm development strategies in terms of either growth or diversification. The farmers were likely to have adopted special agri-environmental measures ($p < 0.1$), which suggests that perceptions of environmental performance were grounded in these farmers' actual management decisions to work for environmental issues at the farm. Social capital supported the observed resilience: the resilient group was the only group in which farmers held positive perceptions about the local socioeconomic development and administrative process.

The observed characteristics of resilient farms formed a striking contrast with vulnerable farms especially in terms of farmer agency. The resilient farms were the only group characterised by adoption of development-oriented strategies instead of business-as-usual or downsizing, positive perceptions of social capital, and the adoption of special agri-environmental measures. However, farm structure also made a difference: large farms were far more likely to be resilient in comparison with small farms. The opposite was true for the vulnerable farms, which were of small or average size. Factors depicting farmers' agency had statistically significant relationships with the vulnerable groups, but predominantly in the negative direction: for the most part, vulnerable farms did not indicate possession of positive agentic capabilities.

It could be argued that operationalising resilience in this way actually arises from the farmers' perceptual tendencies – the same farmers found their environmental and economic performances improved and seemed to possess social capital both in relation to the local social environment as well as towards the administration. However, it is important to note that perceptions concerning social capital only affected farmers' ranking within the resilience typology when both environmental *and* economic performance had improved. In all the other cases – also in those cases where farmers were resilient in either but not both of these dimensions – the relationship with factors depicting social capital was negative. Thus, while the perceptual tendencies undoubtedly are real, they at the same time seem to reproduce farm-level resilience, as well as being given rise to by structural conditions that enable resilience, most importantly large size of the farm. The size of farm holdings is one of the most important factors that guarantees for example access to capital, and thus allows investments. Apart from cereal production and pig and poultry production, which were linked to vulnerability, the line of production did not place decisive structural constraints on resilience. The same goes for the biophysical production conditions; even though initial screening suggested covariance, this factor was not related to farms' resilience in the final analyses. The role of structure worked in different directions for resilient and vulnerable farms: resilience was enabled by especially large farm size, while the small size along with specific production activities placed constraints on resilience at the vulnerable end.

In all, both the structure and agency matter for resilience: the structural factors as either enabling or constraining farmers' agency, and agency as making interpretation of the structures and interacting with them. When farmers' agency is manifested in interaction, it can take the forms of strategic decision-making as in the case of the farms' development strategies or making use of the available policy measures as in the case of adoption of special AEMs or organic farming. When it is manifested in interpretation, it relates to the farmers' perceptions concerning the environment (as in perceived needs for environmental management) or to the socio-cultural environment (as in the perceptions concerning the social capital). It is obvious that there are numerous other factors that could and will contribute to farm-level resilience that were not included in this survey but merit further research – such as issues related to trade channels, nutrient balances, off-farm working, attitudes and values, knowledge etc. The findings do, however, indicate that farmers' perceptual tendencies – their very agency – is central for resilience, but this resilience takes place in a specific context, which in this case was large farms.

5. Discussion

In this study, my aim was to 1) describe the baseline of the resilience of Finnish farms: what kind of distribution of farms can be observed in a resilience-vulnerability typology; 2) explore the factors that contribute to this baseline in terms of structure and agency; and 3) discuss the implications of the findings in relation to the development dynamics of the Finnish agrifood system. The operationalisation strategy for resilience was built on the relationship between environment and economy: a resilient farm system performs well in both domains. The economic dimension represents the private function of farm systems (Meuwissen et al., 2019): farming as a source of income and viable business for the practitioner, the farmer. The environmental dimension then stands for ecological sustainability, in which the farming practices are aligned with the local environmental characteristics, and thus represents the public function of the farm system (Meuwissen et al., 2019). These development trajectories were captured through farmers' perceptions, with the presumption that the relevant information regarding resilience is condensed in the farmers' mindsets and understandings of the system they are embedded in. With such an operationalisation strategy, the majority of farms were deemed vulnerable in either or both of these dimensions. However, a general positive correlation between perceptions farmers held about their farms' development trajectories in these dimensions was found, suggesting that these functions are likely to coexist on farms. The literature that explicitly tracks the relationship of environmental and economic performance on farms using e.g. indicators derived from life cycle assessments credit this positive relationship to efficiency of production, which improves economic performance and reduces the amount of environmental pollution, resulting from e.g. excessive fertiliser use (e.g. Groot et al., 2006; Ondersteijn et al., 2003). While based on the data of this study it is impossible to infer e.g. farmers' fertilisation practices, a common denominator can be found in the farmers' development orientation.

Strategic orientation plays an important role in reproducing farm resilience (Darnhofer 2010; de Roest et al., 2018). In this study, a development trajectory related to either growth or diversification was unlikely to be found among vulnerable farm groups, while it solely characterised the resilient group. The tendency for alignment of environmental and economic performance trajectories can be seen as an impact resulting from this development orientation. While such an orientation can lead to more effective farm management, an orientation towards farm development and the future generally has been found to positively affect farmers' decisions to adopt environmentally friendly farming practices (Morgan et al., 2015; Peltomaa 2015), while pessimistic perceptions and orientations act in an opposite way (Wilson et al., 2013). The results of this study suggest that resilience of Finnish farms was more related to adaptability or transformability type of resilience than perseverance, indicated on one hand by the change-oriented development strategies on resilient farms and on the other, the vulnerability of farms that aimed at practicing business-as-usual.

Farm resilience can be seen as a manifestation of several factors reflecting farmers' agency, both in terms of the interpretations they make as well as actions they take. The farmers in the resilient farm group were able to benefit from the policy measures available, to lean on social capital and to aim for constant development of the farm system. These traits are likely to work in reciprocal relationships, reinforcing each other, as has been found in the case of farmers' development intentions and their proactiveness in social networks (Hansson and Ferguson 2011, Methorst et al., 2016) and social capital and adoption of agri-environmental measures (Allo et al., 2015). Social capital in itself has been seen as a central element contributing to resilience or even being a part of it (Adger 2003), and the strong relationship found here indicates to this direction as well. One specific type of social capital measured in this study was related to the relationship with the administration and perceptions of the administrative processes. Positive perceptions of and relationships with the administration can enhance sustainable management practices (Hall and Pretty 2008; Kaljonen 2006), which can also enhance the resilience of farms in enabling them to benefit from the policy measures available (Ashkenazy et al., 2018). The interrelatedness of these aspects of agency contributing to farm resilience indicates the existence of a virtuous cycle with self-reinforcing feedback loops (Gosnell et al., 2019). Such self-reinforcing feedback loops 'are found whenever a system element has the ability to reproduce itself or to grow as a constant fraction of itself' (Meadows 2008, 31).

Yet the resilience (and vulnerability, respectively) of farms was conditioned by the external structure, most importantly farm size. Farm size is one of the most important structural factors manifesting the adaptation of the farms to their current operational environment, which allows farms to 'exploit current strengths and focus on efficiency' (Darnhofer et al., 2010a, 192). Large farms are able to benefit from economies of scale in a regime characterised by low and volatile farm incomes (de Roest et al., 2018), and they are more likely to possess slack resources enabling development activities than small farms are (Baumgart-Getz et al., 2012). The starting point for a virtuous cycle is most likely to be the result of a combination of farmers' agency and the farm structure. Emery and Flora (2006) describe in their community capitals framework how the interaction of various forms of capitals, such as social, natural, human and financial capitals, yields spiralling effects both upwards and downwards. While the upward spiral characterised the resilient farms, the downward spiral could be observed in the case of vulnerable farms, when farmers on these farms perceived their environment negatively, were confined to business-as-usual or even downsizing strategies, did not opt into special agri-environmental schemes etc.

The effect of structural factors, and especially farm size, is derived from the larger agrifood context: when the agrifood system is progressing from the exploitation phase towards the conservation phase in the adaptive cycle, the centralisation within the system increases throughout the systemic scales, including the farm systems. During the exploitation phase in the adaptive renewal cycle, the regime grows more robust, homogeneous and productive. For farms, these developments imply a tightening cost-price squeeze and increased volatility for price shocks (Lamine 2014; van der Ploeg 2017). Large farms are usually best equipped to meet these challenges. The effect of the other structural factor, line of production, indicates the market volatility cascading through the agrifood system, but the effect on resilience was not as strong as the effect of farm size. Diversity has been seen as an important feature of farm resilience, while specialisation can increase vulnerability in the long term, even though it is a profitable option in the short term especially during the conservation phase (Darnhofer et al., 2010b). The resilient farms in this study utilised both strategies of specialisation through aiming at economies of scale and diversification through aiming at economies of scope.

For the resilience of farm systems, boosting virtuous cycles of farm development thus seems to be a critical task. Yet the resilience of farms does not simply arise from positive thinking and trusting that in the future things will turn out well. The systems need to be tuned into enabling such mindsets. As expressed by the majority of farms being vulnerable rather than resilient, and these farms being affected by things they cannot influence such as the prices of agricultural products, it is entirely possible that the leverage point for a virtuous, self-reinforcing cycle lies in the structures, and not in the farmers' mindsets or in their agency. It is possible that vulnerable farms have found themselves within a self-reinforcing cycle similar to that of the resilient farms, but one that is vicious. Darnhofer et al. (2016) point to the pitfalls of the normative use of the resilience concept in describing strategies to achieve resilience within the neoliberal agricultural regime, which are evident when interpreting the results of this study as well. My point is not to elaborate on how farms could be more resilient if the farmers would simply utilise the available policy measures, trust each other and aim for constant farm development. Rather, the results indicate that resilience demands alignment of structure and agency – a project that is not getting easier from the farmers' point of view, with the regime proceeding towards the conservation phase and simultaneously limiting farmers' room of manoeuvre.

The findings of the study bear some limitations as well as merit some avenues for future research. First of all, there is a need to connect the perceptual world of farmers to indicators depicting the dimensions of environmental and economic performance. While the results of this study suggested that the environmental perceptions are related to at least some environmental management decisions, this link deserves much further scrutiny. Second, exploration of the agency-structure constellations in the farm system context is necessary to understand this reciprocal relationship better. The list of variables included in the survey used in this study were by no means exhaustive, and further research could identify a wider set of structural factors affecting farm-level resilience. The extant literature on farm resilience has widely explored the universal capabilities of buffering, adapting and transforming enhancing resilience, but connecting these findings more strongly to analyses of the characteristics of the dominant agrifood regime could yield interesting insights.

6. Conclusions

Resilience within farm systems was the result of a self-reinforcing feedback loop created by the fit between the material structure of the farm with that of the agrifood system, coupled with farmers' agency in making use of the available resources. In practice this means that resilience was a property of large farms that were developed in terms of either specialisation or diversification, the farmers of which possess high levels of social capital and opted into special-level agri-environmental schemes. In contrast, vulnerable farms tended to be smaller farms with no development intentions, suffering from market volatilities and not manifesting possession of social capital. The observed resilience of Finnish farms in 2010 was characterised more by adaptability than by perseverance. This is due to the characteristics of the dominant neoliberal agrifood regime: in progressing from exploitation phase towards conservation in terms of the adaptive cycle, it is inflicting ever-growing pressures of increasing productivity on farms. This cost-price squeeze leads to centralisation processes penetrating all levels of the system, including the farm systems, and explains the confinement of resilience to large farms. In this light, the current crises of low agricultural profitability in Finland seems to be a natural continuum for a development that was observable among farms already in 2010. Thus, for farm resilience, it is not so much about what a farmer can do to enhance their resilience (Darnhofer et al., 2016), but about under which conditions a farmer can do anything to enhance it.

Author statement

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Declaration of competing interest

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III

FARMING ON THE MARGINS: JUST TRANSITION AND THE RESILIENCE OF PERIPHERAL FARMS

by

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Farming on the margins: Just transition and the resilience of peripheral farms

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A B S T R A C T

Sustainability transition demands fundamental changes taking place at the farm system level. At the same time, many farms are operating on the verge of financial profitability, especially in geographically disadvantaged peripheral regions with a limited range of production opportunities. These observations raise concerns about the transition's justice aspects. Using the concept of resilience, we analysed farmers' capacities for transformation in a peripheral context in Finland. The results from our farmer survey ($n = 577$) indicated that the regime exerts a strong cost-price squeeze on farmers, escaping of which is difficult also for farmers deliberately seeking new pathways beyond it. Due to farmers' dependence on the regime, drastic changes to 'the rules of the game' could undermine their resilience. We argue that for transition processes to be both sustainable and just, proactive restorative justice should aim at promoting resilience at the farm level by deliberately building inclusive and accessible transition pathways.

1. Introduction

The current food regime has created a number of persistent environmental problems, such as climate change, environmental degradation and biodiversity loss, while it has also driven many farms to the verge of financial profitability. Addressing these problems through a fundamental reorientation of the food system—a sustainability transition—calls for substantial changes taking place at the level of farm systems. However, farmers have been frequently described as being amongst the least powerful actors in food systems, acting mostly as price-takers, which makes them ill-equipped to act as transition agents (Gottlieb and Joshi, 2010; Glover and Touboulic, 2020; Kaljonen et al., 2021; Tribaldos and Kortetmäki, 2021; Vermunt et al., 2022). The contemporary food system is pushing farms towards more specialisation, intensification and growth to keep up with the cost-price squeeze (van der Ploeg, 2017; Huttunen, 2019; Stringer et al., 2020), while the pressures for a fundamental reorientation in farming are mounting for the sake of environmental sustainability.

The traditional approach to confronting sustainability problems as related to production practices (Garnett, 2013) and farm management has been advocated for decades through, for example, agri-environmental policies within the European Union. However, critics argue that many such strategies do not challenge the systemic features that contributed to the problems in the first place (Clapp et al., 2018) and are thus inadequate to address the root causes of sustainability problems. The consumption approach takes a different position, attributing the environmental crisis to consumption patterns, especially overconsumption of high-impact animal-based products (Garnett, 2013; Westhoek et al., 2014). Under this approach, a dietary transition towards more plant-based consumption is

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the most critical solution to address the sustainability problems of the food system. However, the dietary transition translates as a threat to the livelihood of especially many peripheral regions where farms and farmers lack feasible production and employment alternatives due to unfavourable growing conditions and paucity of non-agricultural jobs (Kaljonen et al., 2019; Kuhmonen and Kuhmonen, 2019; Huan-Niemi et al., 2020; Yli-Viikari et al., 2021; Puupponen et al., 2022).

The problem with both production- and consumption-oriented perspectives is that they do not address questions of power and agency that are fundamental elements of the unsustainability of the contemporary food system (Neufeld et al., 2020). Accordingly, as Garnett (2013, 34) states: "The concern lies not just with production, and not just with consumption: it is the outcome of unequal relationships between and amongst producers and consumers, across and within countries and communities." Yet the questions of power, agency and social justice have received limited research interest in relation to initiatives promoting sustainability and climate change mitigation amongst food systems (Clapp et al., 2018; Janker et al., 2018). To this end, an emerging area of 'just transitions' research has been gaining a stronger foothold amongst the sustainability transitions literature (Newell and Mulvaney, 2013; McCauley and Heffron, 2018; Köhler et al., 2019). In the context of food systems, research on just sustainability transitions draws from existing scholarship on food justice, which is devoted to studying power and agency in food system, food system transformation, and distribution of harms and benefits of food system activities across various social groups and spatial scales (Gottlieb and Joshi, 2010; Cadieux and Slocum, 2015; Kortetmäki, 2019).

Despite the urgency of efforts to promote sustainability transition within the food systems, and the observations related to farmers' weak power position, there is very limited understanding about farmers' capacities to transform (Darnhofer, 2021; Vermeulen et al., 2018). In this study, we examine the transformative capacities of farmers in a peripheral context to understand how they are positioned relative to the prospective sustainability transition. We operationalise farmers' transformative capacities through the concept of resilience: by referring to resilience as persistence, adaptability, and transformability (Folke et al., 2010; Meuwissen et al., 2019), we analyse the 'fit' of farms with the external system, characterised by rigidity and path-dependency on the one hand and mounting pressures for a disruptive transition on the other. The concept of resilience allows us to move beyond analysis of production lines or practices to be promoted or debilitated and analyse the position of farms as parts of the food system: whether and under which conditions peripheral farms can participate in the main function of food systems—food production.

We discuss our findings in the context of just transition, which addresses social inequalities and tensions related to transition processes along the dimensions of distributive, procedural, recognitive, cosmopolitan and restorative justice (Kaljonen et al., 2021). While the uneven consequences of transition processes are usually analysed in terms of distributive justice (e.g., Kaljonen et al., 2021; Tribaldos and Kortetmäki, 2021), we argue that the concept of restorative justice offers a theoretically unelaborated but promising pathway to understand the ways forward from the detected inequalities: how to compensate or restore the actors' positions shaken by the transition processes (McCauley and Heffron, 2018; Kaljonen et al., 2021). In particular, we elaborate on the recently developed proactive elements of restorative justice (Schiff and Hooker, 2019) and argue that restoration should go beyond only reacting and compensating for harm created but also promoting the actors' resilience in transition processes.

Our empirical context is Finland, particularly its eastern, peripheral regions, where the livelihoods of many farmers (especially those employed in agriculture full-time) and, partly, regional economies are dependent on cattle production. This is due to the region's climatic conditions and soil properties being particularly suited for grass production, whereas crop cultivation suffers from profitability problems or from a short growing season (Huan-Niemi et al., 2020). Furthermore, crop production does not offer possibilities for full-time employment in peripheral areas, which also lack the abundant job markets of economically prosperous regions (Yli-Viikari et al., 2021). We base our findings on representative survey data retrieved from farmers in eastern Finland in 2018 ($n = 577$).

2. Conceptual framework

Our conceptual framework builds on three key concepts: sustainability transition, agency and resilience. These are interlinked by the concepts of just transition, adaptive and transformative capacities, and transformation pathways (Fig. 1). In the following, we will discuss the framework in more detail.

2.1. Sustainability transition and the resilience of farms

Social systems, such as food systems, may accommodate several stability domains. These stability domains (Kauffman, 1993; Kuhmonen, 2016) are analogous with regimes as temporally stable configurations of a social-ecological or socio-technical system.[1] We understand regimes as dynamically stable configurations of social systems prevailing over specific timeframes. Sustainability transitions can thus be conceptualised as regime shifts (Runhaar et al., 2020) or moves into new stability domains. These systemic transformations affect the subsystems residing within larger-scale systems, such as farms as parts of food systems. The specific transformation pathways that farms take can be conceptualised in terms of resilience.

Resilience refers to the capacity of social-ecological systems to fulfil their function in changing conditions, thus withstanding disturbances and being able to adapt and transform while delivering on their main goal (Gunderson and Holling, 2002; Walker et al., 2004). Although resilience is sometimes portrayed as stability, resilient systems can—and should be able to—transform. The strategies

[1] A food system can be conceptualised both as a social-ecological and a socio-technical system. The schools of thought behind these concepts have developed largely isolated from each other, but they also share some common vocabulary and research topics, and similarly embrace system dynamics as giving rise to processes of social change.

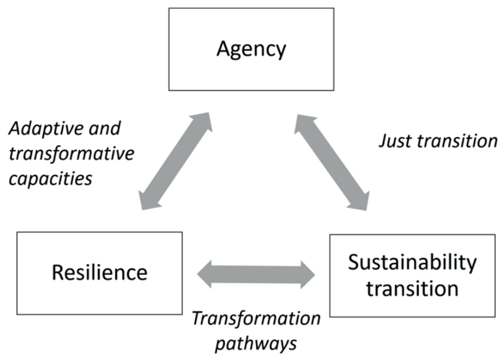

Fig. 1. The conceptual framework of the study.

through which a social-ecological system may retain its resilience can be characterised in terms of persistence or robustness, adaptability, and transformability (Fig. 2; Walker et al., 2004; Folke et al., 2010; Darnhofer, 2014; Meuwissen et al., 2019).

Robustness refers to the capacity of the (farming) system "to withstand stresses and (un)anticipated shocks" (Meuwissen et al., 2019, 4). Adaptability, in turn, entails "the capacity of actors in a system to influence resilience" (Walker et al., 2004, 5) by, for example, changing "the composition of inputs, production, marketing and risk management in response to shocks and stresses but without changing the structures and feedback mechanisms of the farming system" (Meuwissen et al., 2019, 4). Lastly, transformability is about "the capacity to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable" (Walker et al., 2004, 5). Such changes can imply a changing function of the farming system (Meuwissen et al., 2019).

A farm system may employ different resilience strategies over time. The food system and the embedded farm systems are in a flux of constant interaction: the dynamics on both levels condition each other. The employed resilience strategy depends on the transformative capacities of the farm and the farmer—what they can do with the resources they have. This makes resilience a question of agency and power. In a situation where the regime is strongly locked-in, farmers' choice space becomes substantially limited (Kuhmonen, 2020). The pressures are manifest in how farmers are acting mostly as price-takers and carry the responsibility for mitigating environmental impacts in the food system (Glover and Touboulic, 2020). However, not all farmers are similarly affected by transition processes, which calls for analyses of the transformation pathways accessible to farms.

2.2. Resilience, agency and adaptive capacities

Agency and power are longstanding areas of research in social sciences. Agency can be seen as the actors' capacity to act, and it constitutes power, intentionality, freedom of choice and reflexivity (Dietz and Burns, 1992; Teerikangas et al., 2021). Power, in turn, is understood here as "the capacity of actors to mobilise resources and institutions to achieve a goal" (Avelino, 2017, 507).

When resilience is understood as the capacity of a system to achieve its goal, the notion of power in achieving that goal is central to the analysis of resilience. Resilience requires adaptive capacity, which refers to the potential of system agents to fulfil their goals, act independently, and exert their own agency (Folke et al., 2010; Berkes and Ross, 2013; Olsson et al., 2014). As such, the concept of adaptive capacity is practically identical to the concept of social power. Analyses of resilience and adaptive capacity at the level of farm systems require identifying the kinds of goals farmers hold regarding food production, the resources available, as well as the capacities to utilise them to achieve those goals (Rauschmayer et al., 2015). Thus, even though the concept of resilience has sometimes been used without being attentive to the societal context, questions of regime reproduction, or social power (MacKinnon and Derickson, 2013; Taylor, 2018; Darnhofer, 2021), it holds potential in analysing questions of agency, power, and social justice related to systemic transformations (Olsson et al., 2014; Ingalls and Stedman, 2016; Popke et al., 2016)

As systems may employ very different strategies to retain their resilience, it is presumed that system actors also employ different capacities in accordance with their resilience strategy. Avelino (2017) argues that transformative capacities are different from capacities that reproduce the existing structures, as in the case of persistent or adaptive versus transformative types of resilience. According to Patterson et al. (2017, 9), "Transformative adaptation approaches take as a starting point that power relations condition the options available to marginal and vulnerable groups to shape their own desirable futures, thus requiring keen attention to issues of social difference, power, and knowledge." Tribaldos and Kortetmäki (2021) see capacity development as a criterion for a just transition in the sense of whether food system actors can respond to transition pressures. Thus, resilience capacities depend on what people can do and be with those resources and goods they possess or have access to (Nussbaum, 2003; Sen, 2009). How farmers as system actors employ their capacities is a function of their internal goals and the external conditions defined by the food system (Eakin et al., 2016). When the distributive effects of external conditions fall unequally upon the food system actors, restorative justice can reveal new perspectives on mitigating these effects.

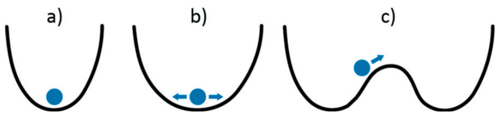

Fig. 2. Modes of resilience: a) persistence, b) adaptability and c) transformability (after Meuwissen et al., 2019).

2.3. Restorative justice in the sustainability transition

Restorative justice approach is traditionally understood as a non-adversarial response to harm and conflict that derives from violations of law, rules, ethics, or a general sense of moral obligation (Walker, 2003). The concept originates from criminal justice studies seeking to repair the damage and restore the dignity and wellbeing of all those involved in causing harm (Eglash, 1977). However, restorative justice has increasingly been acknowledged in the field of sustainability, particularly from the perspective of energy transition, nature conservation, food transition and human rights (Figueroa and Waitt, 2010; Heffron and McCauley, 2017; Schormair and Gerlach, 2020; Hazrati and Heffron, 2021). The common characterisations of restorative justice emphasise face-to-face dialogue between different parties configured as offenders or perpetrators of harm and the subjects-of-harm (Hazrati and Heffron, 2021). The latter is often conceptualised as a "victim", a condition under which agency and relationship with offenders are to be transformed. The

Fig. 3. Location of the research area in Finland.

process of restorative justice involves a reactive mechanism to address the damage already done. In other words, the process seeks to restore justice within the structures of the existing system. Accordingly, the individual is expected to undergo a transformation process (to move from the position of victim into non-victim) while the surrounding system does not change.

Recent proactive approaches to restorative justice have emphasised more anticipatory elements of restorative justice. This means involving a range of actors and adopting a forward-looking approach that is both preventive and strategic (Hazrati and Heffron, 2021). However, to be genuinely proactive and transformative, justice cannot be achieved by restoring the status quo ex ante (Schiff and Hooker, 2019). We further argue that the main challenge of restorative justice during systemic changes is that the transformation is not only about individuals but the system itself. Thus, individuals cannot be easily 'restored' with the logic of a system on the move. In systemic transitions, this would mean that those at risk of becoming 'transition victims' should also have the opportunity not to become ones.

However, the application of the restorative approach to sustainability transition is not unproblematic, as the actors who fall victim to the transition processes have at the same time contributed to the problems that call for a transition in the first place. To what extent this contribution can be credited to the deliberate choices of the actors or just to them operating by the rules of the game remains debated. However, the current financial position of farmers suggests that the system itself is the most crucial factor in delimiting their choice space. The just food transition poses a fundamental challenge to restorative justice; the food system itself is enduring a major transformation which is also expected from the actors within the system. We argue that a genuinely transformative and proactive approach to restorative justice should aim at resilience and capacity building not only in terms of the existing system, but also in terms of the systemic transformation. We now move on to examine farmers' transformative capacities and then discuss our findings from the perspective of restorative justice.

3. Research design

In this section, we present the research design through which we explore the transformative capacities of farmers. We base our exploration on farmers' self-stated goals and development intentions, which reflect their resilience strategies within a given moment in time. By analysing the resilience profiles against various background variables, we describe the source and content of farmers' adaptive capacities. Finally, we discuss the justice implications of our findings against the backdrop of the contemporary food regime, as well as the pressures exerted by the sustainability transition. Our study area is a peripheral region with limited livelihood options, thus highlighting the pregiven power imbalances of the socio-economic system.

3.1. Research area and data collection

The research area in Eastern Finland comprises three provinces: North and South Savo and North Karelia (Fig. 3). The area is characterised by a sparse settlement structure and rather unfavourable socio-economic development patterns. The area adds up to 18% of the total area in Finland and 10% of the total population, with 557,000 inhabitants. On average, the farms in Eastern Finland are smaller than the national average, and the fields tend to be fragmented into small plots. The share of utilised agricultural area (UAA) in Eastern Finland is 5% of the total area in comparison with the Finnish average of 7.4% (Natural Resources Institute Finland, 2021). The climatic conditions and soil properties are particularly suitable for grass production, and consequently, the role of cattle production is pronounced with 33% of all farms in Eastern Finland being cattle farms in comparison with the Finnish average of 20% (Natural Resources Institute Finland, 2021). A significant share of the yields produced on crop farms are used for feed on cattle farms in the area (A. Huuskonen, personal communication, February 2022). Regarding farm sales, in Eastern Finland 68% comprises animal products in comparison with the 58% average of mainland Finland (Natural Resources Institute Finland, 2021).

This study is based on survey data collected during the mid-term evaluation of the 2014–2020 Rural Development Program (RDP) of Eastern Finland (Kuhmonen et al., 2018). The programme addresses a wide range of social, economic, and environmental issues of farms and rural areas by channelling the funds of the second pillar of the EU's Common Agricultural Policy for farmers, rural firms, and non-profit organisations. A survey request was sent to all farmers in Eastern Finland who had received agricultural support from the programme and who had registered an email address in the IACS farm register (7796 farmers). All active farmers in Eastern Finland with at least 5 hectares of arable land are entitled to LFA support, and in Finland, the support encompasses nearly all agricultural land (Niemi and Väre, 2018). As a result, 577 responses were retrieved, with a response rate of 9% despite several requests to fill out the questionnaire. The low response rate was partly due to unfavourable timing of the survey at the beginning of spring but is in line with many recent farmer surveys conducted in Finland.

The survey addressed issues related to the farm and its production activities, the farmer and the farming family, farming as a livelihood, environmental aspects related to farm management, and the main types of subsidies received and their perceived effectiveness. The basic characteristics of the surveyed farms are presented in Appendix 1 in comparison with all farms in Eastern Finland and all farms in mainland Finland. The survey respondents farmed slightly larger farms than farmers in the area on average but were broadly representative of farmers in the area. Most of the survey respondents (30%) were cattle farmers (dairy and beef), followed by other crops (typically hay production; 29%) and cereal production (22%). Garden crops, especially strawberry and currant, are typical crops in eastern Finland and had a share of 9% in the dataset.

3.2. Analysis

We performed an analysis to understand the farms' adaptive and transformative capacities as contributing to their resilience.

Farms' resilience was operationalised based on the farmers' goals and future plans for farming, thus reflecting three distinct resilience strategies: persistence, adaptability, and transformability. The resulting farmer groups were then profiled against a set of background variables to make sense of the various resources and capacities that gave rise to the observed resilience strategy. By multivariate analysis, we identified the factors most strongly contributing to the adaptive and transformative capacities of farms. In what follows, we will present these steps in more detail.

3.3. Operationalisation strategy for resilience

We operationalised the concept of resilience according to the three dimensions of resilience: persistence, adaptability, and transformability. In addition, we also identified a non-resilient group. The operationalisation strategy was based on three variables: 1) the future strategic orientation stated by the farmer (closed question), 2) an additional open question related to the farmer's strategic orientation asking the respondent to specify his or her plans, and 3) freely expressed goals for farming (open question). Out of the 577 responses, 575 were analysable in terms of resilience; thus, the final dataset consisted of 575 responses.

Coding farm resilience was an iterative process between the three variables. Table 1 presents the coding principles for each resilience group. In short, a farm was coded as *persistent* when the farmer aimed at business-as-usual and did not indicate development intentions. Those farms that aimed at developing the farm within the existing operations were coded as *adaptable. Transformable* farms indicated a deliberate search for a new direction for the farm business by diversifying the farm operations or doing something new in comparison with the existing operations. *Non-resilient* farms aimed to quit farming by retirement or moving into another business; they did not have successors and their intention was to lease or afforest the fields.

3.4. Profiling farms according to the resilience typology

The resulting four farm groups with diverging resilience orientations were profiled in terms of variables concerning the farm and its production activities (e.g., farm size, forest acreage, line of production, business model), the farmer and the farming family (e.g., age, gender, children, education), farming as a livelihood (e.g., share of farming income, assessment of profitability, past development strategy), environmental aspects related to farm management (e.g., soil condition, existence of wetlands and seminatural habitats), and the main types of subsidies received and their perceived effectiveness (adoption and perceived effectiveness of agri-environmental scheme (AES), adoption of agri-environmental (A-E) contracts, investment support, organic farming, extension support). These variables reflect the availability of resources, as well as how farmers make use of them and how they relate to environmental management at the farm level, reflecting the mobilisation of environmental values and motivations. A complete list of the variables included in the analysis is given in Appendix 2.

To determine whether the differences between the resilience groups were statistically significant, ANOVA tests were performed for continuous variables for the comparison of means, and contingency tests (X^2) were performed for categorical and dummy variables for comparison of the distributions.

A set of variables representing farmers' goals, the perceived barriers in achieving their goals, problems related to soil condition, and the approach for preventing waterway eutrophication were derived from content analyses, as these questions were open-ended. The responses were analysed with conventional content analysis, in which the coding categories were derived from the data (Hsieh and Shannon, 2005). Content analysis allows the qualitative organisation of large amounts of text into a restricted number of categories (Weber, 1990), which may then be analysed using quantitative methods. The categories were retrieved iteratively; thus, the coding categories were detailed during the coding process. The codes for each category derived from the content analysis were given as 0/1; 0 indicated that the category was not mentioned in the response, and 1 indicated that it was mentioned. Thus, it was possible to observe more than one category in one response. A more detailed description of the content analysis is provided in Appendix 3.

Table 1
Coding principles for the resilience typology.

	Future development strategy	Specification of the development strategy;goals for farming
Persistent farms	Business-as-usual	With no development orientation
Adaptable farms	Growth within existing line of production	(All)
	Business-as-usual	With a development intention or farm succession
	Downsizing	By giving up extra workforce or giving up animal production; coinciding with a development orientation
	Major turn	But search for a new direction missing
Transformable farms	Diversification strategy	(All)
	Major turn	With a deliberate search for a new direction
Non-resilient farms	Quitting farming within the next ten years	(All)
	Business-as-usual; downsizing	With the intention to move into another business, lease the fields, or retire

3.5. Regression analysis

To differentiate the strongest predictors for the resilience groups, we performed multinomial logistic regression analysis. With this method, it is possible to describe the relationships and interdependencies of one research variable with several explanatory variables simultaneously. Logistic regression is feasible in cases where the dependent research variable (the resilience typology) is categorical and the independent variables are categorical or continuous. A forward stepwise method with 18 explanatory variables was used with an entry probability of 0.05. Out of this group of variables, the analysis indicated predictors for the membership of the farms in the resilience groups step by step, starting from the strongest predictors. The analysis was based on 489 observations when cases with missing values were excluded.

The regression function can be written as follows: $\text{logit}(p) = \log(p/1\text{-}p)) = \beta_0 + \beta_i X_i$; $i = 1\ldots n$, where p is the probability of a given value of the research variable, β_0 is the constant term (intercept), and β_i is the set of parameters (regression coefficients) for the set of the independent variables (X_i) (Hosmer and Lemeshow, 2000). Maximum likelihood was utilised for the estimation, and the statistical significance of the coefficients was evaluated by Wald statistics. The results are given as regression coefficients (β).

4. Results

In this section, we first present the profiles of the farms as classified in the four-group resilience typology based on the distribution of the explanatory variables, and then identify the strongest predictors for group membership with multinomial logistic regression. The results thus indicate how the resilience of the surveyed farms in Eastern Finland was composed of their adaptive and transformative capacities, as well as their robustness, as in the case of persistence.

Table 2
Resilience profiles of the surveyed farms in Eastern Finland based on the distribution of explanatory variables.

	Persistent	Adaptive	Transformable	Non-resilient
n	212	176	48	139
Share	37%	31%	8%	24%
Description	Satisficing; aims at business as usual	Regime aligners; aims at continuous improvements, development strategy	Experimenting at the outskirts; looking for new paths, aims at multifunctional strategy, major turn	Quitters that aim at giving up farming
Farm	Smallish farms Cereals, other crops Produce raw materials only	Large farms Dairy and cattle farms, garden crops and other animals emphasised Also upgrading activities	Large farms Other animal production, special crops and garden crops emphasised Also upgrading activities	Small farms Garden crops and other crops emphasised Produce raw materials only
Farmer and the farming family	Vocational education Living alone No children emphasised	Younger farmers Higher education Farming couple with children	Younger farmers Higher education No children emphasised	Oldest farmers Vocational or basic education Have children
Farming as a livelihood	Farming not that important source of livelihood, small farming income Business-as-usual in the past Satisfied with profitability emphasised Economic and personal goals, barriers in markets and physical environment	Farming important source of livelihood, relatively high farming income Growth in the past Satisfied with profitability emphasised Economic and social goals, barriers related to markets, policies, economic performance	Farming important source of livelihood, farming incomes are both small and large Diversified or changed in the past Not satisfied with profitability Economic and social goals, barriers in markets and the farm	Farming not that important source of livelihood, small farming income Business-as-usual or downsizing in the past Not satisfied with profitability Economic and personal goals, personal barriers, social barriers emphasised
Environmental aspects related to farm management	Moderate soil condition	Good soil condition emphasised, hydrological problems. Prevention of eutrophication through runoff prevention and farming methods.	Good soil condition emphasised, hydrological problems. Prevention of eutrophication through runoff prevention and farming methods. Wetlands and semi-natural habitats most commonly identified	Moderate soil condition (also weak); nutrient and pH related problems. In the prevention of eutrophication, reducing input use emphasised.
Subsidies	When assigned to agri-environmental scheme (AES), perceived no effect, not assigned emphasised	Effectiveness of AES: done something new Adoption of subsidy schemes larger than average apart from A-E contracts	Effectiveness of AES: done something new Most likely to have opted into A-E contracts, organic farming, extension support, investment support	When assigned to AES, perceived no effect, not assigned emphasised Least likely to have opted into subsidy schemes apart from A-E contracts.

4.1. Resilience profiles of farms

The largest proportion of farms in Eastern Finland were categorised as persistent (37%), followed by adaptable (34%), non-resilient (24%), and transformable (8%) farms. In Table 2, we summarise the farm profiles according to the resilience typology in terms of the background variables. The distributions upon which the profiling is based, along with test results for the statistically significant deviations of the distribution amongst the entire survey population, are provided in Appendix 2.

The main strategy of the **persistent farms** can be characterised as satisficing: doing the things that have been done previously without major attempts for development, let alone trying out new things. These farms were small farms typically producing cereals or other crops (typically hay). Farmers on these farms most often received less than 50% of their total income from farming (typically less than 5000 EUR annual income). However, the farmers were relatively satisfied with the profitability of farming. Environmental aspects did not play a major role in this group, and the persistent farmers were less likely than average to have signed into any of the subsidy schemes observed here. Their farming goals were related to the economy, but also personal goals, such as living on the farm, or a general surrender mentality in which there were no longer any grand goals identified, were relatively common in this group. The farmers of these farms typically had their educational background from vocational schools, and relatively many of these farmers lived alone and did not have children. In sum, the robustness of the persistent farmers arose from them not being dependent on agricultural income, which also meant that they did not have major ambitions for the farm development neither in terms of economy nor the environment.

Adaptable farms aimed at continuous development of the farming business while having a good fit with the existing food regime. The farm size was the largest in this group, as these farms had also previously proceeded on the growth track. Half of the adaptable farms practiced animal husbandry—mostly dairy or cattle; garden crops were also a typical production line. Farming was an important source of income for the adaptable farms, typically constituting 75–100% of their total income. On over half of the farms, the income from farming was more than 15,000 EUR. These farmers perceived the profitability of farming most positively. Farmers in this group were younger than average, and they farmed typically with a spouse and had children. Approximately half of farmers on adaptable farms were highly educated. Almost all adaptable farmers identified economic goals, but also social goals such as continuity over generations, sustainability, and contribution to food provision within the society were prevalent. Environmental management played an important role in this group. Larger than average share of farmers managed wetlands and semi-natural habitats on their land. They described the soil condition as good, indicating a tendency for active soil management. These farms had most often opted into the agri-environmental scheme, which the farmers also perceived as effective. Other subsidy schemes, including the organic scheme, extension support and investment support, were relatively widely utilised by the adaptable farms. The group was by and large characterised by a commitment to farming as a source of livelihood, and a focus on operating by the rules of the regime. To make a living from farming, they had enlarged their farming business in order to keep up with the cost-price squeeze, as well as committed to agri-environmental management on various fronts.

Transformable farms also held a development strategy. However, instead of developing the existing business, they were looking for a new path for their farm-based ventures. Transformable farms were large, and they represented all lines of production, but special crops (such as pulses, oil plants, potatoes and seed crops) and animal husbandry other than cattle and dairy (such as sheep, pig and poultry) were overrepresented within this group. Farmers in this group were young, had the highest education level of all groups and typically had a spouse but farmed alone. For these farms, farming was either the primary source of income or constituted less than 50% of income. Most transformable farmers evaluated profitability as weak, and they were driven by a search for better profitability. However, such a search had been ongoing in the past as well, as these farms had diversified or applied major changes to farm operations also in the past, indicating the difficulty to find a profitable direction fitting the goals of the farmer. These goals were related not only to the economic performance, as a substantial proportion of transformable farmers also mentioned social goals such as sustainability. Indeed, the environmental aspects played the biggest role in this group, encompassing management of soil condition and nutrients, identification of wetlands and management of seminatural habitats, important for agricultural biodiversity. Transformable farmers were the most active in utilising the available subsidy measures. Transformable farms encompassed the largest share of farms (10%) that also practiced upgrading of products by on-farm processing instead of only producing raw material. In short, transformable farms were trying to do things differently. The need for transformation stemmed from the efforts to increase the profitability of farming, to make farming a full-time profession, and to reconcile economic aspects with environmental ones. Their perceived barriers were mostly related to markets but also to the farm and its management, entailing issues such as lack of time due to being employed at the farm only part-time or lack of fields.

Non-resilient farmers—who form a strikingly high proportion of all farmers—faced a dead-end in terms of agriculture and had the aim of running down the farming business altogether. Non-resilient farmers had a low education level, and they were the oldest in all groups. Even though they were likely to have children, they did not have successors interested in taking over the farm, and thus they aimed at retirement, afforesting, or leasing the fields. The farms were small, and they typically farmed other crops or were in other production. The farmers were mostly part-time farmers, with agriculture constituting less than 50% of their total income, and the farming income was less than 15,000 EUR in 71% of cases. Over half of these farmers had proceeded on a business-as usual track previously, and a substantial proportion had downsized their production in the past. Most non-resilient farms assessed the profitability of farming as weak. Although the majority held economic goals, their frequency was clearly lower than in other groups, and the largest share of farmers in this group identified personal goals such as retirement or maintenance of good health. On the barrier side, social and personal barriers prevailed. Social barriers typically included the lack of a successor or a buyer, and personal barriers included high age and poor health. The soil condition was perceived as weaker in comparison with other groups, and the identified problems in soil condition were often related to the pH status of the fields and lack of nutrients. At the same time, even though these farmers felt that the fields suffered from a lack of nutrients, they also mitigated waterway eutrophication by reducing input use. Non-resilient farmers were most likely to have opted out of the agri-environmental scheme, and those enrolled frequently cited that the scheme did not have any effects whatsoever. These farmers were least likely to be organic farmers and to have received extension support or investment support.

4.2. Regression analysis

With regression analysis, we took a closer look at the predictive power of the explanatory variables in comparison with the general descriptions based on the distributions of the variables. The results of the regression analysis are presented in Table 3, including the statistical significance and odds ratios (Exp(β)). When the value of the odds ratio is larger than 1, it implies a positive effect, while a value smaller than 1 implies a negative effect. The model was statistically significant. In the stepwise regression, we included seven explanatory variables that demonstrated the strongest predictive power to classify farms into the resilience groups: farmer age, farmer's assessment of the farm's profitability, farm size, education, use of subsidised extension services, adoption and perceived effectiveness of agri-environmental subsidies, and whether the farmer had children.

In comparison with the non-resilient farm group, a farm was more likely to end up in the persistent group when the farmer had no children, had a high education level (statistical significance 10%), assessed the profitability of farming as moderate or good instead of weak, and was young. In a similar comparison, the adaptable farm group was characterised by a high education level, positive assessment of the farm's profitability, large farm size, and young age of the farmer. The farmers on adaptable farms were also likely to have indicated that they had implemented some measures earlier than planned because of the agri-environmental subsidies (statistical significance 10%). Similarly, farmers on transformable farms were young, had a high education level, had used subsidised extension services, and had large farms. Farmers on transformable farms were more likely to have adopted agri-environmental subsidies, which also had an effect on farm management in comparison with the subsidies having no effects.

Table 3
Results of the regression analysis, including the step summary and parameter estimates for included explanatory variables.

STEP SUMMARY FOR STEPWISE REGRESSION						
Effects	Model	Model Fitting Criteria	Effect Selection Tests			
		−2 Log Likelihood	Chi-Square	df	Sig.	
Intercept	Step 0	1261.5				
Farmer age	Step 1	1170.6	90.94	3	0.000	
Assessment of profitability	Step 2	1138.3	32.25	3	0.000	
Farm size	Step 3	1116.7	21.69	3	0.000	
Education	Step 4	1089.8	26.85	9	0.001	
Extension subsidies	Step 5	1075.1	14.75	3	0.002	
Agri-environmental subsidies	Step 6	1045.8	29.30	15	0.015	
Children	Step 7	1037.7	8.06	3	0.045	
PARAMETER ESTIMATES FOR MULTINOMIAL LOGISTIC REGRESSION						
	Persistence		**Adaptability**		**Transformability**	
	Exp(B)	Sig.	Exp(B)	Sig.	Exp(B)	Sig.
Intercept		0.001		0.002		0.152
Children (reference: no children)						
*Have children	0.539	0.046	1.020	0.959	0.484	0.136
Education (reference: only basic level)						
*University	2.175	0.056	2.927	0.026	16.750	0.011
*Vocational school	1.428	0.325	1.010	0.982	3.136	0.307
*High school	0.801	0.671	0.597	0.413	5.493	0.160
Assessment of profitability (reference: weak)						
*Moderate or good	1.896	0.036	3.866	0.000	1.114	0.822
Agri-environmental subsidies (reference: not adopted)						
*No effect	0.760	0.491	0.534	0.227	0.185	0.021
*Done something new	0.808	0.598	1.084	0.871	0.647	0.498
*Done something earlier than planned	0.842	0.843	4.371	0.085	0.389	0.489
*Done something differently	0.871	0.783	2.231	0.160	0.383	0.251
*Has preserved something	0.787	0.574	1.005	0.993	0.447	0.253
Extension subsidies (reference: not adopted)						
*Has adopted	1.067	0.837	1.635	0.151	4.908	0.000
Farm size	1.007	0.151	1.016	0.001	1.015	0.012
Farmer age	0.942	0.000	0.907	0.000	0.905	0.000
n	178		152		42	
Reference category: non-resilient. $n = 119$						
−2 log likelihood	1037.7					
Likelihood ratio	223.84. $p < 0.000$					
Cox & Snell R2	0.37					
Nagelkerke R2	0.40					
McFadden R2	0.18					

5. Discussion

5.1. Who is resilient in the face of a sustainability transition?

From our data, we have identified four different resilience strategies and differing capacities giving rise to these strategies. The central differences between these strategies lie within their relationship with the contemporary food regime and the related capacities for transformation. The persistent and adaptable farmers (altogether 68% of respondents) stick to the logic of the dominant regime, while the transformable and non-resilient farmers (32% of respondents) are looking to shift towards new stability domains outside the dominant regime. This intent is driven by financial concerns: both the transformable and non-resilient farmers are not satisfied with the financial performance of their farms. However, the conclusion drawn differs between these two groups. The non-resilient farms do not have the resources necessary for transformation: they are old, their farms are rather small, they do not have successors, and their education level is low; thus, exiting farming altogether is a consistent intent. The transformable farmers represent the opposite in almost all respects: they are young, their farms are large, they are well-educated and development oriented.

The transformable farmers hold latent potential to act as change agents in sustainability transition, but this potential remains so far largely unfulfilled. This is due to the tightness of the contemporary regime: the transformable farmers aim at playing by new rules that do not yet exist. Their operations are not very well aligned with the commercial logic of the dominant regime, yet they have utilised the agricultural policies to the fullest extent; in this sense, they are also confined by the regime. The previous attempts of these farms of doing things differently suggests that finding a profitable direction is a struggle, highlighting the rigidity of the current regime (Kuhmonen, 2020). In this sense, resilience at the farm level is significantly more challenging to achieve by creating entirely new and profitable paths than by adapting to the current macro structure (see also Eakin et al., 2016).

Adapting to the current macro structure, i.e., the regime logics, is what the persistent and adaptable farmers were doing. Apart from being relatively content with what the regime has to offer in terms of profitability of farming, the strategies of the persistent and adaptable farms were quite different. The persistent strategy was enabled by non-agricultural income. Because of not being dependent on agricultural income, these farmers are relatively robust and possibly able to persist considerable hardships in their operational environment, but for the very same reason, their incentives to continue farming might also be easily lost. These farmers did not have much development intentions and their environmental orientation was weak. On the contrary, the adaptable farmers were dependent on agriculture for their income. They had been striving to align their farm operations according to the regime rules in terms of continuous growth and investments to production factors. The growth strategy had allowed these farmers to make farming the primary source of income. At the same time, it makes these farms most vulnerable to changes in the 'rules of the game', such as disincentivising animal production.

Even though the adaptable and transformable groups had a different orientation in terms of the contemporary regime, they were both characterised by a development orientation, which had spillover effects in terms of the orientation toward environmental management. These farms were likely to commit to several practices promoting soil carbon sequestration, prevention of nutrient run-offs, and biodiversity protection. Previous studies have also noted the coexistence of a general development orientation and susceptibility toward an environmental agenda (e.g., Wilson et al., 2013; Morgan et al., 2015; Peltomaa, 2015; Kuhmonen, 2020), which can be credited to the capacities the farmers hold (such as intellectual capital manifesting as high education levels), and the possibility and necessity of gaining a livelihood from farming.

The capacity and willingness of transformable and adaptable farmers to commit to sustainable modes of production reflect the production-oriented approach of addressing sustainability problems as part of day-to-day farm management (Garnett, 2013) and can be instrumental in the search for sustainability transition. However, from the perspective of dietary transition, such changes may not suffice and need to be accompanied by increasing share of animal farms converting to crop production (Huan-Niemi et al., 2020). The inherent transformative capacities of peripheral farms to face these challenges are limited, as indicated by our analysis. A small minority of farms are deliberately pursuing transformation. Non-resilient farms—a quarter of all—are likely to be driven out of the food system at all events. The adaptable farms have fine-tuned their production systems according to the current regime's requirements, highlighting the difficulties of diverting away from the contemporary trajectory. The persistent farms, in their turn, are unlikely to act as transition agents, as their operations are characterised by satisficing rather than development aspirations.

5.2. Towards proactive restorative justice in sustainability transitions

Our analysis of the peripheral farmers' resilience strategies and the capacities giving rise to them indicates that farmers are currently profoundly interwoven with the regime, including those farmers who search for a new direction beyond it. The contemporary regime is a double-edged sword from the viewpoint of farmers. On the one hand, a significant share of farms depends on it to survive, yet it is the very same regime that weakens their long-term resilience by continuously increasing the cost-price squeeze and dependence on agricultural subsidies for income. The contemporary regime undermines farmers' agency, yet finding an alternative pathway is a difficult task for them. The situation exemplifies, how within many resilience initiatives, resilience is framed as a capacity to be expected from those facing a disruption, rather than something to be facilitated and built at a systemic level (Fougere and Meriläinen, 2021). This leads to only those with the capacity to act and mobilise within the existing system to be able to maintain or become resilient. We, therefore, argue that just food transition should address proactive restorative justice through systemic resilience-building beyond the traditional approaches involving transition periods and compensation systems (Alkon et al., 2011).

Traditional conceptualisations of restorative justice are based on a linear understanding of systems. In linear systems, compensation for the harm created would be enough to restore the position of marginalised groups, but this does not hold true in complex systems. Even a proactive stance on restoration does not necessarily change the situation. When transformative changes take place in complex systems, they are usually irreversible due to the system moving into a new stability domain. Taking these concerns into account, proactive restoration within transition processes in food systems and beyond should aim at building resilience, especially for those actors most vulnerable in the face of systemic transformations. Our observations concerning the transformative capacities of peripheral farmers indicate that consumption-led dietary transitions are likely to signify hardships for regional food systems, where the role of animal production is pronounced. This threatens to exacerbate existing inequalities caused by effective socio-economic relations (Karlsson et al., 2018; Ciplet and Harrison, 2020; Golubchikov and O'Sullivan, 2020). Such hardships cannot be addressed through short-lived compensations, as the previous positions of the actors cannot be restored in the case of systemic transitions.

Instead, resilience-building requires systematically creating alternative pathways suitable to a wide diversity of geographical contexts and production conditions (Knickel et al., 2018; Stringer et al., 2020; Vermunt et al., 2020). In this vein, the premise for proactive restoration in a complex system should lay on an understanding of the future as yet to be determined. Accordingly, proactive restoration calls for dialogic means that enable diversity in the visions of sustainability transitions (see, e.g., Kuokkanen et al., 2018) and conceptualisations of alternative transition pathways. Proactive restorative policies could offer a space for acknowledging possible solutions and pathways ranging from systemic innovations, such as agroecology, to more incremental approaches of creating markets for new or underexploited agricultural products, such as pulses, fibre plants or energy crops.

The resilience of food systems depends on the resilience of the farms. We are currently witnessing a looming food crisis due to increased costs of production inputs and the war in one of Europe's most important food production areas, Ukraine, which highlights the need for resilience-building across food systems. Retaining food production ability in different regions is an elemental part of food system resilience. Thus, transition policies should address the inherent limitations in the production capacity of different areas while attending to the transformative capacity of farms. While the unsustainability of the current food regime is related to several mutually enforcing attractors (Karlsson et al., 2018), which cannot be addressed only through production or consumption, similarly the transition policies should build on a variety of measures that target several dimensions of the system.

6. Conclusions

For long, the change processes in food systems have overlooked aspects of justice in the pursuit of sustainability transitions. By analysing farmers' transformative capacities in a peripheral context, we have found that while there is potential for transformation amongst a minority of farmers, the change-oriented farmers are at the same time vulnerable to regime-level changes affecting farm income. Our findings call for more contextual designs of sustainability transitions that acknowledge the limitations of the different regions and farms in achieving these goals. For a transition to be genuinely sustainable and transformational, it also needs to address power imbalances that squeeze farmers' room for manoeuvre, as well as take a stance on new openings that could offer new sources of livelihood for peripheral farms.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Appendix 1

Distribution and means of background variables and data representativeness (data source for farms in Eastern Finland and mainland Finland: Natural Resources Institute Finland, 2021). $n = 577$.

Variable Share of respondents (%)	Survey farms	All farms in Eastern Finland in 2018	All farms in mainland Finland in 2018
South Savo	28	30	
North Savo	42	44	
North Karelia	30	26	
Farm size (ha)	44	39	48
Line of production (%)			
- Dairy	20	29	13
- Beef	10	10	6
- Pork	1	0	1
- Poultry	0	0	1
- Other cattle	3	6	4
- Cereals	22	9	32
- Other crops	29	41	33
- Horticulture: garden crops	9	6	3
- Horticulture: greenhouse production	0	1	2
- Other production	6	2	4
Farmer age (years)	52	52	53

Appendix 2

Distribution and average values of explanatory variables within the resilience typology. Statistical significance for ANOVA or X^2 tests is indicated in the second column. The third column indicates the share for the categorical variables or average for the continuous variables in the whole survey population, and the subsequent columns within the resilience classes. Larger than average values are bolded.

Variable	**Test and significance**	**Share or average**	**Persistence**	**Adaptability**	**Transformability**	**Non–resilient**
Farm						
Farm size (ha)	Anova: 0.000	44.4	36.5	**65.6**	**52.8**	25.7
Share of rented field (%)	Anova: 0.000	28	24.7	**34.5**	**34.0**	21.3
Forest acreage (%)	Anova: 0.449	81.8	74.1	**87.4**	**84.2**	**85.7**
Length of shoreline bordering fields (m/ha)	Anova: 0.048	8.2	6.4	7.7	13.5	9.9
Region (%)	X2: 0.172					
*South Savo		28.3	**31.1**	26.1	**31.3**	25.9
*Northern Karelia		29.6	**34.4**	26.7	22.9	28.1
*Northern Savo		42.1	34.4	**47.2**	**45.8**	**46.0**
Line of production (%)	X2: 0.000					
*Dairy		20.2	16.0	**29.0**	14.6	17.3
*Cattle		9.6	9.0	**13.6**	6.3	6.5
*Other animal husbandry		4.7	0.5	**7.4**	**14.6**	4.3
*Cereals		22.1	**25.0**	22.7	18.8	18.0
*Special crops		4.5	4.7	3.4	**14.6**	2.2
*Garden crops		8.5	4.7	**11.4**	**12.5**	**9.4**
*Other crops and other production		30.4	**40.1**	12.5	18.8	**42.4**
Business model (%)	X2: 0.029					
*Produce only raw material		94.8	**97.6**	92.0	89.6	**95.7**
*Also upgrading of products		5.2	2.4	**8.0**	**10.4**	4.3
Farmer and the farming family						
Farmer age (years)	Anova: 0.000	52.3	52.5	48.3	47.2	**59.1**
Gender: female (%)	X2: 0.250	15.3	12.3	18.2	20.8	14.3
Children: yes (%)	X2: 0.024	75.0	68.9	**79.9**	68.8	**80.5**
Education (%)	X2: 0.000					
*Primary		12.6	12.4	8.0	2.1	**22.5**
*Secondary (high school)		8.2	7.1	7.4	**12.5**	**9.4**
*Secondary (vocational school)		45.2	**50.0**	38.9	33.3	**50.0**
*Tertiary (university)		34.0	30.5	**45.7**	**52.1**	18.1
Livelihood and family relation (%)	X2: 0.022					
*Farming couple		39.6	33.7	**47.6**	39.1	38.8
*In a relationship but farms alone		38.4	37.1	38.2	**41.3**	**39.6**
*Lives alone		22.0	**29.3**	14.1	19.6	21.6
Farming as a livelihood						
Share of income from farming (%)	X2: 0.026					
*< 50%		52.2	**58.0**	40.3	52.1	**58.3**
*50–74%		13.2	11.3	**17.0**	10.4	12.2
*75–100%		34.4	30.7	**42.6**	**37.5**	28.8
Farming income (%)	X2: 0.000					
*Less than 5.000 euro		33.0	**42.7**	18.5	27.7	**38.4**

(continued on next page)

Appendix 2 (*continued*)

Variable	Test and significance	Share or average	Persistence	Adaptability	Transformability	Non–resilient
*5000–14,999 euro		28.6	24.6	27.2	**40.4**	**32.6**
*15,000–24,999 euro		15.5	12.3	**20.2**	12.8	15.2
*25,000–34,999 euro		9.1	9.0	**12.7**	2.1	7.2
*35.000 euro or more		13.7	11.4	**21.4**	**17.0**	6.5
Assessment of profitability (%)	X2: 0.000					
*Weak		66.0	64.9	53.4	**77.1**	**79.7**
*Moderate or good		34.0	**35.1**	**46.6**	22.9	20.3
Development during the past 10 years (%)	X2: 0.000					
*Business as usual		49	**61.3**	36.9	22.9	**56.1**
*Growth within existing line of production		22	18.4	**42.0**	22.9	2.2
*Growth by diversification		5	1.4	5.7	**18.8**	2.9
*Major change		7	5.2	7.4	**22.9**	2.9
*Downsize production		17	13.2	8.0	12.5	**35.9**
Goals for farming						
*Had identified an economic goal (%)	X2: 0.000	91	87.4	**98.0**	**93.0**	80.9
*Had identified a social goal (%)	X2: 0.000	16.3	8.4	**23.2**	**30.2**	5.9
*Had identified a personal goal (%)	X2: 0.067	16.0	**19.3**	11.9	9.3	**23.5**
Barriers in achieving the goals						
*Barriers in the physical environment (%)	X2: 0.417	3.7	**5.7**	3.5	0.0	3.3
*Market barriers (%)	X2: 0.000	43.2	**45.3**	**48.3**	**58.1**	16.7
*Political barriers (%)	X2: 0.854	21.0	20.8	**23.1**	18.6	18.3
*Social barriers (%)	X2: 0.001	6.3	1.9	6.3	2.3	**16.7**
*Personal barriers (%)	X2: 0.013	14.8	11.3	11.9	14.0	**28.3**
*Farm-related barriers (%)	X2: 0.002	7.7	5.7	7.7	**20.9**	1.7
*Economic barriers (%)	X2: 0.804	25.6	24.5	**28.0**	20.9	25.0
Environmental aspects related to farm management						
Soil conditions (%)	X2: 0.035					
*Weak		3.8	3.8	2.3	2.1	**6.5**
*Moderate		57.1	**61.6**	50.0	52.1	**61.2**
*Good		39.0	34.6	**47.7**	**45.8**	32.4
Identified problems related to soil condition						
*Hydrology (%)	X2: 0.012	60.0	55.4	**66.7**	**76.9**	39.4
*pH or nutrients (%)	X2: 0.135	29.3	29.2	23.5	26.9	**45.5**
*Locational factors (%)	X2: 0.741	21.0	18.5	**23.5**	15.4	**24.2**
*Other factors (%)	X2: 0.352	15.1	**18.5**	12.3	**23.1**	9.1
Existence of wetlands: yes (%)	X2: 0.012	9.7	8.0	**11.9**	**20.8**	5.8
Prevention of waterway eutrophication						
*By reducing input use (%)	X2: 0.114	22.8	**23.5**	20.1	13.2	**31.6**
*Through farming methods such as tillage practices (%)	X2: 0.012	36.2	34.8	**41.0**	**50.0**	22.4
*Through preventing runoffs with riparian zones etc. (%)	X2: 0.015	61.0	51.3	**68.8**	**71.1**	56.6
Existence and management of seminatural habitats (%)	X2: 0.12					
*No habitats		72.5	**78.8**	69.9	54.2	72.7
*Yes but unmanaged		8.5	6.1	7.4	**14.6**	**11.5**
*Yes and managed		19.0	15.1	**22.7**	**31.3**	15.8
Subsidies						
Effectiveness of agri-environmental subsidies (%)	X2: 0.003					
*Not received		14.9	**17.8**	8.8	13.3	**18.6**
*No effect		22.4	**26.9**	15.6	13.3	**27.1**
*Preserved something		17.9	**18.3**	**18.1**	15.6	17.8
*Done something earlier		4.9	2.5	**9.4**	4.4	3.1
*Done something differently		12.4	10.7	**17.5**	11.1	9.3
*Done something new		27.5	23.9	**30.6**	**42.2**	24.0
Agri-environmental contract: yes (%)	X2: 0.108	16.9	14.6	15.9	**29.2**	17.3
Organic farming: yes (%)	X2: 0.010	16.9	14.2	**22.7**	**25.0**	10.8
Extension support: yes (%)	X2: 0.000	28.3	21.7	**36.4**	**54.2**	19.4
Investment support: yes (%)	X2: 0.000	8.7	5.2	**15.3**	**22.9**	0.7

Appendix 3. Coding process and main results of the content analysis

Farmers' goals were identified on three dimensions: economic, social, and personal. Out of the 577 responses received, 381 farmers answered the question concerning the goals for farming. Most of the respondents (91%) expressed economic goals, such as attaining profitability or decent livelihood; 16% expressed social goals, such as continuity over generations, sustainability, or maintaining rural landscapes; and 16% expressed personal goals, such as quality of life or retirement plans.

The respondents were asked about the *barriers* they faced while pursuing their goals. This question received 352 responses. The barriers related to the market environment such as low producer prices (57%), financial performance, such as profitability of farming (27%), political environment, such as contents of the policies (24%), the farmers themselves, such as high age (17%), the farm and its management, such as lack of time (9%), social environment, such as lack of successor (7%), and physical environment, such as weather (4%).

The respondents were asked to rate the soil condition of their fields and then to specify the *kinds of problems they had identified in terms of soil condition*. This question was answered by 224 respondents. The problems were coded under four categories: hydrology, which refers to drainage issues (60%); pH or nutrients, referring to lack of nutrients or the need to add lime to the fields (29%); locational factors, such as stony fields and small plot sizes (21%); and other factors, such as weeds, crop rotations, compaction, and lack of organic matter (15%).

In a similar vein, the respondents were asked whether their fields were bordered by lakes or rivers, whether they had wetlands in their lands, and *whether and how they mitigated the nutrient leakages to waterways*. This question was answered by 371 respondents. Three main groups of mitigation practices were identified: preventing runoffs from fields with different kinds of filter strips and/or riparian zones (61%), applying farming methods that prevent nutrient leakages, such as specific tillage practices (36%), and reduction of input use (23%).

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IV

TRANSITIONS THROUGH THE DYNAMICS OF ADAPTIVE CYCLES: EVOLUTION OF THE FINNISH AGRIFOOD SYSTEM

by

Irene Kuhmonen and Tuomas Kuhmonen, 2023

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Transitions through the dynamics of adaptive cycles: Evolution of the Finnish agrifood system

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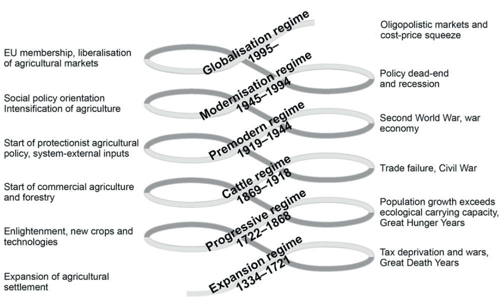
HIGHLIGHTS

- A qualitative analysis of 700 years of Finnish agrifood system's history was conducted.
- Adaptive renewal cycles capture the regime shifts in the Finnish agrifood system.
- The elements of growth have turned to seeds of destruction during each regime.
- Regime shifts were driven by loss of resilience.
- Metabolic changes induced the most far-reaching regime shifts.

GRAPHICAL ABSTRACT



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ABSTRACT

CONTEXT: The escalating sustainability problems of the current agrifood regime call for a radical, systemic transformation. Such a transformation implies a move into a new stability domain, defined by a new set of systemic attractors. These transformations can be conceptualised as regime shifts.

OBJECTIVE: In this study, we explored the history of the Finnish agrifood system in order to learn from the past transformations of the system and to inform the current attempts to steer its development in a more sustainable direction.

METHODS: We conducted a qualitative analysis on literature discussing the history of the Finnish agrifood system by utilising the concept of the adaptive cycle, which captures the cyclicity of the evolution of social-ecological systems.

RESULTS AND CONCLUSIONS: We identified six regimes from the 14th century onwards: Expansion (1334–1721), Progressive (1722–1868), Cattle (1869–1918), Premodern (1919–1944), Modernisation (1945–1994) and Globalisation (1995–). During each regime, the evolution of the system organised around specific attractors which initially opened up new possibilities for the actors, but over time, the very same attractors became the main source of vulnerability in the system. Along with the system's maturation, path-dependency created rigidity, escalating sustainability problems and decreasing room for manoeuvre for the system's actors, concomitantly decreasing the system's resilience. When an external shock related to climatic conditions, economic turbulence or wars coincided with such a rigidity, the system collapsed, the consequences

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of which span from food shortages to large-scale, deadly famines. The collapse of the old regime opened up the window of opportunity for a regime shift. The most profound regime shifts were related to changes in the system's metabolism and trade orientation.

SIGNIFICANCE: While the conservation phase of the adaptive cycle increases systemic vulnerabilities, it also offers an opportunity for systemic transformation. Allowing the adaptive cycle to play out on smaller scales—such as at the level of farm systems—helps to avoid collapse on the scale of the whole food system. The current agrifood regime in Finland indicates strong path-dependency and rigidity, manifesting a conservation phase, to be followed by release and reorganisation. This observation calls, first, for considering the resilience of the current system to anticipate a crisis and, second, for outlining alternative visions for the sustainable future of the agrifood system.

1. Introduction

During the past century, agrifood systems have undergone major changes globally. In the processes of modernisation, industrialisation and globalisation, locally oriented, more or less self-sufficient systems have transformed into systems tuned around relative competitive advantage, ever-increasing productivity fuelled by fossil and synthetic inputs, and dependence on the international trade of foodstuffs (McMichael, 2009; Oosterveer and Sonnenfeld, 2012; Kummu et al., 2020). While these developments have made it possible to feed a population that has more than quadrupled from 1920 to 2020, they have also contributed to a number of persistent problems, from biodiversity loss to environmental degradation and climate change, as well as social problems such as unequal nutrition and animal welfare issues (Pretty, 2008; Marsden and Morley, 2014; Eakin et al., 2017). To address these problems, it is of utmost importance to understand their systemic origin (Rotmans and Loorbach, 2009; El Bilali, 2018; Béné et al., 2019).

The shift towards a more sustainable future calls for a radical departure from the current ways of production and consumption within the agrifood system: a societal, systemic transformation. The questions of societal transformation are addressed within the field of transition studies, which explore causes, effects and processes related to the evolutionary dynamics of social systems (Geels and Schot, 2010; Loorbach et al., 2017; Ollivier et al., 2018; Köhler et al., 2019).[1] Understanding how and why systems undergo radical transformations calls for long-term historical analysis (Fraser and Stringer, 2009; Parsons and Nalau, 2016; Nicoll and Zerboni, 2020). Such an understanding can prove to be pivotal for the current attempts to steer the sustainability transition of our contemporary social systems (Garud and Gehman, 2012; Van Bers et al., 2019). However, the majority of transition studies in the field of agrifood systems as well as beyond them tend to be concerned with the dynamics of the present-day transition processes or limit their investigations to specific transition periods in history and the dynamics prevailing in those relatively short timeframes. Accordingly, Van Bers et al. (2019) argue that in order to navigate the transition of agrifood systems towards more sustainable pathways, far more empirical research is needed about (a) their historical transformations, and (b) the incremental vs. radical forms these transitions can take.

What constitutes a radical transformation of a social system remains ambiguous in the contemporary transition literature (Geels and Schot, 2007; Feola, 2015; Hölscher et al., 2018). Such transformations essentially relate to the stability of regimes, which can be seen as the dominant structural configurations of social systems prevailing across certain time periods. Regimes are characterised by stability and path-dependency anchored around strong social forces such as norms, routines, power relations and technologies (Loorbach et al., 2017). Regimes are path-dependent and resistant to change, but not immutable; thus, a regime shift – a significant change in the structural configuration, processes and functions of a system – can be seen to constitute a radical transformation, while incremental transitions may change some dimensions of the regime yet leaving their basic structures untouched.

Over the long term, the transition dynamics in social systems tend to take a cyclical form, as indicated by, for example, Schumpeter's cycles (Schumpeter, 1934) and Kondratieff's waves (Nefiodow and Nefiodow, 2017). Analysis of the macro-level development taking place within food systems (the food regime theory) has indicated that food systems are not in a state of constant flux, but they are characterised by multiple stability domains and consequent transformations (McMichael, 2009). In other words, social systems tend to spend considerable periods in a state of incremental developments that do not challenge the essence of the regimes, but these periods of stability are at times interrupted by events that reconfigure the structural foundations of the regimes.

A prominent framework for addressing both the cyclic nature of evolution of the social systems, as well as the multidimensional dynamics giving rise to It, is the concept of the adaptive (renewal) cycle (AC). The adaptive cycle is a heuristic model that captures the life cycle dynamics of social-ecological systems through phases of exploitation, conservation, release and reorganisation (Holling and Gunderson, 2002; Folke, 2006; Walker and Salt, 2006). As an integral part of resilience theory, it captures the dynamics occurring at multiple spatial and temporal scales across a system; this hierarchy of nested scales is referred to as panarchy (Holling and Gunderson, 2002). The theory holds that regime shifts take place as a result of a system exceeding resilience threshold—with resilience understood as "the capacity to absorb disturbance, to undergo change and still retain essentially the same function, structure, and feedbacks" (Walker and Salt, 2006: 32)—and entering a new regime or stability domain (Holling, 2001). The concept of adaptive cycle was originally coined within the field of ecology (Holling, 1986), and it was later adopted by social scientists to uncover and interpret development patterns of various kinds of social-ecological systems. In the context of agrifood systems, the adaptive cycles have been used to illustrate long-term transition dynamics observable in various geographical regions, as in the analysis of systemic lock-ins (Allison and Hobbs, 2004), spatiotemporal change dynamics and transformations (Vang Rasmussen and Reenberg, 2012; Winkel et al., 2016; Antoni et al., 2019), the resilience of local agroecosystems (Abel et al., 2006; van Apeldoorn et al., 2011; Tittonell, 2020) and agrarian soil use (Teuber et al., 2017) as well as industry restructuring (Sinclair et al., 2014).

In this study, our aim is to explore the long-term evolution and transition dynamics within an agrifood system. Our case concerns Finland, a developed country in Northern Europe. More specifically, we aim at identifying regime shifts from the history of the Finnish agrifood system, starting from the 14th century, as well as the conditions predating the radical changes of the system. Using the adaptive cycle heuristic as a theory of change in the Finnish agrifood system has significant value for revealing the key drivers and patterns of change across time, and the lessons learned might have value for other countries and agrifood systems as well, regardless of whether or not they have experienced similar transitions over time or have operated in similar regimes. Finland is an interesting target of investigations for a variety of reasons.

[1] The literature discussing large-scale changes of social systems uses both terms *transformation* and *transition*. The difference between the two is not clear-cut, but studies on social-ecological systems generally refer to *transformations* whereas the term *transitions* is commonly used by the socio-technical stream (Hölscher et al., 2018).

On the one hand, it serves as an example of the historical transformation trajectory observable across the Global North, with a changing metabolic basis of the agrifood system and the interrelated, escalating sustainability problems and increasing efforts to address them. On the other hand, the Finnish agrifood system has witnessed many periods of food-related vulnerability and crises, which are partly related to Finland's northern location at the edge of the bread-grain cultivation zone. To analyse the historical evolution of the Finnish agrifood system, we conducted a qualitative survey of the agrifood and historical literature within the framework of the adaptive cycle, depicting its development from the 14th century all the way to the present day. Our paper is organised as follows. In section 2, we discuss the theoretical background: the theory of complex adaptive systems and adaptive cycles, and how these theoretical frameworks can be utilised in analysing the transition dynamics of social systems. In section 3, we present our methodological approach. In section 4, we present our results concerning the identified regimes and regime shifts, as well as the system dynamics that have given rise to these shifts. In section 5, we discuss the relevance of our findings especially from the viewpoint of sustainability transitions.

2. The dynamics of adaptive cycles in social-ecological systems

Agrifood systems are a type of social-ecological system, but they are also complex adaptive systems (CAS). Complex adaptive systems are open systems that exchange matter, energy and information with other systems, lack central coordination and self-organise around systemic functions (Byrne and Callaghan, 2014; Boulton et al., 2015), such as food provision in the case of food systems (Hodbod and Eakin, 2015). These systems alternate between several equilibria or steady states (Holling and Gunderson, 2002; Folke, 2006). These alternative equilibrium states converge around attractors. The system dynamics take place within the power field set up by attractors, forming a basin of attraction (Kuhmonen, 2016). Depending on the system and the context, attractors can take various forms: norms, practices, technologies and so on. Basins of attraction are manifestations of a system's path-dependency, as they limit the possibilities towards which a system can evolve within a specific development trajectory (Kauffman, 1993). Thus, they can be conceived of as 'cups' or 'valleys' in which the system lives.

Within the transition literature and political economy, similar dynamically stable configurations of social systems are captured by the concept of regime. Here, the concept of regime depicts the patterned development trajectories of socio-technical systems featured by cognitive routines, regulations and standards, the interlinkages between lifestyles and technologies, sunk investments as well as path-dependencies related to investments in machines, infrastructures and competencies (Geels and Schot, 2007). In this way, the cyclical evolution of complex adaptive systems can be traced back to consecutive regimes (equilibrium or steady states) and regime shifts (transformations). According to resilience theory, a resilient regime remains within the state space defined by a set of attractors (Gunderson and Holling, 2002; Walker and Salt, 2006). When the system loses its resilience, typically resulting from an exogeneous shock coupled with internal vulnerability, the threshold delineating this state space—the 'cup' within which the system lives—is crossed, and the opportunity for a regime shift opens up (Walker and Salt, 2006). In this situation, the system may either return to its earlier steady state, defined by the same attractors as before, or reorganise around a new set of attractors (Gunderson and Holling, 2002).

The evolutionary dynamics of social-ecological systems underlying regime shifts can be conceptually modelled using the adaptive (renewal) cycle (AC; Fig. 1). The AC can be seen as a life cycle model entailing the imminent stages of birth, growth, maturation and decline. The equilibrium states or regimes – captured by a basin of attraction – form during the reorganisation phase (α), grow during the exploitation phase (*r*), stabilise during the conservation phase (K) and decline during the release phase (Ω) (Walker et al., 2002; Sundstrom and Allen, 2019). This sequence is indicative in the sense that not all systems at all cycles pass through all of the phases in consecutive order (Walker and Salt, 2006). According to this model, a regime shift is most likely to take place as a result of a systemic collapse taking place in the release phase, which opens up the window of opportunity for the system to reorganise towards a new stability domain. Thus, the 'front loop' consisting of exploitation and conservation phases represents incremental change, while a radical transformation and a regime shift can follow from the system entering the 'back loop', consisting of release and reorganisation phases.

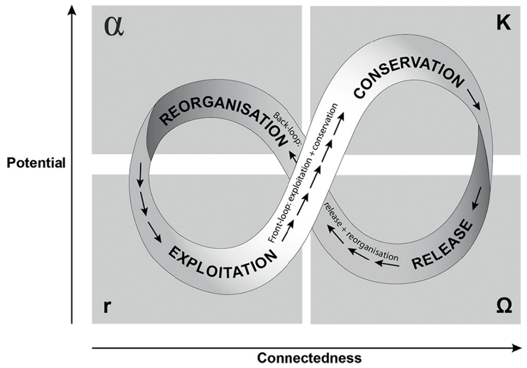

Fig. 1. The logic of the adaptive cycle (adapted from Gunderson and Holling, 2002, 34).

In the *exploitation phase* (r), new opportunities and resources are available for the system agents to exploit (Walker and Salt, 2006). This phase is marked by continuous accumulation of different forms of capital facilitated by self-reinforcing feedback loops between the system's components, which leads to accumulating resources, know-how and welfare (Renfrew, 1984; Gunderson and Holling, 2002; Walker and Salt, 2006; Fath et al., 2015; Faulseit, 2016). At the beginning of the exploitation phase, the system is weakly regulated and interconnected, but the connectedness of the system increases along with the system's growth (Walker and Salt, 2006). Due to these positive feedback loops, resources and power centralise to the hands of the most successful actors (Gunderson and Holling, 2002; Walker and Salt, 2006)—peripheralising less powerful actors (such as farmers within the food system; Kuhmonen, 2020).

Accumulation and centralisation of different forms of capital indicates a transition to the *conservation phase* (K) (Walker and Salt, 2006). The conservation phase typically means "a move toward more specialization and greater efficiencies or large economies of scale: bigger machines, bigger outputs, smaller costs per unit, larger profits over longer timeframes" (Walker and Salt, 2006: 77). Increasing connectedness creates rigidity within the system and slows down the system's growth rate (Gunderson and Holling, 2002; Walker and Salt, 2006). Acting otherwise becomes increasingly difficult, as the search for efficiency eliminates diversity and alternative ways of doing (Walker and Salt, 2006). Reinforcing feedbacks maintain the system's growth in the exploitation phase, but growth also creates unintended consequences. These can turn some of the reinforcing feedbacks to balancing feedbacks, which then resist change in a particular direction. As a result, the growth of the system eventually slows down, and path-dependency of the regime consolidates. The resulting centralised system is tuned around efficiency, has eliminated redundancy, and has its capital tightly bound into existing structures. The resilience of such a system is low, and that is why any external disturbance—such as drought, political unrest, major institutional change or economic recession, but also a relatively small disturbance—can push the system over a critical threshold and cause a release phase (Allison and Hobbs, 2004; Abel et al., 2006; Walker and Salt, 2006; Chaffin and Gunderson, 2016; Hartel et al., 2015). In other phases of the cycle, the system is more resilient to such disturbances and is less likely to cross a critical threshold that could lead to collapse of the system.

In the *release phase (Ω),* natural, social and economic capital leak out of the system, which leaves room for uncertainty or even chaotic conditions (Walker and Salt, 2006). The conditions are favourable for the reorganisation and emergence of a new regime. During the *reorganisation phase* (α), the system converges either around the same attractors as before or around new ones, thus moving towards a new basin of attraction. Due to the loose organisation of the system, the reorganisation phase is favourable to the emergence of new actors, new modes of organisation and governance, and new kinds of networks between the actors (Walker and Salt, 2006; Fath et al., 2015). Resources released in the collapse of the previous regime are available to be harvested, but the process of reorganisation can benefit from receiving additional activation energy from the broader scales in the panarchy structure, or, in some cases, from beyond the focal system (Gunderson et al., 2002; Abel et al., 2006; Vang Rasmussen and Reenberg, 2012; Fath et al., 2015). The concept of panarchy refers to the hierarchy or embeddedness of nested scales (Holling et al., 2002): in the case of food systems, such scales could include global trade systems, national level food systems (which is the focus of inspection in this study), regionally organised supply chain systems and, finally, farm systems. The dynamics of adaptive cycles are affected by similar dynamics occurring both at the broader and lower levels of the system; at the broader level cycles tend to last longer than at the lower levels (Holling et al., 2002). The resulting pattern of interactions is called ‘revolt and remember’. The term *revolt* refers to the faster renewal rate of smaller-scale systems affecting cycles at broader scales, whereas the term *remember* refers to the confining effect of how broader scales condition the options available for systems at smaller scales (Gunderson et al., 2002; Holling et al., 2002).

During the four phases, a system manifests diverging levels of connectedness, potential and resilience (Holling, 2001; Sundstrom and Allen, 2019). The concept of *connectedness* captures the amount and quality of interdependencies and feedback loops in the system (Holling and Gunderson, 2002). The degree of connectedness generally grows along with the maturity of the system through the organisation, structuration and institutionalisation of the behaviours of the system agents and their interactions (Walker and Salt, 2006). Connectedness peaks in the conservation phase and collapses in the release phase. The concept of *potential* refers to the options available for the system agents (Holling, 2001). In the conservation phase, the system is rich in resources but poor in options, whereas in the release phase there is a lot of latitude for improvisation, initiative and innovation (Fath et al., 2015). In a more abstract setting, potential can be seen to capture the oscillating power balance between structure and agency (see Giddens, 1984; Archer, 2000). A *resilient* system is able to navigate among these phases while retaining its ability to fulfil its systemic functions (Holling, 2001; Meuwissen et al., 2019). However, resilience or the capacity to adapt often weakens because of the growing rigidities during the conservation phase, which may cause the system to enter the release phase after losing resilience partly or completely (Walker et al., 2006).

In sum, in the light of the theory of resilience and adaptive cycles, a regime shift, representing a radical systemic change, is most likely to result from a collapse of the system of some magnitude. Such a collapse typically results from a loss of resilience, which drives the system over the threshold delineating the system’s basin of attraction. Systems are most vulnerable and thus prone to lose their resilience at the late conservation phase of the adaptive cycle due to growing rigidity and (over)-connectedness of the system elements.

3. Data and methods

To depict the evolutionary dynamics of the Finnish agrifood system and identify its major regime shifts from the 14th century to the present day, we conducted a qualitative thematic analysis by reviewing literature on the history of the Finnish agrifood system. By ‘agrifood system’ we mean the whole system of production and consumption of food, including both its material and cultural dimensions that can assume different manifestations over time. Thus, the Finnish agrifood system is one that aims at feeding the population residing within the country’s boundaries. We reviewed approximately 100 items from the literature, ranging from extensive accounts of the history of Finnish agriculture to detailed research reports concentrating on some specific aspects of the

Table 1
Literature referred to in the analysis by regime.

Regime	Literature
1. Expansion regime (1334–1721)	Huhtamaa and Helama, 2017; Jutikkala, 1958; Katajala, 2003; Korhonen, 2003; Korpela, 2012; Kuisma, 1997; Kylli, 2021; Lappalainen, 2021; Muroma, 1991; Mäkelä-Alitalo, 2003; Niemelä, 2008; Nummela, 2003; Orrman, 2003a; Orrman, 2003b; Rasila et al., 2003; Simonen, 1947, Soininen, 1961; Solantie, 2012; Voutilainen et al., 2020; Wilmi, 2003
2. Progressive regime (1722–1868)	Jutikkala, 1958; Heikinheimo, 1915; Huhtamaa and Helama, 2017; Jutikkala, 2003; Koponen and Saaritsa, 2019; Korhonen, 2003; Kotilainen and Rytteri, 2011; Kuisma, 1997; Kupiainen, 2007; Kylli, 2021; Metsähallitus, 2012; Mykrä, 2015; Niemelä, 2008; Niemelä, 2009; Rasila, 1961; Rasila et al., 2003; Simonen, 1947; Soininen, 1961; Soininen, 1974; Solantie, 2012; Tikkanen, 2019; Voutilainen, 2016; Voutilainen et al., 2020
3. Cattle regime (1869–1918)	Hjerppe, 1988; Heikinheimo, 1915; Huhtamaa and Helama, 2017; Häkkinen and Peltola, 2001; Jutikkala, 1958; Ihamuotila, 1979; Koponen and Saaritsa, 2019; Kotilainen and Rytteri, 2011; Kuisma, 1997; Niemelä, 2008; Niemelä, 2009; Ojala and Nummela, 2006; Peltonen, 2004a, 2004b; Peltonen, 2019; Rantatupa, 2004a; Rasila, 1961; Simonen, 1947; Vihola, 1991; Vihola, 2004a, Östman, 2004
4. Premodern regime (1919–1944)	Granberg, 1989; Hjerppe, 1988; Häkkinen and Peltola, 2001; Ihamuotila, 1979; Jutikkala, 1958; Koponen and Saaritsa, 2019; Kotilainen and Rytteri, 2011; Niemelä, 2008; Ojala and Nummela, 2006; Partanen, 2017; Peltonen, 2004a; Rantatupa, 2004b; Simonen, 1947; Vihola, 2004b
5. Modernisation regime (1945–1994)	Aakkula et al., 2006; Birge, 2017; Granberg, 1989; Granberg, 2004a, 2004b; Haapala, 2004; Hildén et al., 2012; Hjerppe, 1988; Häkkinen and Peltola, 2001; Jokinen, 1997; Kettunen, 1992; Kiander, 2001; Koistinen, 2009; Kola, 2002; Komiteanmietintiö, 1985; Komiteanmietintiö, 1987; Kuhmonen and Aaltonen, 1997; Kuhmonen and Niittykangas, 2008; Kuokkanen et al., 2017; Markkola, 2004; Muilu et al., 2016; Niemelä, 2004; Niemelä, 2008; Ojala and Nummela, 2006; Partanen, 2017; Raatikainen, 2018; Roiko-Jokela, 2004; Vepsäläinen, 2007; Vihinen, 2004; Waris, 1974; Ylivainio et al., 2015
6. Globalisation regime (1995–)	Aakkula et al., 2006; Aakkula and Leppänen, 2014; Ahokas et al., 2016; Arovuori, 2022; Arovuori and Karikallio, 2019; Berninger, 2018; Economydoctor, 2022; EU, 2020; Herzon et al., 2022, Hyvärinen, 2016; Jansik et al., 2021; Jokinen, 1997; Kaljonen, 2006; Kaljonen, 2011; Kaljonen et al., 2019; Kallio, 1997; Karhula et al., 2015; Karttunen et al., 2019; Kiander and Romppanen, 2005; Kivekäs et al., 2015; Koistinen, 2009; Kola, 2002; Koppelmäki et al., 2021; Kotilainen et al., 2010; Kuhmonen, 2018a, 2018b; Kuhmonen and Aaltonen, 1997; Kuhmonen et al., 2015; Kuhmonen and Siltaoja, 2022; Kuokkanen et al., 2017; Kuokkanen et al., 2018; Latvala et al., 2022; Kuosmanen et al., 2009; Lehikoinen, 2020; MAF, 2017; Markkola, 2004; Muilu et al., 2016; Niemi and Väre, 2019; Niskanen and Lehtonen, 2014; Ojala, 2006; Paloviita et al., 2017; Partanen, 2017; Parviainen and Helenius, 2020; Piipponen et al., 2018; Puupponen et al., 2022; Vainio, 2022; Valtioneuvosto, 2005; Vepsäläinen, 2007; Ylivainio et al., 2015; Yli-Viikari, 2019

system. The goal of the literature review was to produce 'data' to be used in the analysis described next. Table 1 summarises the literature used in the analysis per each regime.

The analysis proceeded in three stages. First, we identified the regimes and regime shifts on a coarse level. Second, we finetuned this initial understanding about the regimes by analysing the nature of the agrifood system in nine dimensions. Third, we analysed the temporal development of the regimes in terms of the adaptive cycle. In practice, the research process was iterative and moved back and forth between these stages: understanding about the dimensions of the systems as well as the phases of the adaptive cycle fed back to dating the regimes and regime shifts.

In the first stage, the aim of the analysis was to delineate the regime shifts, that is, those periods of time during which the system endured major changes, as well as the regimes that prevailed in between the regime shifts, during which the system developed on a specific path-dependent trajectory. The initial identification was based on narratives of a dominant idea configuring and delimiting the system dynamics within the agrifood system. While this step could only capture a coarse understanding of the system, it was necessary for building an initial framework about the timing of the regimes and the regime shifts in between.

In the second stage, we worked further with the initial regime framework to dive deeper into the dominant idea of each regime—in other words, this stage served to delineate the basin of attraction for each regime. This was done by analysing the nature of the system in nine dimensions. The dimensions included agricultural production, the main source of energy and nutrients, technology and production methods, food chains, culture and society, climate and environment, demography, international trade as well as agricultural and land use policies. Based on our reading of the historical literature, these dimensions captured the essential characteristics of the agrifood system in all times. These nine dimensions provided historical contexts and fitness landscapes for the regimes, as well as accounted for the structures, functions and processes of the system. This step also contributed to distinguishing between the consecutive regimes in more detail. Upon a regime shift, we expected to see changing contents in these dimensions. The detailed results of this analysis are given in Appendix A, which describes the dimensions of the system for each regime. For a brief presentation of the dimensions, see Table 2.

Third, the development of each regime was broken down into four phases of the adaptive cycle: reorganisation, exploitation, conservation and release. Identification of these phases was based on the indicators of system properties: resilience, connectedness and potential—as suggested in conceptualisations of adaptive cycles (Holling, 2001; Holling and Gunderson, 2002). During the adaptive cycle, *resilience* is at its lowest point in the late conservation phase, which makes a release phase more likely. In contrast, a similar amount of disturbance is less likely to make the system cross a threshold and collapse during the exploitation phase, where the resilience tends to be in its highest peak (Walker and Abel, 2002). Increasing complexity and *connectedness* within the system manifest a conservation phase, whereas in the release phase, these connections are broken to become rebuilt in the reorganisation phase. Source, contents and accumulation of *potential* are phase specific as well. The various forms of capital that become released in the release phase feed the exploitation phase. However, as some of the resources leak out of the system in the release phase (Holling and Gunderson, 2002), gaining resources from broader levels in the panarchy structure can be beneficial for the reorganisation process (Gunderson et al., 2002; Fath et al., 2015). There is also some empirical evidence suggesting that opportunities arising beyond the boundaries of the focal system may play a role in the process of reorganisation (Abel et al., 2006; Vang Rasmussen and Reenberg, 2012). The detailed results of this phase of analysis are presented in Appendix B, describing the systemic properties of each regime and phase of the adaptive cycle.

In addition to resilience, connectedness and potential, we also included two other indicators: type of the major feedback loops (reinforcing vs. balancing; Walker and Salt, 2006; Faulseit, 2016) and manifestations of agency (agency vs. structure; Archer, 2000; Lyon and Parkins, 2013). While these concepts are not the default analytical tools in studies of adaptive cycles within social-ecological systems, stabilisation of growth upon the turn of exploitation to conservation is connected with changing feedback patterns from self-reinforcing or amplifying feedbacks to stabilising or balancing feedbacks (Meadows, 2008; Fath et al., 2015). The growth in the exploitation phase is facilitated by self-reinforcing feedback loops, such as improved technology facilitating improved productivity, allowing again investments in technology. Balancing feedbacks dominate the conservation phase: ultimately, the consequences of growth may begin to 'eat away' at the prerequisites for growth—here the projected detrimental consequences of climate change to humanity perhaps serve as an extreme example.

Our rationale for including agency as an indicator of the adaptive cycle arises from the observation that the phase of adaptive cycle plays a role for exercising human agency (Westley et al., 2013). The findings of Lyon and Parkins (2013) on the relatedness of the adaptive cycle and the conceptualisation of cultural morphogenesis put forward by Margaret Archer (2000), among others, provide a signpost on analysing the comparative 'strength' of agency vs. structure in this setting. Lyon and Parkins argue that the adaptive cycle is a close match with the morphogenetic model, where actors are strongly bound by the structural constraints arising in the conservation phase, but through becoming aware of these constraints, they increasingly start to challenge them, and through reorganisation may contribute to transformation of the system. These ideas have not been widely adopted and tested in empirical research concerning adaptive cycles, but we see similarities in extant theorising of adaptive cycles especially in terms of the impacts of connectedness on the possibilities for (transformative) human agency. This is why we wanted to analyse the latitude for agrifood system actors to exercise their agency in the different phases of the adaptive cycle.

Table 2
Nine dimensions and five systemic properties underlying historical agrifood systems.

Dimension (D) or Property (P)	Description
D1. Agricultural production	Agricultural land use, main crops, new crops, self-sufficiency
D2. Main source of energy and nutrients	Types of energy and nutrient sources, local vs. external sources, new sources
D3. Technology and production methods	Main and new technologies in farming, evolution of mechanisation
D4. Food chains	Members of the food chain, evolution and structural change in the division of labour and markets
D5. Culture and society	Evolution of the nation state, settlement and employment structure, wars and societal reforms
D6. Climate and environment	Evolution of the climatic conditions, status of the environment and natural resources
D7. Demography	Pattern of population growth, farmers and landless people, migration
D8. International trade	Role and main patterns in imports and exports of agrifood products, trade balance
D9. Agricultural policies	Orientation and main measures of agricultural and land policies
P1. Resilience	Ability of a system to navigate the adaptive cycle, to tolerate disturbances, adapt and transform while retaining its essential functions
P2. Connectedness	Strength of internal connections and degree of internal control of a system
P3. Potential	Accumulated stock of various capitals (natural, economic, social, cultural) and capacities
P4. Feedback loops	Internal connections that control self-adaptation of a system contributing to either growth (self-reinforcing) or stability (balancing)
P5. Agency	Capacity of social actors to act intentionally, make deliberate choices and ultimately exercise power to affect social structures

4. Results: System dynamics of the Finnish agrifood system from 1334 to 2022

We identified six successive regimes from the 14th century to the present. The regimes can be conceptualised as multi-dimensional configurations of the agrifood system that are built around a few key attractors that condition the development of the social structure and organisation. The consecutive regimes are called the Expansion regime (1334–1721), the Progressive regime (1722–1868), the Cattle regime (1869–1918), the Premodern regime (1919–1944), the Modernisation regime (1945–1994) and the Globalisation regime (1995–). The regimes and main characteristics of their four phases (reorganisation, exploitation, conservation and release) are presented in Fig. 2 in the form of a continuously evolving adaptive cycle. In the following, the key features of each regime will be discussed.

4.1. Expansion regime: 1334–1721

The first cycle, the Expansion regime, was built on grain cultivation with varying degrees of self-sufficiency. It is considered to begin with a declaration by King Magnus IV of Sweden in 1334 and to last almost 400 years until 1721. The declaration stated that the uninhabited wilderness in the kingdom of Sweden, to which Finland belonged at the time, was to be colonised (Niemelä, 2008). This intent was promoted with exemption from taxes for the colonisers but had the ultimate aim of enlarging the tax base of the kingdom (Korpela, 2012; Huhtamaa and Helama, 2017). The following period was characterised by expansion of settlement further into the inlands (Simonen, 1947; Jutikkala, 1958; Soininen, 1961). Finland was inhabited by three geographically and culturally distinct populations. The western population practiced farming on permanent fields, the eastern population practiced mostly slash-and-burn agriculture and the Sámi people were hunters and gatherers. The Sámi people were slowly pushed towards the northern parts of the Scandinavian peninsula as the farming population spread out into their hunting lands.

Accordingly, the Finnish agrifood system during the Expansion regime was characterised by two distinct basins of attraction. (The hunter–gatherer system of the Sámi people should be considered a distinct system of its own, but as this study is focused on agrifood systems, it is not discussed in more detail here.) In the west, farming on permanent fields was based on fertilisation with cattle manure. The cattle foraged in the woods and meadows surrounding the villages, while the fields were reserved mainly for producing human food and horse feed, along with fibre plants needed for clothing (Nummela, 2003; Niemelä, 2008). The main role of the cattle was moving nutrients from the surrounding areas to the productive fields – for 1 ha of field, 3 ha of meadows were needed in terms of manure sufficiency (Korhonen, 2003). Animal protein was derived mostly from fish as cattle was malnourished in wintertime and only provided milk during the summer (Wilmi, 2003). Two varieties of grains – rye and barley – formed the backbone of the diets (Simonen, 1947; Wilmi, 2003; Niemelä, 2008).

The eastern system was based on slash-and-burn agriculture and the role of cattle was not as pronounced as in the west (Nummela, 2003; Orrman, 2003a; Niemelä, 2008). The nutrient economy in this system was based on releasing the nutrients bound to tree mass by fire. Once the burned land was utilised for a couple of harvests and some years of grazing, the trees were left to grow and reharvest the nutrients without further intervention. The slash-and-burn agricultural system was very productive and could sustain large families, but it also required a lot of labour force (Kuisma, 1997; Orrman, 2003a). The rotation times were very long, and the nature of the system was extremely expansive. It was also vulnerable to variation in weather conditions and could hardly sustain the population of the time. In fact, only the southern and western areas in Finland were self-sufficient in terms of bread grains (Orrman, 2003a). In other parts of the country, the livelihoods relied on a mixture of sustenance farming, hunting and fishing – especially fur animals were important trade items (Orrman, 2003a). In these areas the population also regularly relied on famine foods such as bread partly made of pine

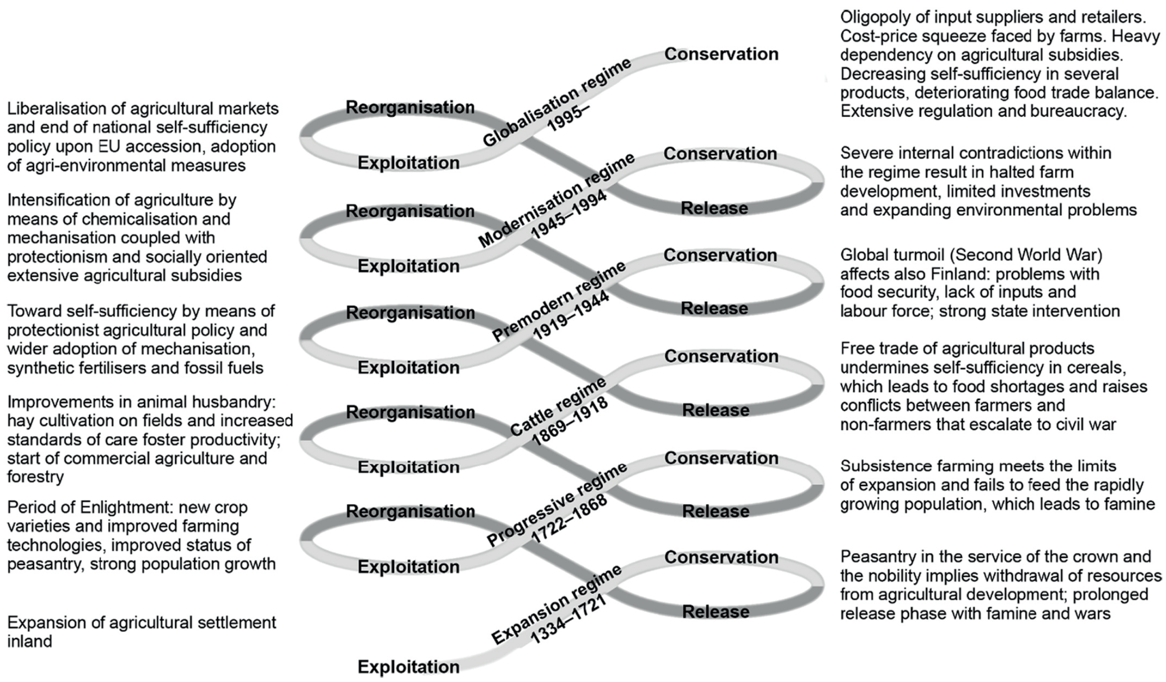

Fig. 2. Adaptive cycles in the Finnish agrifood system since the 14th century.

bark (Simonen, 1947; Orrman, 2003a; Kylli, 2021).

The exploitation phase of the Expansion regime was initiated by self-reinforcing feedback loops created by systemic potential, that is, abundant resources – available uncultivated land – together with population pressure and politics favouring colonisation (Jutikkala, 1958; Orrman, 2003a). This phase lasted until the 16th century. By then, the control of the state increased along with the power politics of King Gustav I to centralise state governance and to strengthen the kingdom's military rule (Jutikkala, 1958; Katajala, 2003; Niemelä, 2008). The web around peasant farmers tightened in relation to the crown (tax burden) and to the nobility (day labour), indicating increasing connectedness of the system and the beginning of the conservation phase. The consequences of these policies were harsh for the peasant farmers (Mäkelä-Alitalo, 2003; Korpela, 2012). Even though promotion of colonisation was continued, the strains imposed by heavy taxation, military service and numerous wars desolated farms and even some villages altogether (Simonen, 1947; Orrman, 2003b; Wilmi, 2003; Niemelä, 2008). The system was rigid, bureaucratic and control oriented (Lappalainen, 2021). The crown wanted farms to specialise in crop cultivation, and secondary or additional sources of livelihood – as important as they were – were not encouraged (Lappalainen, 2021). Growth-maintaining, self-reinforcing feedback loops based on expansionist policies were thus replaced by policies based on the deprivation of peasants, placing balancing feedback loops in the system. These hardships eventually culminated in a severe famine in 1695–1697, called the Great Death Years. The famine was triggered by extremely harsh weather conditions, called the Little Ice Age. This climatically unfavourable period lasted for several centuries (Huhtamaa and Helama, 2017 date the period to 1220–1650) and caused reoccurring harvest losses. During the Great Death Years, approximately 20%–30% of the Finnish population (originally half a million) was wiped out (Muroma, 1991; Voutilainen et al., 2020). Even though cold summers caused food shortages and famine all over northern Europe during this time, the destruction was most complete in Finland. During the Great Death Years, the inherent vulnerabilities of the Expansion regime, such as primitive farming technology, diets being built on only a few crops which were cultivated at the northernmost edge of their cultivation zone (Simonen, 1947; Solantie, 2012), materialised. By then, resilience of the system had declined in the conservation phase along with resources leaking to serve the crown and the nobility, coupled with a lack of secondary livelihoods. The remaining population was further burdened by continuing wars between Sweden and Russia until the early 18th century and thus prolonged the release phase of this cycle to last almost 30 years.

4.2. Progressive regime: 1722–1868

The peace between Sweden and Russia in 1721 meant that the easternmost parts of Finland were placed under the control of the Russian empire. The peace marked the possibility for the agrifood system to reorganise and finally embark on a new growth period. This regime is called the Progressive regime and it lasted almost 150 years until the late 19th century. The system had access to new system-external potential in the form of knowledge brought about by the Enlightenment (Niemelä, 2008), even though the basic nature of the agrifood system stayed untouched (Kylli, 2021) and thus the attraction basin was similar with the previous regime. This potential was translated into incremental improvements in the farming systems: new crop varieties (such as yellow turnip and potato), new farm animals (hens), new tools that allowed cultivation of heavier soils than before as well as developments in ditching and draining techniques (Simonen, 1947; Korhonen, 2003; Niemelä, 2008). The diffusion of knowledge and new innovations became possible through an increasing share of literate people and the establishment of university-level agricultural education during the late 18th century (Simonen, 1947; Niemelä, 2008). At the same time, the process of land parcelling enabled peasants to try out new farming methods on their own land, as peasants farming on common lands were tied by the opinion of the majority (Jutikkala, 1958; Saarenheimo, 2003). The 18th century was a climatically favourable period, and the population grew constantly in the exploitation phase of this cycle (Jutikkala, 2003; Voutilainen et al., 2020). This population growth pushed the government to legalise the establishment of crofts in the mid-18th century, which was earlier forbidden (although poorly supervised) so as to maintain large enough farms and a sufficient livelihood for the farm-based families (Kupiainen, 2007; Rasila, 1961). The establishment of crofts led to the expansion of farmed land, and the development of ploughing technologies led to the expansion of farmland to soils that were not cultivatable earlier (Niemelä, 2008). At the same time, the privileges of the nobility were abolished (Rasila, 1961; Niemelä, 2008). All these developments offered new opportunities for farmers and created self-reinforcing feedback loops that boosted the system's growth. From 1750 to 1850, the population quadrupled from 0.4 million to 1.6 million (Voutilainen et al., 2020).

In 1809, Finland became an autonomous part of the Russian empire, which marked the establishment of central state governance and, at the same time, the beginning of the conservation phase. Becoming part of Russia opened trade relations to the east in the form of butter exports and grain imports (Simonen, 1947). Butter exports allowed for the expansion of animal husbandry in the northern and eastern parts of the country and, at the same time, moved the emphasis of the population northwards and towards climatically less favourable areas (Solantie, 2012). The first agricultural organisations were founded in the 19th century both at the state and local level to develop farming methods (Niemelä, 2008). These were centrally managed and organised and did not lead to extensive grassroot involvement of farmers (Niemelä, 2008), which is also characteristic of the conservation phase.

The extensive farming style coupled with population growth gradually led to reaching the limits of the system. In the eastern areas, where slash-and-burn agriculture was practised, peasants started to complain about the decrease in forest base suitable for burning already in the mid-18th century (Jutikkala, 2003). The tragedy of the slash-and-burn technique was endogenous: it was so effective that it enabled significant population growth, which eventually made continuation of the whole system impossible due to its continuous demand of new areas to be burned. Thus, towards the end of this period, the eastern system based on slash-and-burn agriculture was gradually transformed into a farming system based on permanent fields (Saarenheimo, 2003; Niemelä, 2008). At the same time, the progression of land parcelling and the increasing value of timber made attitudes towards slash-and-burn more negative (Myllyntaus et al., 2002). In the western system, new fields were mostly cleared from meadows that had been previously used for feeding cattle (Wilmi, 2003; Saarenheimo, 2003). This led to reduced acreage for feeding the cattle and consequently to less manure, which was the key input for the whole agrifood system (Jutikkala, 2003; Niemelä, 2008). Towards the end of the period, the proportion of meadows to fields decreased from 3:1 to 2:1, implying severe scarcity of nutrients (Soininen, 1974; Jutikkala, 2003). Concomitantly, production capacity of grains stagnated while the population was becoming increasingly dependent upon them, resulting in a growing role for grain imports (Jutikkala, 2003). At the same time, finding a livelihood was difficult for landless people, who formed a significant part of the growing population (Voutilainen, 2016).

The vulnerabilities of the agrifood system were accentuated further when the availability of game animals no longer acted as a buffer for the fluctuations in crop yields. The eastern and northern populations were not self-sufficient in terms of bread grains but hunting and fur trading had provided important additional resources. Increasing population pressure, however, had led to overexploitation of numerous game and fur animals, as well as the persecution of large carnivores (Kunnas, 2018; Solantie, 2012; Tikkanen, 2019). In the 19th century, populations of species such as moose (*Alces alces*), deer (*Rangifer tarandus fennicus*), bear (*Ursus arctos*), wolves (*Canis lupus*), pine marten (*Martes martes*), squirrels (*Sqiurus vulgaris*) and whooper swans (*Cygnus cygnus*) declined strongly, and some eventually went extinct (Metsähallitus, 2012; Mykrä, 2015; Tikkanen, 2019). Thus, strong balancing elements to the operative feedback loops were created in both the western and eastern systems when the limits of the local environmental carrying capacity were reached in terms of nutrients, the shrinking forest coverage and decrease in game animals as well as by the increasing amount of landless population. The resilience of the system was already weak, when extreme weather conditions caused harvest losses in the 1860s. The resulting Finnish famine, called the Great Hunger Years (1867–1868), was the last major famine in Europe killing 8% of the population (Voutilainen, 2016).

4.3. Cattle regime: 1869–1918

Within the historical literature on Finnish agriculture, the Great Hunger Years represent a threshold: a turn from "old agricultural model" towards a new one, based on new technologies, a reliance on cattle husbandry and the commercialisation of the agrifood system. The roots of these developments were manifold. Already during the Progressive regime in the 19th century, field grasses such as timothy and clover were introduced in Finland (Niemelä, 2008). They provided better yields than wild domestic grass species, but despite this, their adoption rate remained low until the end of the period. Farmers were initially reluctant to cultivate hay for the cattle on their best fields (Kuisma, 1997; Östman, 2004; Kylli, 2021). This changed dramatically after the Great Hunger Years and was strongly promoted by some agricultural experts of the time, who claimed that hunger in Finland would not end until cultivation of bread grains would cease once and for all (Simonen, 1947; Kuisma, 1997). The central innovation that formed the basin of attraction for the regime emerging after the famine in the late 19th century was cultivated grass for cattle feed, which enabled greater milk output of cows and paved the way to large-scale commercialisation of dairy production. This period is accordingly called the Cattle regime. This regime lasted about 50 years and was built on several developments forming self-reinforcing feedback loops. The key drivers were developments in ploughing technology and the processing of dairy products, the free trade of agricultural products and the rise of the forest industry, which were all related to the common development of industrialisation.

The Cattle regime is a good example of a socio-technical system, where the physical and social structuration of the system is anchored around specific technological solutions (Niemelä, 2008). The key technology in this system was the plough. Development in new plough technology was enabled by the improved availability and industrial-scale production of iron, which enabled adoption of grass as part of crop rotation on permanent fields instead of collecting hay from semi-natural meadows (Östman, 2004). With the old-fashioned ploughs, terminating grass on permanent fields to give way to other crops was difficult and in itself prevented the adoption of grass as part of crop rotation. Another important technological innovation was a mowing machine that was suitable for harvesting grass from permanent fields, but not from seminatural meadows (Östman, 2004; Niemelä, 2008). Technological innovations were also introduced in the processing of dairy products, such as milk separators (Niemelä, 2008; Kylli, 2021).

Acquiring the new machines required financial resources from the farmers. Such resources were obtained by selling wood to the growing forest industry, as almost all farms owned forests (Simonen, 1947; Jutikkala, 1958; Niemelä, 2008). The emerging forest industry was thus an important source of system-external potential for the reorganisation of the agrifood system after the Great Hunger Years. The growth in the commercial value of timber meant the end of both slash-and-burn agriculture and the free grazing of cattle in woods, both considered destructive practices for forests (Heikinheimo, 1915). These two practices, coupled with the extensive demand for wood in construction and for energy, had resulted in large-scale destruction of mature forests in vast areas, especially in the southern parts of the country (Niemelä, 2008). Stronger differentiation between the agrifood system and the forestry system thus served the interests of both the emerging Cattle regime and the industrial forestry regime.

The new agricultural system was built around intensive animal husbandry and it expanded at an unprecedented speed. The number of cows doubled during the cattle regime (Simonen, 1947; Niemelä, 2008). Agricultural education and extension were institutionalised and became pivotal in spreading the technological innovations related to dairy farming (Vihola, 2004a). These developments contributed to the improved feeding and productivity of cattle – during the Cattle regime, the milk yield per cow more than doubled – which also encouraged farmers to take better care of their animals (Vihola, 2004a; Niemelä, 2008; Kylli, 2021). As a result, dairy products finally replaced manure as the primary output of cattle husbandry (Soininen, 1974).

At the same time, the global agrifood system was facing major changes. Cheap grain was flowing in from the new world (the US and Australia) and challenged the competitiveness of European bread grain production (Peltonen, 2019). This forced many European countries – including Finland – to seek new competitive advantage in animal husbandry and especially in dairy production. The import of grain was tax-free (Vihola, 2004a). In Finland this period is the first example of an agrifood system oriented towards the idea of comparative advantage in trade. However, the imported grains did not essentially challenge the subsistence farming of bread grains, but contributed to feeding the growing cities, industrial workers and landless people (Vihola, 2004a; Niemelä, 2008). The number of non-farm consumers had increased as a result of industrialisation: in 1910, 66% of employed people were farmers compared to almost 80% during the previous regime (Simonen, 1947; Ojala and Nummela, 2006). The building of the railway network and the growing importance of the monetary economy were integral for the growing role of grain imports in feeding the population (Vihola, 2004a). Finland exported butter but imported 60% of consumed bread grains and significant amounts of pork and eggs (Ihamuotila, 1979).

The exploitation phase of the Cattle regime was marked by various forms of self-organisation. The farmers established local agricultural organisations which were, unlike in the previous regime, controlled bottom-up (Jutikkala, 1958; Vihola, 2004a; Niemelä, 2008). Agricultural production and especially dairy production commercialised and self-organised into local cooperatives processing dairy products (Vihola, 2004a). Later on, centralisation increased throughout the agrifood system as it matured and marked the turning of exploitation phase into the conservation phase. This was manifested in the establishment of a central organisation within the central government (the agricultural administration *Maanviljelyshallitus* in 1892), among dairy cooperatives (the central cooperative Valio in 1905) and among farmers' organisations (farmers' union MTK in 1917), with the latter two remaining important actors in the field to this day.

The vulnerabilities of the Cattle regime related to the strategy of relying on the comparative advantage in the national food supply became apparent along with the growing global political instability that ultimately led to World War I. Due to this unrest, the global food trade started to flounder (Rantatupa, 2004). In 1917, Finland declared its independence from Russia. At the time, the domestic harvests were poor due to difficult weather conditions and grain imports from Russia stopped (Rantatupa, 2004; Niemelä, 2008). As a result, food shortages among the landless people emerged, intensifying the juxtaposition between the social classes (Häkkinen and Peltola, 2001; Rantatupa, 2004; Niemelä, 2008). Food shortages sparked conflicts that eventually led to the Civil War between land-owning farmers and landless people as well as industry workers in 1918. The release phase of the Cattle regime was chaos.

4.4. Premodern regime: 1919–1944

The Civil War left behind a deeply divided nation. Even though agricultural productivity had risen fast during the Cattle regime, the system had lost its resilience. The chosen free-market orientation in agricultural policy entailed vulnerabilities that were related to fluctuations of food prices as well as varying availability of food products. These vulnerabilities had materialised during the global unrest. At the same time, the share of farmers in the population was decreasing due to emerging industrialisation, which meant that the interests of farmers and the interests of the growing consumer class had started to diverge.

In the reorganisation phase of the emerging regime, the young nation based its agricultural policy on the idea of self-sufficiency (Vihola, 2004b). During this regime, agricultural policies delivered social policy goals as much as they regulated food production. This was manifested, for example, in the case of crofters, as they became entitled to the land they farmed through redemption of their crofts. The basin of attraction for the Premodern regime formed around the promotion of self-sufficiency by means of small-scale farming and the clearing new fields, but also by mechanisation as well as the introduction of a completely new resource base: synthetic fertilisers and fossil energy.

Achieving self-sufficiency in food products was largely based on inputs that were, to a growing extent, imported from overseas: fertilisers, fuels, and, most importantly, animal feeds (Niemelä, 2008). Self-sufficiency was about achieving an equivalence between the food produced and food consumed, even though the agrifood system was paradoxically all but self-sufficient in terms of the inputs and the resource base that allowed such production. Synthetic fertilisers and fossil fuels had been introduced already during the Cattle regime but started to affect the composition of the system only during the Premodern regime. They served as the system-external resource that allowed the system to reorganise and grow after the release phase of the previous regime, accompanied by a 30% growth in the agricultural land (Niemelä, 2008). The exploitation phase of the Premodern regime was characterised by increased agricultural output – even to the extent of surpluses in the 1920s (Ihamuotila, 1979; Ojala and Nummela, 2006). Meeting the goal of self-sufficiency also required protectionism to prevent cheap imports of foodstuff from overseas. The bureaucratic apparatus to implement the policy objectives was based on customs duties, export subsidies, various kinds of regulations and finally agricultural subsidies (Ihamuotila, 1979). Surpluses of dairy products were significant in the 1930s and agricultural policies were initiated to regulate this development (Niemelä, 2008). These measures formed balancing feedback loops in the system and indicated the beginning of the conservation phase.

The Finnish economy and its agrifood system were strongly linked to the global economy, and despite the promising development witnessed during the Premodern regime, other kinds of development trajectories overseas affected Finland as well. The American economy was in a release phase in the 1930s, which triggered a global recession (Niemelä, 2008). The economic downturn hit especially hard on farmers who had invested and developed their farms and become indebted; many of these farms faced bankruptcies and forced sales (Rantatupa, 2004b; Niemelä, 2008). The system was recovering in the late 1930s, but the waves of the World War II struck Finland as well, and the country went to war with the Soviet Union in 1939. The war years in the 1940s (Winter War 1939–1940 and Continuation War 1941–1944) upset the system and caused a food shortage especially due to the limited supply of inputs, many of which had been imported, and by limiting the supply of labour and power: the men and the horses were away at war (Niemelä, 2008). The Finnish agrifood system was in crisis and the rather short (25 years) Premodern regime was in the release phase. Wartime policies succeeded in food rationing, however, and the population avoided full-scale famine.

4.5. Modernisation regime: 1945–1994

While the Premodern regime introduced the first steps towards a new fossil-fuelled metabolic basis for the agrifood system, this development was in full swing during the next cycle, which we call the Modernisation regime. The basin of attraction was organised around fossil fuels and nutrients together with the policy goal of maintaining the self-sufficiency of agricultural products (as during the Premodern regime) and embracing agricultural policy as a part of social policy through the aim of securing farmer incomes throughout the country and also on small farms. The reorganisation of the agrifood system after wartime was characterised by resettlement and strong striving for self-sufficiency. The peace treaty awarded half of the region of Karelia to the Soviet Union. The population coming from this area, representing 12% of the total population, was resettled all over Finland by splitting existing farms (Roiko-Jokela, 2004). Within a decade, 100,000 new farms (+50%) were established, 75,000 new houses were built, and a large amount of new farmland was cleared (Granberg, 2004b; Haapala, 2004; Roiko-Jokela, 2004). To encourage production and survival of farm livelihoods in all parts of the country, agricultural prices were regulated starting in the 1950s, and an extensive system of agricultural subsidies was introduced in the 1950s and 1960s (Kuhmonen and Aaltonen, 1997; Granberg, 1989, 2004a; Kola, 2002). Small farms and disadvantaged regions received additional subsidies (Kettunen, 1992). Food security improved and the population grew by 34% during the regime. Many new tractors and machines were sold to farms (the number of tractors on farms exceeded the number of horses in 1967; Waris, 1974), the use of chemical fertilisers was promoted even by subsidies ('agricultural billion'), and new crop varieties, animal breeds and farming techniques were adopted (Niemelä, 2004).

Strong growth in agricultural productivity was facilitated by the availability of system-external inputs in the form of nutrients and energy, enlarged farm and farmer populations, and the post-war reconstruction mentality, together with the adoption of production-oriented agricultural support policies and the progress of technology, mechanisation and chemicalisation of farming. The development pattern was the same as in other parts of the western world, relying on rapidly increasing productivity resulting from displacing human labour with financial capital in the form of synthetic inputs, fossil fuels and machinery. The application of chemical fertilisers released farming from the limitation set by the availability of manure, and applying pesticides allowed long monocultures, which reduced the need for fallowing, further promoting productivity growth (Aakkula et al., 2006; Niemelä, 2008; Kuokkanen et al., 2017). Productivity growth released large amounts of agricultural labour force to other sectors of society (Kuhmonen and Niittykangas, 2008). The development of technology boosted industrialisation, whereas the motorisation of the transportation system fuelled by fossil fuels promoted the centralisation and urbanisation of society. Productivity growth boosted specialisation throughout the food chain, as both production of inputs (energy and nutrients, machinery) and processing of products were peeled off from the farms to specialised processors and traders. Not only farms but also agricultural regions became specialised (north-eastern 'Cattle-Finland' and south-western 'Crop-Finland'), which reduced traditional mixed farming systems and ultimately meant a disconnection between cropping systems and animal farming systems (Granberg, 1989, 2004b; Markkola, 2004).

Following the growth of the agrifood system, already by the late 1960s the surpluses of several agricultural products had become established (Granberg, 2004b). An extensive system of policy measures to balance the food market was introduced: obligatory fallowing, slaughter and afforestation premiums, export subsidies, production quotas, establishment licences for animal units and so on (Komiteanmietintö, 1987; Kettunen, 1992; Kola, 2002). This restrictive balancing feedback marked the beginning of the conservation phase of the regime. Agricultural production was encouraged and restricted simultaneously with an extensive mix of policy measures. Upon the shift from the exploitation to the conservation phase, the number of farms, people employed in agriculture as well as food retail stores started to decrease (Koistinen, 2009; Granberg, 2004b; Muilu et al., 2016; Statistics Finland), which were all manifestations of the increasing centralisation throughout the agrifood system. At the same time, environmental problems started to become visible. Concerns about the excessive use of fertilisers causing eutrophication in both inland waters and the Baltic Sea emerged in the

1980s, while agriculture was later identified as the single most important cause of eutrophication (Jokinen, 1997; Aakkula et al., 2006; Ylivainio et al., 2015). The biological diversity of agricultural environments impoverished along with the intensification development (Vepsäläinen, 2007), which was not, however, a major public concern during this period. The decline took place especially through the discarding of meadows and traditional rural biotopes that used to play a major role in both feeding cattle and collecting hay during the Expansion and Progressive regimes (Birge, 2017; Raatikainen, 2018).

The conservation phase of the modernisation regime has been considered a ‘period of helplessness’ (Kuhmonen and Niittykangas, 2008, 27), as the internal connectedness increased alongside the consecutive introduction of new measures, which created new lock-ins and contradictions. For example, in the 1970s and 1980s about one half of the agricultural budget was used for encouraging production and about one third for cutting off production and for subsidised exports of the surpluses (Komiteanmietintiö, 1985). Incentives for farmers were mixed and farm development was halted due to restrictions. Agricultural investments had been in steady decline since the early 1980s, and from 1991 to 1994 as much as 22%–23% of the farmland lay fallow (Statistics Finland). Rapid industrialisation, urbanisation and post-industrialisation, which manifested in the development of a service economy, had emptied rural areas throughout the country (Vihinen, 2004). The regime was in a dead-end stage in terms of economy, ecology, markets and public spending, when it faced the consequences of the disintegration of the Soviet Union.

The disintegration of the Soviet Union in 1991 destroyed important trade relations. Along with the collapse of overheated financial markets, Finland was thrown into a severe economic recession lasting from 1990 to 1993, during which the GDP dropped by 13% (Statistics Finland). Even though the origins of this crisis were not related to the food system, the resilience of the food system was affected as the regime approached the release phase. Over 100,000 Finns reported hunger, and ‘bread lines’ made a return after decades of mounting welfare (Kiander, 2001). In the aftermath of this turmoil, Finns voted for EU membership in 1994. The expectation of EU membership set in motion the release phase of the Modernisation regime, as many policy instruments were abandoned or transformed to comply with the regulations of the EU (Kuhmonen and Aaltonen, 1997; Markkola, 2004). The Modernisation regime in Finland lasted almost 50 years, until 1994.

4.6. Globalisation regime: 1995 onwards

Finland’s accession to the EU on 1 January 1995 initiated the Globalisation regime, which to date has lasted over 25 years. While the metabolic basis for this regime is built, as it was during the previous regime, on fossil fuels, on the policy level the system’s basin of attraction relies, contrary to the previous regime, on the free trade of agricultural products within the European Union and selectively across its bordersas well as on the aim of retaining a fair self-sufficiency in food at the EU level rather than on the national level (Kuhmonen and Aaltonen, 1997). These goals are accompanied by objectives related to environmental sustainability and climate change mitigation, the role of which has grown stronger throughout the regime (Kuhmonen, 2018a; EU, 2020). Attaining these goals simultaneously requires extensive agricultural subsidies; without these subsidies the production would move away from less favourable areas, the Union’s food sovereignty would decrease, and the environmental burden of agricultural production would increase.

The reorganisation of the Globalisation regime took place through the abandonment of the extensive national policy measures – which were favourable to small farms and disadvantaged regions – and the adoption of the measures of the Common Agricultural Policy (CAP). As a result, farm gate prices (the prices farmers receive from their products) were cut by about 40% overnight (Kiander and Romppanen, 2005). The transition period from 1995 to 1999 to level out the national subsidies and some remaining nationally funded long-term subsidies for northern agriculture alleviated the economic losses for farmers, however (Markkola, 2004). The transition period corresponds with the growth phase of the Globalisation regime. The growth of the system was based on farmers’ changing investment behaviours – investments doubled during this period (Hyvärinen, 2016). Finnish farmers were introduced to a wide array of new subsidy schemes, such as the organic farming scheme that rapidly found a foothold within the Finnish agrifood system. CAP funds thus acted as the system-external potential that enabled the growth of the system.

Farm investments were boosted by both stick and carrot: farms had to grow in order to provide a living for the farm families, while the subsidy system also provided incentives for investments. Growth resulted in increasing productivity, specialisation and centralisation, from which the food industry and retail trade have greatly benefitted. The share of food processing and retail trade in consumer food expenses has grown at the cost of primary production (Kuosmanen et al., 2009; Kotilainen et al., 2010; Piipponen et al., 2018). From the beginning of the Globalisation regime, average farm size has grown from 22 to 51 ha (Natural Resources Institute Finland, 2022), while the number of farms has decreased by 55% (Natural Resources Institute Finland, 2022). The growth of farm size has been especially strong in animal husbandry (Economydoctor, 2022). At the same time, despite increasing farm size and productivity, the profitability of farming has been in constant decline throughout the whole period (average profitability ratio 0.55 in 2000–2007 and 0.40 in 2008–2019; full compensation for labour and capital in 1.0; Economydoctor, 2022), which manifests as an unescapable cost–price squeeze at the farmgate. Securing farm income through scale economies has been the standard solution to the decreasing prices of agricultural products, which has strengthened the trend of regional specialisation of production that started already during the Modernisation regime.

Despite the continuing trend of increasing productivity at the farm level, the growth phase of the Globalisation regime did not last long, and the system moved into the conservation phase already around the year 2000. During the conservation phase, centralisation and complexity within the system have increased, which can be observed through several balancing feedback loops limiting the growth of the system. These balancing feedbacks are observable as conflicting aims of system actors and trade-offs that create rigidity and unintended consequences through the system dynamics. For example, the redirection of agricultural support upon EU accession from production subsidies to area-based payments to counteract the productivist tendencies entailed two major consequences. First, by subsidising ownership of resources (farmland and animals), it resulted in elevated prices of agricultural land. This trend has contributed to the increasing debt burden of developing farms (MAF, 2017) and the difficulties of enlarging farmers to acquire new farmland especially in areas specialised in cattle husbandry, which the farmers have counteracted through clearing new fields from forests (Niskanen and Lehtonen, 2014; Huttunen, 2015) – a practice considered detrimental for both climate targets and nutrient leakages. Second, the new incentive logic, which made farmers subject to external control and on-spot checks, caused a cultural clash in terms of the basic ideology of farming between agricultural administration and farmers: whether it is about producing food or following subsidy prescriptions (Kaljonen, 2006). Despite the continuous attempts to decrease the bureaucratic burden related to agriculture, the complexity and multiplicity of agricultural policy objectives (some of which conflict with each other) have increased to the extent where simplification has itself become a policy objective (Kuhmonen, 2018a, 2018b).

The CAP sets significant environmental objectives that aim at controlling the negative externalities caused by agricultural production as well as at strengthening the public goods provided by agriculture, which are both enforced through prescriptions related to subsidy measures. Over the course of more than 25 years of membership, agriculture’s negative externalities, especially those related to nutrient-loading potential, have indeed diminished (Natural Resources Institute Finland, 2016), but reduced pollution potential only slowly translates into observable changes in water quality, and at the same time, climate change increases runoffs and thus counteracts these efforts (Aakkula and Leppänen, 2014). The CAP, however, is not a very effective tool in intervening in issues such as recycling nutrients throughout the food system or disengaging from the use of fossil inputs. The overarching trends of specialisation and centralisation of production are difficult to counteract through the measures offered by agri-environmental schemes, and thus the measures can, at best, only slow down the negative environmental developments such as declining agricultural biodiversity or dwindling carbon content in the soil (Herzon et al., 2022; Yli-Viikari, 2019). For these reasons, the agri-environmental policies are considered to have failed to meet their environmental targets (Kaljonen, 2011; Kuokkanen et al., 2018). These failures stem from the difficulty to resist the path-dependency of the contemporary regime (see Kuokkanen et al., 2017) with policy tools that are themselves an integral part of the regime.

While the Finnish agrifood system is still fairly self-sufficient in many products, the self-sufficiency rates have been in constant decline in several products, especially meat (Statistics Finland), and the diversity of domestic food production has decreased (Lehikoinen, 2020). The trade balance of agricultural and food products is negative and has been in a linear decline since accession to the EU: about −0.5 billion euros in 1995, −1 billion euros in 1998, −2 billion euros in 2008, and − 3 billion euros in 2017 (Niemi and Väre, 2019). The increasing concentration throughout the agrifood system has created oligopolistic markets, where the ownership of the input suppliers, food processors and wholesale trade has become more centralised and partly transferred to international operators and the power of trade has strengthened in relation to other actors (Muilu et al., 2016; Paloviita et al., 2017; Arovuori, 2022). Sanctions placed upon Russia in 2014 by the EU stopped eastern dairy exports and have ever since put further downward pressure on the prices of dairy products. Due to the tightening financial situation on farms, the increasing bureaucratic burden and the heated societal debate on the negative environmental impacts of farming and especially animal husbandry (Karhula et al., 2015; Puupponen et al., 2022), there are signs of an increasing abundance of mental health problems among farmers (Kivekäs et al., 2015). The Finnish agrifood system is very reliant on imported inputs (Lehikoinen, 2020; Jansik et al., 2021), especially fertilisers, the price of which has skyrocketed since the war in Ukraine started in 2022 (Latvala et al., 2022). The pressures for a fundamental reorientation of the agrifood system are increasing. The production-oriented approach of confronting sustainability problems as questions of agri-environmental management no longer suffices, and the scope of animal production and the need for a transition towards plant-based diets is under heated debate (Kaljonen et al., 2019). Yet geographically inclusive visions of alternative pathways for the system to embark on are scarce (Kuhmonen and Siltaoja, 2022).

5. Discussion

In this study, we set out to explore the long-term evolution and transition dynamics within the Finnish agrifood system. Through identifying the historical regime shifts, we aimed for our findings to increase understanding on the prerequisites for transformation and thus to help navigate the prospective sustainability transition in the agrifood system in Finland and possibly also in other contexts. By utilising the adaptive cycle as the organising theory for our analysis, we were able to trace the origins of the cyclical evolution pattern of the agrifood system and the recurring sustainability problems and crises. Specifically, we observed that sustainability problems were related to the very nature of the regimes: in essence, the attractors upon which they were built. The immanent stages of the cycle therefore provided a firm causal texture for the cyclical behaviour of the agrifood system.

Our analysis indicates that regime shifts in the Finnish agrifood system have occurred when the low resilience of the system in the late conservation phase has coincided with an external disturbance: extreme weather conditions, wars and an economic recession. The system had been exposed to such disturbances in other stages of its evolution, but for a disturbance to cause a system-wide collapse, the overall resilience of the system had to be low. For example, while the Little Ice Age caused reoccurring harvest losses throughout the country during the Expansion regime, a system-wide collapse was only triggered when the bad weather conditions coincided with the internal vulnerability of the system. However, not all of the regime shifts were transformative in terms of switching the attractors upon which the system was built. For example, the Expansion and Progressive regimes were built on rather similar attractors as were the Premodern and Modernisation regimes. However, the system never returned to same organisation or structure as before—the fitness landscape and the basin of attraction changed in all of the regime shifts observed here. As such, the 'transformability' of the regime shifts varied along a continuum rather than along a clear-cut incremental/radical duality.

When radical transformations within the Finnish agrifood system did take place, they required changes in the system's socio-metabolism (see also Fischer-Kowalski, 2011; Haberl et al., 2011). Such metabolic changes could be dated to the turn from the Progressive regime to the Cattle regime, where the system shifted from a meadow–field and slash-and-burn agriculture to field-based production, and to the transition from the Cattle regime to the Premodern regime, where the agrarian model transformed to an industrial one (Pichler et al., 2017). The shift from agrarian to industrial model could be depicted as a shift from the era of scarcity to the era of abundance. Upon this shift, the resource use changed from extensive and decentralised to intensive and centralised. During the era of scarcity, the inputs were mostly internal to the system. Livelihoods and nutrition relied on the surrounding nature and its resources. Relatedly, population growth implied increasing pressure on the local natural resources which could be observed in several developments especially in the 19th century: destruction of forests and extinction or near-extinction of several animal species, especially macro fauna. The era of scarcity prevailed until the mainstreaming of fertilisers, pesticides and energy, which were brought to the agrifood system from external sources. This change of socio-metabolism made it possible to decouple food production from the limitation set by the natural capacity of the system based on soil productivity and the availability of manure. When livelihoods and nutrition were released from the limits set by the local resource base, some of the pressures for exploiting them were also released (e.g., the need to clear more fields) – yet at the same time giving rise to new kinds of problems brought about by the adoption of fossil and synthetic inputs, such as overproduction and waste issues (including climate change, eutrophication and other forms of pollution).

Growth and its maintenance have been central questions for the Finnish agrifood system throughout the history of 700 years explored here. Not only has the population grown, but so has welfare and material consumption—exponentially so during the last 100 years. The growth orientation bears important implications for the observed system dynamics. The reorganisation taking place after the release phase can be based on existing resources—those that are released in the systemic collapse—but as, for example, Gunderson et al. (2002) and Fath et al. (2015) note, importing resources from broader scales in the panarchy structure may help, especially as some of the released resources tend to leak out from the system during the release phase. Our results imply that such activation energy has played a role in facilitating reorganisation towards a new growth phase. Such activation energy—originating either from higher hierarchical levels in the panarchy structure or from adjacent systems—has enabled reaching a growth track within the agrifood system. They have taken the form of knowledge and innovations originating elsewhere in Europe (Progressive regime), the commercial value of forests allowing investments in iron tools and farm machinery (Cattle regime), imported synthetic fertilisers and fossil fuels (Premodern and Modernisation regimes) and EU subsidies (Globalisation regime). At the same time, the source of new potential is decisive for forming the basin of attraction that starts to define the development of the emerging regime, and later on contribute to the path-dependency of the established regime.

As well as igniting growth, the maintenance of growth tends to be the objective for system management and interventions – growth brings new opportunities to exploit, it is usually related to peaceful times, and growing systems tend not to collapse (Walker and Salt, 2006). At the same time, growth brings a system closer to its boundaries, which will eventually limit its growth by turning some of the positive, self-reinforcing feedback into negative, balancing feedback. These developments can be observed as sustainability problems that have accompanied the Finnish agrifood system throughout its history. Essentially, in the course of each regime's maturation, things that were initially desirable became detrimental from the viewpoint of the regime's sustainability. These included expansion of population and farmland during the Expansion and Progressive regimes (which contributed to growing the tax base but eventually led to reaching the carrying capacity of the system), reliance on comparative advantage in foreign trade during the Cattle regime (which allowed technological development and productivity growth within the sector but eventually created food shortage when the global trade channels choked up), reliance on the external inputs during the Premodern regime (that allowed productivity growth but led to food shortage during the war years) and reliance on protectionism, regulation and subsidies during the Modernisation regime (that secured both productivity and farmer incomes but blocked innovations and structural development as well as caused environmental damage).

Specialisation, centralisation, connectedness, regulation and complexity tended to increase within all six regimes along with their maturation. This implied that more system resources were needed for maintenance and legitimacy of the system (see also Renfrew, 1984; Faulseit, 2016). The growing rigidity and escalating sustainability problems observable during the conservation phase make a system vulnerable to external disturbances and lead to the loss of resilience. When an external disturbance such as a war, economic recession and harsh weather conditions coincides with an internal vulnerability such as tax deprivation, shortage of nutrients, overexploitation of natural resources or extensive dependence on global trade, the agrifood system crosses a critical threshold and dives into a release phase (see also Tubi, 2020). All the release phases during the history of the Finnish agrifood system observed here have taken place as a result of the system losing its resilience, the manifestations of this extending from the emergence of food help, with 100,000 Finns reporting hunger in the transition from the Modernisation regime to the Globalisation regime, to large-scale, deadly famines killing 20% to 30% of the population, as in the shift from the Expansion regime to the Progressive regime.

Despite the destructive nature of the crises, they were critical in opening up the window of opportunity for the transformation of the system (Young, 2010; Herrfahrdt-Pähle et al., 2020): the emergence of a new set of attractors and a regime shift. In other words, no regime shifts took place without crises. The elements of the newly emerging regime often originated from the sustainability problems of the dominant regime, which paved the way to discursive contests about the direction of the future developments. Interestingly, when the basin of attraction of the system changed profoundly, the new regime took an opposite direction from the old one in terms of trade orientation: from free trade to protectionism in the shift from the Cattle to the Premodern regime, and from protectionism to (EU-free) trade in the shift from Modernisation to Globalisation. The agency of actors determined to take the system in a new direction played a key role during the reorganisation phase. The role of single decisions and single decision-makers was also pronounced during the release phase, as it is these decisions that could determine whether the system was heading towards full-scale chaos or a milder disturbance (Fath et al., 2015).

Predating most of the radical transformations, the ingredients for the emerging regimes had already existed during the previous regime, but were unable to break through due to systemic rigidities. These rigidities of the conservation phase decrease the actors' room to manoeuvre and weaken their opportunities to manage the mounting sustainability problems. For example, despite the strong sense of a dead-end that was observable at the end of the Modernisation regime, the system actors were unable to deliberately lead the system towards transformation. The fight to keep the system in the conservation phase despite clear signs of weakening resilience can be detrimental for the outcomes when the system finally collapses. On the other hand, the resilience theory argues that allowing the adaptive cycle to play out at smaller scales of the panarchy can promote the resilience of the system at larger scales. Observations from the farm system level in Finland—the most critical subsystems for the resilience of the whole agrifood system—suggest that the renewal and transformation of farm systems is currently strongly constrained, which increases the vulnerability of the whole agrifood system.

The sustainability problems are the consequence of the open nature of complex systems such as agrifood systems: there is no one 'perfect' and conflict-free solution for the organisation of the system (Holling and Gunderson, 2002; Folke, 2006). The sustainability transition currently sought for implies a radical change in the metabolic basis of the agrifood system through a shift from fossil inputs to renewables. Such a transformation is likely to affect the resilience of the system as well. The contemporary constellation of the agrifood system – the Globalisation regime – is in the conservation phase: the system displays various signs of rigidity and lock-in, the system structure significantly limits actors' room to manoeuvre, the pressures for a radical transformation are mounting and the discursive contests about the future direction are becoming heated. To date, the current regime has proved to be resilient to shocks such as the Covid-19 pandemic (Meuwissen et al., 2021). However, the system is also approaching the carrying capacity of the Earth system especially in terms of multiple planetary boundaries (Steffen et al., 2015), which accentuates the need for systemic change. In the light of our analysis, it is not likely that such a change can be achieved without a crisis. One potential such crisis is currently gaining strength in the form of the Russian invasion of Ukraine and its consequences, which are being seen in the shortage of fossil energy and nutrients as well as the looming food crisis due to the cessation of food exports from Ukraine.

The results of this study make several calls for further research as well as highlight questions of relevance in the practical sphere of agrifood policies. First, we argue that in order to navigate the developments arising after the Globalisation regime, we need alternative visions about the elements of the regime, specifying the 'sustainability' of the sustainability transition sought for (Feola, 2020; Jensen, 2012; Meadowcroft, 2011), as well as delineating the pathways needed to attain such visions. Throughout the history of the Finnish agrifood system, both population growth and economic growth have led to reaching the limits of the system's carrying capacity. Objectives, policies and practices targeted at growth need critical scrutiny and alternative frameworks that are not centred around growth, since in the past the elements and drivers of growth have been the seeds of the sustainability and resilience crisis. It would be of utmost importance to explore the compatibility of post-growth and degrowth scenarios with the resilience theory, as it is the very growth that is a central part of the system dynamics but that also takes the system closer to collapse. The paradoxical finding about the impetus for a system's growth turning into seeds of destruction at the conservation phase also requires further research from different geographical contexts and different systems. Second, our results call for attention to strategies that build resilience, adaptive capacity and food security for both good times (as in the front loop of the adaptive cycle) and bad times (as in the back loop). Allowing the system to regenerate from within is a prerequisite for resilience. Developing policies for a post-fossil future and letting the farm systems transform accordingly instead of collapse would build resilience for the emerging regime within the Finnish agrifood system. Third, we also point to the most obvious limitation of this study and suggest that quantifying the mostly qualitative findings of this study would shed more light on the system dynamics observed here.

6. Conclusions

In this study, we set out to explore the historical regime shifts that have taken place in the Finnish agrifood system from the 14th century to the present day by utilising adaptive cycles as the analytical device. The adaptive cycle accommodates the idea of changing stability domains within a social-ecological system, which can be conceptualised as regimes: the temporally stable modes of organisation of a system, organised around a set of (changing) attractors. We found that it is these very attractors that gave rise to the growth of the system, associated with the growth of both human population and agricultural production—and eventually, to its collapse. While growth tended to be a central goal for those managing the system, it also created unintended and unwanted consequences, such as rigidity and centralisation of resources into the hands of the few, as well as environmental problems ranging from resource depletion and loss of biodiversity to different forms of pollution, such as climate change and eutrophication. These unintended consequences weakened the system's resilience and made it prone to disturbances, such as extreme weathers, wars and economic recessions. The vulnerabilities originate from the same source as the system's growth: geographical expansion, (over)exploitation of local resources and reliance on externally sourced food products or inputs. After collapse following the materialisation of these vulnerabilities, the Finnish agrifood system has reoriented towards more or less different pathways. Changes in the system's energy and nutrient metabolism have implied more fundamental regime shifts than those related to changes in the policy orientation or introduction of new innovations of more incremental nature. Thus, while the release of the contemporary mode of organisation can have detrimental consequences for the system's capacity to deliver on its central function—feeding the people reliant on it—it opens up the window of opportunity for systemic renewal.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Central dimensions of the agrifood regimes in Finland

Dimension	Expansion regime (1334–1721)	Progressive regime (1722–1868)	Cattle regime (1869–1918)	Premodern regime (1919–1944)	Modernisation regime (1945–1994)	Globalisation regime (1995–)
Agricultural production	Main crops: barley and rye. Introduced: oats, buckwheat, beans, peas. Animal protein mainly from fish and dairy products, in smaller amounts meat from livestock and game. Famine foods are widely used (except for the best farming areas).	Increasing acreage. Main crop: rye. Expanding: oats. Introduced: yellow turnip, hemp, hens, potato, red clover, field grass. Famine foods are widely used (except for the best farming areas).	Increasing field acreage, two-thirds of which is used for fodder production. A very rapid growth of animal husbandry. Growing productivity of cattle: milk yield per cow doubles. Self-sufficiency in many products is declining, e.g. self-sufficiency in bread grains is 35%–40% in the early 1910s. Half of the cereals is rye. Increasing importance of potato. Introduced: sugar beet.	Increase in productivity and in cultivated acreage. Overproduction of some products. Increasing self-sufficiency in bread grains: from 60% to 90%. Milk remains important: half of the sales income in agriculture.	Increased productivity. Growth in the production of barley (becomes more popular than rye from 1951 and more popular than oats from 1977), pork and poultry. Decreasing grass area since 1958: more than 50% of the field area in the 1950s, 30% in the 1960s. Transition from horses to tractors releases 0.5 million hectares horse feed area. Gradual mounting of structural surpluses in several products.	Decreasing number of farms and increasing farm size. Production remains regionally specialised. Growth in the production of poultry continues. Growth of organic farming (2% of the field area in 1995, 14% in 2019).
Main source of energy and nutrients	Human and animal labour, wood; emerging local water and wind power. Naturally occurring nutrients from the meadows and forests are harvested with cattle (manure) or fire.	Human and animal labour, wood, local water and wind power. Naturally occurring nutrients from the meadows and forests are harvested with cattle (manure) or fire.	Human and animal labour, wood, local water and wind power, introduction of fossil fuels. Clover establishes and allows fixing nitrogen from the air. Introduction of synthetic fertilisers, but manure remains important.	Human and animal labour, wood, local water and wind power, fossil fuels, expansion of electricity network. Synthetic fertilisers, nitrogen fixing plants, fossil fuels, manure.	Electricity, fossil fuels, wood. Synthetic fertilisers, nitrogen fixing plants, manure.	Electricity, fossil fuels, wood; emerging heat pumps, local solar and wind power. Synthetic fertilisers, nitrogen fixing plants, manure, introduction of recycled fertilisers.
Technology and production methods	East: slash-and-burn. West: permanent fields, cattle; rotational farming (2 crops),	In the east slash-and-burn with shortening rotation times. In the west, meadow–field ratio	Lack of meadows was resolved by producing cattle fodder on fields instead of meadows, which was possible due	Regional specialisation of production: bread grains in the west and fodder elsewhere.	Deepening of regional specialisation of production. Adoption of agri-industrial model	Improved fertilisation practices. Large animal units after removal of restrictions: milking robots, automation.

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Dimension	Expansion regime (1334–1721)	Progressive regime (1722–1868)	Cattle regime (1869–1918)	Premodern regime (1919–1944)	Modernisation regime (1945–1994)	Globalisation regime (1995–)
	meadow–field ratio 3:1. Watermills and windmills for grinding grain in the west.	diminished from 3:1 to 2:1 (implies a lack of manure in southern Finland). Cattle fodder almost solely from meadows. Rotational farming (2–3 crops). Developments in ploughing technique allow cultivation of grass and heavy soils. Developments in ditching and draining.	to improved iron tools. End of slash-and-burn. Technological innovations in the processing of dairy products.	Early mechanisation: land engines, first tractors.	through intensification of production on all fronts: new crop varieties and breeds, synthetic fertilisers, herbicides and pesticides (resulting in fallowed fields to be less than 100,000 ha in 1950–1985), improved drainage, intensified tilling. Overfertilisation is established as a practice due to the history of a constant lack of nutrients. Decoupling of production and land capacity through external inputs. Expansion and development of tractors, harvesters and farm machinery.	
Food chains	In the best farming areas (south and west) subsistence farming, in other areas primitive exchange economy (especially furs). Grain forms the backbone of diets.	Subsistence farming, also exchange economy in the east and north. The limits of the local environment's carrying capacity are approaching with the current technology, which accentuates in the Hunger Years 1867–1868.	Commercialisation of agriculture, foundation of agricultural cooperatives. Reliance on comparative advantage in animal husbandry while importing grains. Increasing prices of agricultural products.	Recession in the 1930s hits especially developing farms. Increasing food prices. Self-sufficiency by the end of the period in terms of many products but not in terms of inputs.	Activities are divested of the farms to the specialised input industry and food industry. Expansion of domestic input and machine industry. Increased division of labour. Drastic decrease in the share of agricultural employment and GDP. Number of production, processing and trade units starts to decrease since the 1960s.	Number of production, processing and trade units decreases further. Strong centralisation in both ends of the food chain. Profitability of agriculture is in steady decline in the 2010s.
Culture and society	Living in villages, farming on common fields (west). Reformation of the church. Finland is part of Sweden. Centralisation of power to the King. Wars during the 1600s.	Change from densely populated villages to unified farms along with the Great Partition from 1750s onwards. Share of literate population increases, which enables agricultural extension and education. Weakening status of the nobility. From Swedish to Russian control in 1809.	Formation of agricultural organisations and cooperatives. Emerging industrialisation alleviates the situation of landless people and increases the importance of monetary economics. About two-thirds of population gains their livelihood from farming. Building of railway network. Economic recession in 1910s due to global unrest. Independence from Russia in 1917. Growing inequality between social classes escalates into the Civil War in 1918.	Strengthening of the national identity. Crofters become entitled to claim the land they farm. About 60–70% of population still gains their livelihood from farming. Global economic recession in 1929–1934 due to overheating of both agricultural and industrial markets. World War II spreads to Finland: Three interrelated wars in 1939–1945.	Reconstruction and war compensations as a national project. Establishment of 100,000 new farms for war refugees. The share of farm employment diminishes from 50% to 8%. Building of the welfare state. Urbanisation depopulates rural areas. From agrarian to industrial and from industrial to post-industrial service economy. A serious economic recession in 1990–1993 as the result of an overheated economy and collapse of trade with the Soviet Union.	Rising environmental awareness and sustainability concerns. Consumers are becoming increasingly detached from food production. Digitalisation and web-based interaction; rise of social media. The share of farm employment continues to decrease and is less than 3% in 2018.
Climate and environment	'Little Ice Age' 1450–1850. Yield losses on a regular basis. Local timber shortages due to slash-and-burn agriculture and cattle foraging.	Unfavourable climatic period continues. Vast destruction of mature forests, local timber shortages. Many game animal populations and	Strong decline of meadows and expansion of fields. Declined stocks of game animals; some species have disappeared. Better climatic conditions until the 1910s.	Meadows cleared to fields, grazing cattle in the forests decreases due to the rising value of forests and changes in the production system.	Eutrophication of surface waters due to excessive nutrient application and drainage of peatlands. Intensive application of pesticides. Declining biodiversity	Accelerating climate change due to the use of fossil fuels. Application of fertilisers and pesticides becomes controlled. Continued decline of biodiversity of agricultural areas due to

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Dimension	Expansion regime (1334–1721)	Progressive regime (1722–1868)	Cattle regime (1869–1918)	Premodern regime (1919–1944)	Modernisation regime (1945–1994)	Globalisation regime (1995–)
		large carnivores decline or go extinct.		Favourable climatic period in the 1930s.	of agricultural areas due to disappearing meadows and pastures. Growth of game animal populations.	decreasing grazing of cattle. Problems with soil quality.
Demography	Slow but fluctuating population growth, expansion of settlements into new areas. Population pressure especially in the slash-and-burn areas. Crop failures and small-scale famines are common but worst in the Great Death Years 1695–1696 (25%–30% dies).	Accelerating population growth (quadruples in 1750–1850) and regional expansion of the settlement (population growth boosted to strengthen military power). Population growth and harvest failures lead to large-scale famine in 1867–1868 (8% dies).	Strong population growth, emigration overseas. Share of farmers in the population starts to decrease. Rural landless population is double the land-owning population. Limited imports and crop failure in 1918 lead to food shortages and Civil War.	Steady population growth, expansion of city network.	Steady population growth. Fast urbanisation and rural depopulation.	Slow population growth. Growing immigration, foreign seasonal labour on farms.
International trade	Grain imports from Sweden and Baltic countries. Exports of butter from Western Finland.	Butter exports doubles (north, east). Free trade of grains in 1780–1809. Growing imports of grains during the 1800s (not enough manure for the new fields).	Free trade of grains since 1864. Exports of dairy products increases (also timber). Agricultural trade balance turns negative in the 1910s: dairy exports halts and imports of grains, pork and eggs increases. Import becomes difficult due to the First Word War.	Grain imports from the US removes the food shortage in 1919. Exports of dairy products (profitable until the 1930s) and eggs. Imports of fertilisers, feed and fuels increase. In the wartime, imports of grains.	Overproduction of agricultural products all over Europe. Imports of bread grains, subsidised exports of animal products and feed grains.	Decreasing self-sufficiency in several products, start of net imports in meat. Steady deterioration of the agricultural and food trade balance: negative trade balance grows by sixfold in 1994–2018.
Agricultural policies	Favourable policies for colonising new areas since 1300s. Independent farmers. Domestic production.	The Great Partition enables independent farming decisions and moderate growth of productivity. Establishment of crofts allowed since 1743. Both policies promoted clearing of new land and population growth (the number of crofts grows by tenfold in 1760–1860 contributing to 1/3 of the population growth).	Change in the policy focus from self-sufficiency to comparative advantage (animal products > crop products). First agricultural subsidies introduced. Increasing value of wood and forests; crofter issue becomes political.	Crofters gain independence: lots of small farms are established. Introduction of protectionist agricultural policies to guarantee self-sufficiency (especially in grains). Establishment of public grain storage in 1928. Start of complicated and contradictory agricultural subsidy policy.	Agricultural policy as a social policy, focus on small family farms. Development of agricultural income was detached from supply and demand. Increasing complexity and inconsistencies: restrictions on and support for production at the same time. Strict import protection (quotas, licences, levies, duties).	Adoption of the Common Agricultural Policy: common market, common finance, community preference. Abandonment of the concept of national self-sufficiency. Additional nationally funded subsidies. Heavy bureaucracy and control. Institutionalisation of agri-environmental policies.

Appendix B. Systemic properties of the agrifood regimes in Finland

Phase of the cycle	Resources (potential)	Connectedness	Resilience	Feedback loops	Agency
Expansion regime 1334–1721. Basin of attraction: Extensive mixed farming based on permanent fields and meadows in the west, slash-and-burn agriculture in the east.					
Exploitation 1334–1549	Land resources available to settle and clear new land.	Interdependency between peasant and the crown increases along with the willingness of the crown to collect more taxes.	Agricultural hardships are common, but no widespread famines.	Population pressure and politics favouring colonisation promote the expansion of settlements and cultivated areas.	Expansion of farming towards uninhabited areas is a private and family enterprise, supported by the crown.
Conservation 1550–1694	Provision of more taxes for the crown and services to the nobility by the peasants degrades the resource base. Harsh climate period cuts yields (Little Ice Age). Population base and tax	Centralisation of state governance (creation of the basis for a modern Nordic state). Specialised production of bread grains. Peasant are tied to serve two ends: to produce more food and to	Hunting for fur animals lead to their local extinction. Desolation of farms due to inability to pay taxes.	Wars and increased taxes put a burden on the peasant farmers and halts expansion. Overexploitation of fur animals limits livelihoods in the peripheries.	Deprivation of the peasants by the crown and by the nobility in the 17th century.

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Phase of the cycle	Resources (potential)	Connectedness	Resilience	Feedback loops	Agency
	revenues start to decline from 1570s onwards.	serve better the crown and the nobility.			
Release 1695–1721	Resources are both lost (wars, famines) and released (from fiefdoms).	Reduction of the fiefdoms releases established institutional relationships; nobility loses power and property.	High dependency on bread grains results in hunger. 25%–30% of the population dies due to famine during the Great Death Years 1695–1696; The Great Northern War in 1700–1721 increases losses.	The nobility and the crown lose control, focus is on survival.	Resourceless peasants are burdened by continuous wars.
Progressive regime 1722–1868. Basin of attraction: Extensive mixed farming based on permanent fields and meadows in the west, slash-and-burn agriculture in the east.					
Reorganisation 1722–1749	Period of enlightenment and appreciation of knowledge and innovations, new crop varieties.	Abolishment of the land ownership privileges of the nobility.	Peaceful and climatically favourable period.	Establishment of crofts and the adoption of new ploughing technologies promote expansion.	Improved opportunities for the peasants due to the right to establish crofts and better access to knowledge.
Exploitation 1750–1809	Basic Land Consolidation increases productivity and innovativeness. Strong population (and labour) growth. Reduced tax burden due to reorganisation of the military system. University-level agricultural education begins. First Finnish agricultural extension materials (people are becoming literate).	Increasing trade and exports of agricultural products. Free trade in cereals. Incremental innovations in farming techniques. Advisory organisations are founded.	The period is depicted as peaceful, although Central and Eastern Finland suffers from food shortages on a regular basis. Grain exports from south-west Finland.	Within the slash-and-burn system: high production capacity and demand for workforce promote population growth and expansion. Within the field farming system: Basic Land Consolidation, incremental innovations, establishment of crofts and decreased tax burden promote expansion and population growth.	Rights of the peasants are strengthened further. Basic Land Consolidation from the 1750s onwards allows farmers to make individual decisions about farming practices.
Conservation 1810–1865	The limits of expansion are approaching in land use.	Establishment of central governance along with the adoption of Russian rule. Centralisation of land ownership. New local farmers' unions are founded, but their management takes place top-down. First steps of regional specialisation. Growth of foreign trade, which leads to centralisation of wealth.	Population is growing and spreading northwards. Crop yields are decreasing due to nutrient problems. Cheap grain from Russia starts to flow in due to removal of customs; dependency on grain in diets grows further. Food security is increasingly sensitised to climatic fluctuations at the northern edge of grain production zone.	Population growth asks for expansion of fields in the west, which leads to competition between meadows and fields. Availability of manure limits the productivity of fields in the west. In the east, population growth asks for expansion of slash-and-burn agriculture which leads to diminishing forest cover. In both areas, the result is decreasing room for further expansion of agriculture. Increasing population also leads to increasing hunting pressure in the woodlands and disappearance of moose and deer.	Rural inequality grows especially in the western parts of the country due to population pressure and centralising land ownership; the situation of landless population is getting more difficult. Centrally established agricultural organisations do not lead to extensive grass-root involvement of farmers.
Release 1866–1868	The limits of production growth are met with the technology in use.	Existing production systems start to disintegrate.	8% of the population dies during the Great Hunger Years 1867–1868.	The capacity of extensive and grain-oriented farming to feed the people is at stake.	Peasants have a pressure to adopt new practices.
Cattle regime 1869–1918. Basin of attraction: Grass cultivation for cattle feed on permanent fields; reliance on comparative advantage in international trade.					
Reorganisation + Exploitation 1869–1904	Introduction of iron tools such as ploughs. Timber trade provides additional income for the farmers and enables investments in new technology. Milk production grows due to increased availability of cattle fodder. Agricultural education is institutionalised. Synthetic fertilisers and fossil fuels are introduced. New crop varieties and cattle breeding. From 1860 to 1900, number of employed in primary	Importance of international trade grows due to removal of customs. Exports of dairy products and imports of grain, pork and eggs.	Commercialisation of agriculture implies a trade-off between the commercial production and own consumption on the farms. Growing reliance on markets to maintain resilience of the food system.	Rotational farming practices, new plough technology, new knowledge, industrial-scale production of iron, new income sources and new markets for dairy products promote increasing productivity and specialisation.	Strong sentiment towards animal-based production systems instead of reliance on grain production. Local agricultural organisations and cooperatives are formed bottom-up.

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Phase of the cycle	Resources (potential)	Connectedness	Resilience	Feedback loops	Agency
	production grows from 0.5 m to 0.7 m.				
Conservation 1905–1917	Economic recession, unrest, poor harvests (bad weather) and imports of cheap grains undermine farm development.	Centralisation in the governance of the cooperatives. Dependence on international trade. Agricultural policies strengthen and lead to increasing food prices.	Global political instability manifests the vulnerabilities arising from the reliance on international trade. Harvest losses. Low self-sufficiency in other than cattle products.	Agricultural policies aim at regulating farmers' incomes and food supply, which results in food price increases and increasing tension between farmer and worker populations.	A more centralised, collective agency takes place.
Release 1918	Conflict over resource (land) ownership contributes to the start of the Civil War in 1918.	Dependence on international trade becomes a problem due to ceased imports resulting from the First World War.	Grain imports from Russia cease and self-sufficiency is low, which lead to shortage of food and unrest culminating in the Civil War in 1918.	Increased specialisation in cattle products and low self-sufficiency in other products leads to food shortages when import channels flounder.	Escalating conflicts between the farmers/ landowners and workers/ landless people.
Premodern regime 1919–1944. Basin of attraction: self-sufficiency in food driven by fossil energy.					
Reorganisation + exploitation 1919–1929	Fossil fuels and synthetic fertilisers become common. Mechanisation proceeds rapidly, e.g. combustion engines. Redistribution of land resources along with independence of crofters.	Adoption of protectionist agricultural policies in products reduces external connections and intensifies internal connections within the national food system. Extensive imports of feed, fuel and fertilisers.	Growth and intensification of production results in a change from food scarcity to occasional surpluses.	Promotion of small-scale farming and establishment of many small, independent farms.	Reorientation towards self-sufficiency. Crofters gain their independence and small-scale farming develops.
Conservation 1930–1938	Introduction of the agricultural support system.	Strengthening of the protectionist policies deepens internal connections within the national food system further; regional specialisation intensifies.	Turbulent time is characterised by forced sales, hardships and again recovery.	Introduction of policies to regulate production. Increased dependency on external inputs.	Farmers' economic situation is fluctuating; occasional farm failures.
Release 1939–1944	Resource base narrows due to wartime economy (labour, horses, machines).	Wartime economy and central regulation replace many commercial connections.	Food shortages during the war years due to decreasing imports of foodstuff and inputs accompanied by difficult weather conditions.	Limited availability inputs and labour in the war years (men were at war) lead to a decrease in animal production. This results in the decline of fertilisation (manure), which brings about food shortages.	Focus on survival.
Modernisation regime 1945–1994. Basin of attraction: self-sufficiency in food driven by fossil energy.					
Reorganisation 1945–1955	Oil, combustion engine, synthetic fertilisers. Reconstruction mentality, new farms become established and new agricultural land is cleared.	Policies aiming at self-sufficiency in products, extensive imports of inputs.	Recovery from the wartime economy and encouraging policies.	Establishment of many small, independent farms. Subsistence of refugees, national self-sufficiency, food security and social integration go hand in hand.	Resettlement of war refugees. Post-war reconstruction and clearing of new agricultural land. Strong reconstruction mentality.
Exploitation 1956–1969	Increasing use of fossil fuels, fertilisers, machinery. Agricultural subsidies, education and extension, plant and animal breeding. Increasing field acreage.	Agricultural policies to safeguard a comparative level and development of farm income in relation to other groups (cohesive or social agricultural policy).	Increasing productivity and crop yields. Self-sufficiency improves in products but deteriorates in inputs.	Clearing of new fields and intensification of production lead to increase of production and gradually to overproduction. Increasing input of fertilisers leads to increasing yields, which results in more money to be invested in more nutrient inputs and machinery.	Key role of farmers, input suppliers and advisory organisations in the adoption of new knowledge about input-intensive and machinery-based farming techniques. Farmers are 'safe' and indemnified by the state.
Conservation 1970–1989	The subsidy system becomes more extensive. Limitations in the possibilities to expand production. Decreasing field acreage.	Increasing specialisation both horizontally (production lines) and vertically (growing dependency on input suppliers and food processors). Institutionalisation of the extensive subsidy system.	Environmental problems accentuate especially in nutrient management. Farm development is halted.	Agricultural production is at the same time encouraged and restricted. Increasing application of fertilisers reduces the need for fallowing or using manure. This leads to weed problems which is alleviated by increased application of herbicides. The herbicides allow monocultures which promotes divergence between animal husbandry and crop cultivation. This results in the accentuation of environmental problems.	Very limited possibilities for farm growth, investments in productivity rather than in structural development.

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Phase of the cycle	Resources (potential)	Connectedness	Resilience	Feedback loops	Agency
Release 1990–1994	Policies limiting farm development are gradually relaxed in the anticipation of EU membership.	Old agricultural policies become gradually dismantled in anticipation of accession to the EU.	Part of the population suffers from hunger during the economic recession, demand for emergency food supply ('food help') increases.	Dead end: impossibility to expand production without effective market demand becomes obvious, increasing farm subsidies prove difficult, negative impacts of continuous intensification become visible, halted structural development of farms highlights low international competitiveness.	Farmers oppose EU membership.
Globalisation regime 1995–. Basin of attraction: maintenance of European production in global markets by means of subsidies.					
Reorganisation + exploitation 1995–1999	While producer prices are cut by 40%, a very extensive subsidy system becomes a new source of potential for agriculture.	Agri-environmental management institutionalises. Increasing centralisation in production, input supply, processing and retail trade. Introduction of extensive regulation and control of farming activities.	'Food help' institutionalises. Rise of organic farming and diversification of farm activities.	All obstacles for farm expansion and all specific subsidies for small farms are removed; average farm size increase by 1 ha/year (before EU accession 0.1 ha/year). Strong price cuts and constantly increasing input prices motivate farmers to increase the number of hectares as the subsidies are paid per hectare.	The number of small farms (1–20 ha) decreases by 36% in 1995–2000. The remaining farms start investing to grow or diversify supported by subsidies and released resources.
Conservation 2000–	Potential and resources are concentrated in the hands of a few (input suppliers, farmers, processors, retailers).	Heavy bureaucracy, high level of global interconnectedness, oligopoly in trade.	Climate change is established as a phenomenon and force field. Specialisation strategy replaces diversification strategy on developing farms. Reorientation at the farm level becomes difficult.	Incentives for owning the means of production grow further in relation to incentives to produce, which fortifies the centralisation of resources.	Power basin in the food chain lays increasingly in retail and input suppliers. Farmers' room to manoeuvre becomes limited between rising input prices, stagnating producer prices and high dependency on the agricultural support system. Mental health of farmers deteriorates.

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