TURUN KAUPPAKORKEAKOULU
Turku School of Economics

ABSTRACT

- [x] Master´s thesis
- [ ] Licentiate´s thesis
- [ ] Doctor´s thesis

Subject	Futures Studies	Date	9.6.2015
Author(s)	Titta Tapiola	Student number	41946
		Number of pages	112
Title	FUTURES OF FINNISH FOOD SYSTEM BY 2050 The perspective of resilience		
Supervisor(s)	Professor Petri Tapio and Professor Pirjo Ståhle		

Abstract

Modern food systems face complex global challenges such as climate change, resource scarcities, population growth, concentration and globalization. It is not possible to forecast how all these challenges will affect food systems, but futures research methods provide possibilities to enable better understanding of possible futures and that way increases futures awareness.

In this thesis, the two-round online Delphi method was utilized to research experts' opinions about the present and the future resilience of the Finnish food system up to 2050. The first round questionnaire was constructed based on the resilience indicators developed for agroecosystems. Sub-systems in the study were primary production (main focus), food industry, retail and consumption. Based on the results from the first round, the future images were constructed for primary production and food industry sub-sections. The second round asked experts' opinion about the future images' probability and desirability. In addition, panarchy scenarios were constructed by using the adaptive cycle and panarchy frameworks. Furthermore, a new approach to general resilience indicators was developed combining "categories" of the social ecological systems (structure, behaviors and governance) and general resilience parameters (tightness of feedbacks, modularity, diversity, the amount of change a system can withstand, capacity of learning and self-organizing behavior).

The results indicate that there are strengths in the Finnish food system for building resilience. According to experts organic farms and larger farms are perceived as socially self-organized, which can promote innovations and new experimentations for adaptation to changing circumstances. In addition, organic farms are currently seen as the most ecologically self-regulated farms. There are also weaknesses in the Finnish food system restricting resilience building. It is important to reach optimal redundancy, in which efficiency and resilience are in balance. In the whole food system, retail sector will probably face the most dramatic changes in the future, especially, when panarchy scenarios and the future images are reflected. The profitability of farms is and will be a critical cornerstone of the overall resilience in primary production. All in all, the food system experts have very positive views concerning the resilience development of the Finnish food system in the future. Sometimes small and local is beautiful, sometimes large and international is more resilient. However, when probabilities and desirability of the future images were questioned, there were significant deviations. It appears that experts do not always believe desirable futures to materialize.

Key words	Resilience, resilience indicators, general resilience, Delphi method, scenarios, future images, adaptive cycle, food system
Further information	

Turun yliopisto
University of Turku

TIIVISTELMÄ

x	Pro gradu -tutkielma
	Lisensiaatintutkielma
	Väitöskirja

Oppiaine	Tulevaisuuden tutkimus	Päivämäärä	9.6.2015
Tekijä(t)	Titta Tapiola	Matrikkelinumero	41946
		Sivumäärä	112
Otsikko	Suomen ruokasysteemin tulevaisuudet 2050 – resilienssin näkökulmasta		
Ohjaaja(t)	Professori Petri Tapio ja professori Pirjo Ståhle		

Tiivistelmä

Modernit ruokasysteemit ovat vaikeiden ja monimutkaisten haasteiden edessä kuten ilmastonmuutos, resurssien väheneminen, väestönkasvu, keskittyminen ja globalisaatio. Meidän ei ole mahdollista ennustaa miten mainitut haasteet tulevat vaikuttamaan ruokasysteemeihin, mutta tulevaisuuden tutkimuksen metodit mahdollistavat paremman ymmärryksen mahdollisista tulevaisuuksista ja siten lisäävät tulevaisuustietoisuuttamme.

Tutkimuksessa käytettiin kahden kierroksen Delphi metodia, jossa asiantuntijoilta kysyttiin mielipidettä Suomen ruokasysteemin resilienssistä nykyhetkessä ja vuonna 2050. Ensimmäisen kierroksen kysely perustui agroekosysteemeille kehitettyihin resilienssin indikaattoreihin. Tutkimus jakautui neljään osioon: alkutuotanto (pääpaino), elintarviketeollisuus, kauppa ja kulutus. Ensimmäisen kierroksen tulosten perusteella muodostettiin alkutuotannon ja elintarviketeollisuuden tulevaisuuskuvat ja toisella Delphi kierroksella asiantuntijoilta kysyttiin heidän näkemystä näiden tulevaisuuskuvien toivottavuudesta ja todennäköisyydestä. Kirjoittajan toimesta muodostettiin myös erilliset ”panarkia skenaariot”, jotka perustuivat adaptiiviseen sykliin ja panarkia teoriaan. Lisäksi tutkimuksessa syntyi uusi lähestymistapa yleisen resilienssin indikaattoreihin yhdistämällä sosiaalis-ekologisen systeemin ”kategoriat” (rakenne, käyttäytyminen ja hallinto/säätely) ja yleisen resilienssin parametrit (takaisinkytkennät, modulaarisuus, monimuotoisuus, systeemin kyky kestää muutosta, oppimiskyky ja itseorganisoituvuuden määrä).

Tulokset osoittavat, että suomalaisessa ruokasysteemissä on vahvuuksia, joiden avulla resilienssiä voidaan rakentaa. Asiantuntijat näkevät luomutilat ja isokokoiset tilat sosiaalisesti itseorganisoituvina, joka voidaan tulkita innovaatioita ja kokeiluja mahdollistavana tekijänä ja siten edistää resilienssiä. Lisäksi luomutilat nähdään toimivan eniten ekologian ehdoilla verrattaessa muihin tiloihin. Suomen ruokasysteemissä on myös heikkouksia, jotka estävät resilienssin rakentumista. Koko ruokasysteemistä kaupan toiminnot tulevat todennäköisesti kohtaamaan suurimmat muutokset tulevaisuudessa, etenkin kun tarkastellaan panarkia skenaarioita ja tulevaisuuskuvia. Maatilojen kannattavuus on ja tulee olemaan kriittinen tekijä myös alkutuotannon resilenssin kannalta. On tärkeää pyrkiä saavuttamaan tasapaino varautumisen ja tehokkuuden välille Kaiken kaikkiaan asiantuntijoilla on hyvin positiivinen näkemys Suomen ruokasysteemin resilienssistä tulevaisuudessa. Joskus pienimuotoisuus ja paikallinen on paras vaihtoehto ja joskus taas iso ja kansainvälinen on resilienssin kannalta paras vaihtoehto. Kuitenkin, kun asiantuntijoilta kysyttiin tulevaisuuskuvien todennäköisyyttä ja toivottavuutta, vastauksissa oli huomattavia poikkeamia. Näyttää siltä, että asiantuntijat eivät aina usko toivottavan tulevaisuuden toteutuvan.

Asiasanat	Resilienssi, resilienssi indikaattorit, Delphi metodi, skenaariot, tulevaisuuskuvat, adaptiivinen sykli, ruokasysteemi
Muita tietoja	

Turun yliopisto
University of Turku

FUTURES OF FINNISH FOOD SYSTEM BY 2050

The perspective of resilience

Master´s Thesis
in Futures Studies

Author:
Titta Tapiola

Supervisors:
Professor Petri Tapio
Professor Pirjo Ståhle

9.6.2015
Turku

Turun kauppakorkeakoulu • Turku School of Economics

Contents

List of figures

List of tables

1 INTRODUCTION

The introduction discusses the properties of modern food systems and the challenges modern food systems are currently facing. The contemporary challenge of sustainability and its assessment are shortly reviewed. The research gaps and the research question are presented and, at the end of the chapter, the main characteristics of futures research in the context of this research are discussed.

1.1 Modern food systems and global challenges

Modern food systems consist of all the activities and infrastructure needed to feed a certain population. Activities involve: input industries, primary production including growing, harvesting and slaughtering; processing and packaging; distribution such as transport, retail sales, food services, marketing and finally consumption. (Ericksen, 2008b, 16.) Environmental impacts such as waste and pollution from all these processes should also be included. All the activities above have social, cultural, economic, environmental and political aspects including the governing and research institutions and organizations.

According to Ericksen (2008b, 16), the main objective of food systems is food security, and that is certainly something that most researchers agree upon. The FAO (Food and Agriculture Organization of the United Nations) defines food security as:
"*All people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for active and healthy life*" (FAO, November 1996).

Essential inputs into the food system such as energy, fertilizers, pesticides and machinery are also considered as a part of the system. These inputs are vital and are often imported as they are mainly produced from or by using fossil fuels. Modern food systems are heavily dependent on these inputs to be able to function properly. It could be said that modern food systems run on oil. (Bomford, 2010, 121-122; Woods, Williams, Hughes, Black, & Murphy, 2010, 2991-2992.)

Another common factor is that modern food systems face global challenges or drivers such as climate change, growing population – especially, growing elderly population – urbanization, changes in diets and economic crises affecting food prices (Misselhorn, Aggarwal, Ericksen, Gregory, Horn-Phathanothai, Ingram, & Wiebe, 2012, 8). In addition, possible peak oil costs, structural changes in food systems such as homogenization and concentration, and diminishing natural resources will also entail challenges for future food systems and food security. (Ericksen, 2008a, 235; Ericksen, 2008b, 20; Rockström et al., 2009, 473; Woods et al., 2010, 2991-2992, 2998.) Food is also heavily interlinked with water and energy (fossil fuels) (Stigson, 2013, 2). Water scarcities and flooding are estimated to increase as climate change proceeds, and both have impacts on food security (Wheeler & von Braun, 2013). Figure 1 presents some drivers affecting food systems and the goals of well-functioning food systems.

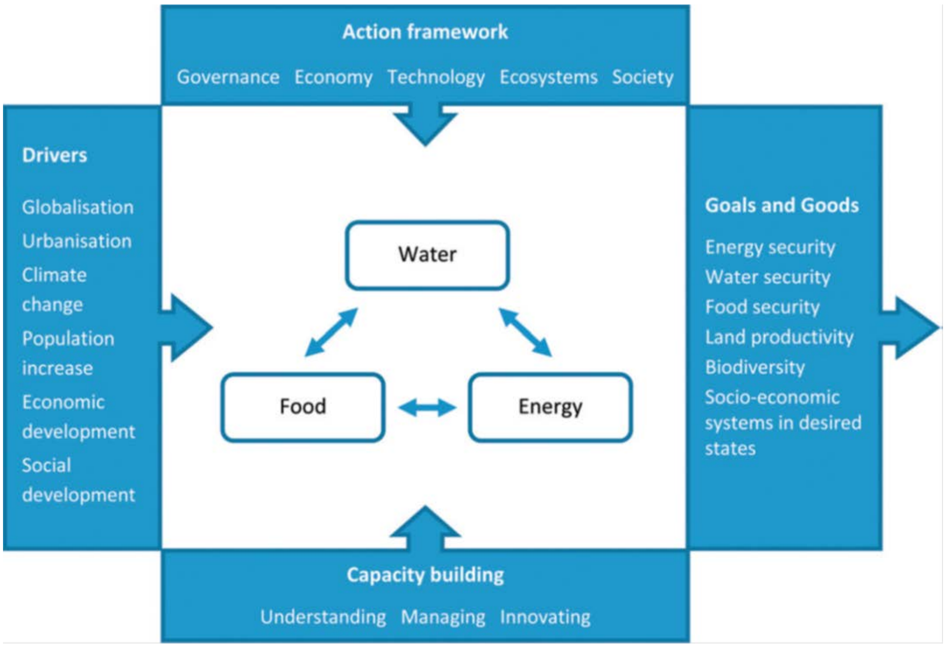


Figure 1 Food is interlinked with water and energy and the same drivers of global challenges influence them (Stigson, 2013).

1.2 Sustainability and its assessment

When thinking about the theoretical framework to be used in this research, one valid option was sustainability. At present, humanity is facing the global challenges and the sustainable development is expected to provide the tools to secure the future where humanity could thrive. The fundamental idea of sustainability is meeting the needs of humans (for the present and the future generations), while preserving the ecosystems around us.

The original discussions of sustainability focused on the conflict between economic growth and ecological impact (Goodland & Daly, 1996). Only later, the original idea of sustainable development was broaden by adding social dimension to it and it started to be seen as a balance of three elements: environmental, economic and social. With the further inclusion of cultural sustainability the sustainability concept developed to have all four aspects.

In 1987 World Commission on Environment and Development (WCED) published the well-known report “Our Common Future”. The report combined social, economic, cultural and environmental aspects and global perspectives. One of the messages was that human society does not exist as a separate entity from its natural environment. The definition of sustainable development given by the WCED (1987):

“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

Sustainability assessment, at its best, should combine economic, ecologic, social, cultural and institutional factors and take into account their connections and wider influences and feedbacks. An assessment should try to foresee the consequences into the futures, further than just one quarter or two ahead. It should also acknowledge the inherent limitations of foresight. The sustainability assessment should also invite and commit the public into the processes – use i.e. participatory methods when applicable. Finally, it should respect equity between generations. (Gasparatos, El-Haram, & Horner, 2008, 287.) One interesting and promising approach developed by FAO, so called Sustainability Assessment of Food and Agriculture Systems (SAFA), seems to fulfill many of the aforementioned goals (FAO, 2014). However, this approach is developed mainly for enterprise, farm or company level evaluations and not for the systemic approaches. SAFA framework begins with four dimensions; good governance, environmental integrity, economic resilience and social well-being. In addition, it provides 21 themes or universal sustainability goals, 58 sub-themes (specific to supply chains) and, finally, 116 indicators. The universal themes could be used for national assessment and policy-making, but again would require the development of appropriate indicators. (FAO, 2014, 4.)

In the end, no common agreement was found how to assess each and every aspect of systemic sustainability (ecological, economic, social or cultural). It is highly dependent on research goals and on a system assessed in addition to temporal and spatial scales. All in all, it appears to be very difficult and laborious to use these kinds of frameworks to assess the sustainability of the whole Finnish food system. That is why the resilience framework was taken as an option and it was researched to see if it is useful in this context.

The next section will examine the relevant literature of futures of food systems and, in addition, of resilience of food systems in order to show that there is not much research about the futures of Finnish food system, especially from the perspective of resilience.

1.3 Research gaps

There is a considerable amount of research on the ability of the global food system to produce enough food for coming generations, with the global population estimated to be

9 billion by 2050. In addition, a wealth of research about global food system's vulnerabilities in connection to different global drivers is available (Ericksen, 2008b, 19-20; Tilman, Balzer, Hill, & Befort, 2011; Wheeler & von Braun, 2013). The perspective in these studies is often possible future states of a certain food system or how the global population will cope with the challenges of the global food system.

In addition, there is futures oriented and foresight research, applying modeling and/or scenarios, on the long-term functioning of certain food systems and how different global or local drivers such as economic recession, climate change, agricultural subsidies, environmental management and trade liberalization impact our food systems (Huan-Niemi, Niemi, & Niemi, 2010; Reilly & Willenbockel, 2010) and specifically related to the Finnish food system (Niemi & Rikkonen, 2010; Niemi, Lehtonen, Liesivaara, Huan-Niemi, Kettunen, Kässi, & Toikkanen, 2014; Rikkonen, 2005). In a study conducted by Niemi and Rikkonen, Finnish experts assessed three global drivers to be especially significant in the future: water scarcities, climate and environmental change, and energy consumption in agriculture (Niemi & Rikkonen, 2010, 3). In the same study, the experts indicated concerns about the future developments of profitability of the Finnish agricultural production, agricultural EU legislation, consumption of Finnish food products and environmental impacts of agriculture. Cabell and Oelofse (2012) also mention some of these factors, which are used in this research (Table 2), as resilience indicators. It is clear that these factors are important for the future developments of resilience of the Finnish food system.

When going further towards resilience research, Australian government has conducted a good example related to food supplies and resilience. The study concludes that resilient supply chain characteristics are commonly identified in terms of redundancy, flexibility and degree of concentration (a highly concentrated network is less resilient than a less concentrated one). (Bartos, Balmford, Karolis, Swansson, & Davey, 2012.) Furthermore, these parameters can be found in the study of Cabell and Oelofse (2012) as resilience indicators.

Resilience has also been studied concentrating on certain geographical areas such as Sub-Saharan Africa and in connection to climate change (Ching, Edwards, & El-Hage Scialabba, 2011). Moreover, considerable research on more or less local ecosystems has been done by studying spatially and temporarily well-defined ecosystems and their specified resilience (Hughes et al., 2003; Walker & Salt, 2006; Walker, Abel, Anderies, & Ryan, 2009). However, there is relatively little research related to the resilience of the Finnish food system. An example of a research done is the food chain's adaptive capacity (i.e. resilience in this case). The research concentrated on the adaptive capacity from the diversity point of view. The conclusion was that to be able to prepare for global changes, it is important for Finnish food chain to sustain diversity at different levels, independency of energy and nutrient supplies (from global markets) and, in addition, to enable and to encourage discussions, knowledge sharing and learning throughout the food chain (Kahiluoto & Himanen, 2012). Some of the indicators of Cabell and Oelofse (2012) are in line with these results.

To conclude, it is apparent that the Finnish food system has not been widely researched from the perspective of resilience or especially general resilience (see chapter 2.1). The challenges of using resilience theory are the measurement and the indicators and how to define the actual "limits" of resilience: when the resilience is at good level and when it is not. That is why this thesis concentrates on investigating the experts' views by using a group of resilience indicators by Cabell and Oelofse (2012), which are in line with other researches discussed above. It is also assumed that experts have the best understanding of the state of the Finnish food system.

1.4 Research question

This thesis presents research conducted on the futures of the Finnish food system from the perspective of resilience. The time frame covering the period from the present to 2050 was chosen in order to have enough time to see the global drivers to evolve. The whole Finnish food system was chosen as a topic. When constructing scenarios the whole food system view allows the examination of interconnections between the different parts of hierarchical structure (panarchy, see chapter 2.4). Although this thesis focuses on the Finnish food system, the surrounding global drivers have significant influence.

It is critical to have an idea where a food system stands in terms of resilience because then it is possible to evaluate if efforts (or not having efforts) are moving the system towards increased or decreased resilience (also towards or away from so called tipping points).

The research question of this thesis is: *How do experts perceive the current resilience of the Finnish food system and how do the same experts foresee the resilience changing by 2050?* The aim is to estimate the resilience of the present Finnish food system and the relative change by 2050 by applying the behavior-based indicators for agroecosystems developed by Cabell and Oelofse (2012). In this case, the interest is mainly in the relative change because there are no absolute values collected or researched - instead of the opinions and insights of the experts regarding to the change between the present and the year 2050. It is also investigated whether there are some types of farms, industries or retail actors that seem to be more resilient than the others according to the experts' views.

This question is researched by applying two rounds of the Delphi method. The first round of Delphi is conducted as an electronic survey sent to a group of Finnish experts.

The first round results are utilized to construct future images. The second round is also an online survey and the experts' views of the desirability and the probability of the future images are collected. It is notable that more emphasis is on primary production because the indicators are designed for agroecosystems.

To conclude this section; the author agrees with Holling that it is time for transformation and an era of incremental increase in efficiency is finally coming to the end (2001, 404). It is somewhat worrying how little time it is spent thinking about futures on longer term and preparing us for different futures. The purpose of theories used in this thesis such as the adaptive cycle or panarchy is not to explain what might or will be. It is not possible to predict futures, but it might be possible to open new windows to endless opportunities (or threats) and that way influence decisions done today and lead our futures development into preferable direction. That is one major reason why this research is done: to raise our awareness to different futures, to raise awareness of resilience thinking and to inspire people to take actions towards preferable futures of our common food system.

1.5 Futures as a research topic

This thesis belongs to the scientific discipline of futures studies, applies some of its basic assumptions and, in addition, uses several futures research methods.

Humans have always had the ability to anticipate, but as a scientific discipline futures studies is a relatively new. Already Roy Amara defined some grounds for futures studies: it is not possible to foresee the future, the future is not predetermined and the future can be influenced (Amara, 1981). Wendell Bell, one of the leading authors in the field, lists nine key assumptions of futures studies. Some are the same as Amara's premises for futures studies (number 5, 6 and 7). These key assumptions are as follows (Bell, 2003, 140-157):

1. The nature of time is continuous, linear, and it cannot be reversed. The sequence of individual events defines the past, the present and the future. A human being is first a baby and then later on a toddler – never the other way around.

2. There will be phenomena, knowledge or technologies that we cannot even imagine today. The future is not purely a continuum of the present. Into this category belong unlikely events (wild cards) discussed later. For example, the industrial or green revolutions were something that was not foreseen beforehand.

3. Future anticipation is a critical ability for humans. It is also critical to think about the time scale that is relevant to each circumstance. Some decisions governments or businesses do may have impacts extending all the way to the future generations. These

are exactly the cases where, for example, scenario work may provide valuable insights and build common understanding of future options among involved.

4. Very close to the previous is the assumption of importance of “the futures knowledge”. For individuals and for larger entities such as communities, organizations, and nations, the futures knowledge is useful and vital. Anticipation of other people’s actions or even anticipation of systems behavior we are part makes our everyday lives smoother and functional, as we know it. However, this anticipation “works” only for rather short-time periods and many times seems to be based on experience of similar situations (social norms and roles). That is why the past should be studied as well to gain all the insights it might offer. The farther we look into the future, the less we can predict and uncertainty increases.

5. There are no facts about the future. “*There are past facts, present options and present possibilities for the future*” (Bell, 2003, 148). However, we can open our minds to new and innovative options and that way increase our futures options and knowledge. Scenario work can help to create new kinds of futures options and combinations of opportunities.

6. The future is not predetermined. This assumption gives us all the reasons to try to influence our futures so that it will be one of the preferred ones (normative approach). This means that the future is “made” based on more or less justified insights and believes (Mannermaa, 1991, 20). Mannermaa also adds that the study of the present may also add valuable information about the reality we live in (ibid.), which may also give additional insights of the possible futures.

7. The future can be influenced. Futurists try to recognize everything that could be influenced to pave the way to preferred futures and try to prevent creating the unwanted ones. Here we do not go into ethical discussions about who decides preferred futures and whose future is that preferred one. Some normative discussion is usually needed when, for example, scenarios are constructed and, especially, if there are in addition to possible and probable also preferred (or undesirable) futures included, which are normative in their nature. It should be clear how and based on what the value judgments and variables of the preferred or undesirable futures are decided. According to Bell, there are universal human values, which can be used in this kind of situations (*“knowledge, evaluation itself, justice and cooperation”* (Bell, 2003, 205-224)).

8. Interdependencies and systemic approach. Futures studies have a transdisciplinary approach acknowledging complex interdependencies in the world. No system can be studied in isolation because it is probably connected to other systems having impact on its functioning (feedbacks). For example, no nation is totally self-sufficient nowadays. Systemic approach is used in this thesis; resilience is systemic in its nature and also systemic theories are reviewed.

9. Preferred futures. Futurists believe that there are preferred futures (and on the other hand futures that are undesirable). How much the future images of people (conscious or subconscious) affect their decisions and actions? The author believes that the future images have huge impact and enormous power. If we never slow down and really think about our personal futures or the futures of larger communities, how can we consciously drive our futures to preferable directions? If we only think the negative future images, how could the positive ones emerge? Actually, there could be the tenth “assumption” - the future we (consciously or subconsciously) believe in will most probably be unfolding for us.

That is why futures studies is also committed to develop and collect the manifold images of futures: try to understand the consequences of them and even to support people’s actions towards the preferable futures (Dator, 1998, 302). Dator has developed four generic images or categories of the futures. He claims that probably all future images can be placed into four categories: 1) continued economic growth (business as usual), 2) collapse, 3) disciplined society (society has comprehensive values, usually traditional values) and 4) transformation society (high tech or high spirit society where instead of traditional solutions emerge new ones). It will be interesting to see if the future images produced in this work will fit into these categories.

This thesis collects experts’ views on resilience of the Finnish food system, and based on these views future images are formed. Recommendations or actual actions towards preferable futures remain out of the scope of this work. However, even thinking about the different futures and the different possibilities may influence future decisions and actions of people involved.

Following section will dive into the theoretical framework discussing resilience and theories of systems thinking.

2 THEORETICAL FRAMEWORK

In this chapter systems and resilience theories are discussed. The resilience theory and its three paradigms are introduced, in addition to self-organizing systems and adaptive cycle framework. Resilience is systemic in its nature, and self-organizing systems theory and adaptive cycle framework bring interesting new insights into resilience thinking. In the end of the chapter, hierarchical panarchy framework is introduced and used constructing panarchy scenarios of the Finnish food system.

2.1 Resilience

2.1.1 Introduction to resilience and related concepts

Because of all major global challenges, it is no longer possible to optimize or solve one single problem at a time. That is why systems thinking, especially resilience thinking, gives us better opportunities to understand complex systems such as food systems.

Resilience is a system level concept and unlike sustainability it is not fundamentally normative i.e. it does not include specific choices about performance measure. Usually, there is a need to define “resilience of what to what” (resilience of a certain system to a certain disturbance or event). When “resilience of what to what” has been defined, it is referred as a specified resilience. However, general resilience refers to a broader set of system attributes such as the capacity for learning and all kinds of external shocks, including unlikely events. Specified resilience, having more carefully defined system boundaries, is close to the concept of robustness. (Anderies, Folke, Walker, & Ostrom, 2013; Resilience Alliance, 2007; Resilience Alliance, 2010.)

Resilience, like sustainability, lacks one clear and common definition, not to mention common assessment tools. One problem is dependence on a clearly defined specific system – its spatial and temporal scales. The area of specified resilience is an active and rich area of research. The same is true for general resilience and its assessment, however, it could be said that the area is still at its early stages of development.

The resilience theory has primarily emerged from natural sciences, especially from ecology, and that has influenced the research traditions often leaving the social aspects with less attention. Resilience approach could be said to be concerned with the system’s ability to cope with uncertainty and to preserve and develop enough flexibility to cope with changes, also unexpected ones (general resilience). Resilience approach recognizes the tradeoffs between efficiency (often the key driver in modern systems such as food systems) and flexibility.

Before going further into resilience definitions, it is necessary to shortly review few closely related approaches or concepts, namely adaptation and vulnerability. Again, these concepts have different definitions depending on the research tradition or discipline, which apply them.

Vulnerability research has been shaped by natural hazard studies, especially in the geophysical sciences. Usually, the starting point is different social groups, which are exposed to stressors or shocks; how they are influenced, how sensitive they are and what their coping capacity is. (Blaikie, Cannon, Davis, & Wisner, 1994, 9.) The adaptation research often focuses more on longer-term changes and has its root in climate change research (Miller et al., 2010). Adaptation and vulnerability research is often actor based and concentrates on reducing risks to specific known shocks (Miller et al., 2010; Nelson, Adger, & Brown, 2007, 412).

All in all, there appears to be division between these different approaches and definitely more communication and networks should be formed to further benefit from the knowledge from related fields. For example, major publications on resilience do not cite adaptation or vulnerability publications, and other way around (Janssen, Schoon, Ke, & Börner, 2006).

Resilience can be seen most useful when considering unlikely phenomena and having little knowledge about its measures (see Figure 2). It is possible to be prepared or to plan for phenomena, which we are aware of and have, for example, some well-educated scenarios available (i.e. climate change and adaptation to it). On the other hand, there are events that cannot be foreseen or anticipated. There are reasons why these kinds of events are increasing and societies should be thinking about how to increase their preparedness, flexibility and, finally, resilience to be able to cope or even to benefit from them.

Figure 2 Resilience concept is most useful when considering unlikely events and when there is only little knowledge about its measures (Howell, 2013, 37).

In addition, there are certain globally noticeable reasons increasing the risk of unlikely events. It is important to understand those reasons because they also influence general resilience. Following list by Casti et al. gives a good overview (Casti, Ilmola, Rouvinen, & Wilenius, 2011, 4-5):

1) Increasing complexity of a system drops human ability to understand and control its behavior. Underlying forces such as globalization, increasing connectivity (both physical and via internet) and diverse feedbacks produce increasing complexity. These are certainly prevailing trends in modern food systems. Local and national food systems, for example, are often very dependent on global markets.

2) Interdependencies of individual actions in global scale. For example, most of us have in theory simultaneous access to the information and this may lead to global herd thinking and behavior leading to all kinds of "bubbles".

3) Paradigm shifts are major large-scale discontinuities and may be induced, for example, by major technological invention or value changes. There are people thinking that the world is at the moment undergoing a paradigm shift, which is a major source for instability. On the other hand, already 1990 Alvin Toffler claimed in his book "Power Shift" that the world is going through major shift (of power) or paradigm change (Toffler, 1990). Maybe the continuous and accelerating change produces an impression of paradigm change.

4) Global drivers add to complexity as well. As discussed earlier, drivers such as climate change, planetary boundaries (Rockström et al., 2009), population growth, decreasing natural resources, and economic recession may reach a tipping point and cause surprising consequences worldwide.

5) Some features of modern societies such as drive for efficiency, appreciation of individualism, specialization and short-sightedness often lead to situation where no one has motivation to have an overview of a whole system considering, for example, its resilience and long-term functioning, not to mention sustainability. In addition, parliamentary and governmental terms last only few years, which also encourage to short-sightedness. The system needs resilience to be able to recover or even benefit from these unlikely but potentially significant events (Casti et al., 2011, 10). Especially, modern food systems are "victims" of efficiency, specialization and short-sightedness and are in great need of resilience.

As the statements above indicate, the importance of resilience is increasing when the complexity is increasing. Later on, when resilience assessment is discussed, some of the above features are noticed to be of importance. Before going further into resilience and its assessment, the review of definitions of resilience is needed.

2.1.2 Definitions of resilience

From the literature, it is possible to find numerous ways, in which the term resilience is used. Four types are commonly mentioned (Hollnagel, 2014, 222): 1. Resilience is a property of materials and the term is used in engineering sciences. 2. Resilience is also a property of ecological systems, which are reactive and able to respond and even change their processes. However, ecological systems are not able to anticipate. 3. Resilience is a common property of psychological systems. In this case, the system can reflect, change its response accordingly and anticipate. 4. Finally, resilience is a property of dynamic and intentional systems such as social system and social-ecological systems. This usage is common when business organizations or any social system in connection to ecological system are discussed or in case of resilience engineering (Hollnagel, 2014, 222). It should be mentioned here that resilience engineering and engineering resilience are two different concepts. Resilience engineering will be discussed later in this chapter.

Like sustainability also resilience has emerged from ecology. Resilience has developed from the narrow to broader concepts to cover more complex systems. The first concept is called *engineering resilience* and it is characterized by system's return time and efficiency. The focus is on recovery and on constancy. The system is more or less predictable and near a single steady state. It is all about conservation and control. (Folke, 2006a, 259.) The second concept is *ecological or social resilience* and its characteristics are buffer capacity and ability to maintain functions. The focus is on persistence and on robustness. The system has multiple equilibria and different stability landscapes and it is able to flip from one regime to another. (Folke, 2006a.) The third concept is called *social-ecological resilience* and its characteristics are interplay between disturbance and reorganization, sustaining and changing. The focus is on adaptive capacity, learning and innovation. The system has integrated feedbacks and cross-scale dynamic interactions. (Folke, 2006a, 259; Hollnagel, 2014, 221.)

To get deeper into the definitions of resilience, the following section will introduce some of them. Holling, the pioneer of the resilience theory, introduced resilience as a capacity of a system to persist within a stability domain (system may have several stability domains or basins of attraction) in the face of disturbance or change (Holling, 1973, 17). Pimm, on the other hand, refers to the time a specific system requires to recover from a change or disturbance – the faster a system is able to return to its equilibrium, the larger its resilience (Pimm, 1984, 322). These both can be seen as the examples of engineering resilience.

Derissen et al. (2011) define resilience relatively, following Hollings footsteps:

"*The ecological-economic system in a given state is resilient to an exogenous disturbance if it does not flip to another domain of attraction*." They define a system's resilience to a specific disturbance. Resilience can be defined only after the disturbance. (Derissen, Quaas, & Baumgaertner, 2011, 1124.)

Walker et al. extended the definition of resilience from ecological science perspective *"The capacity of the system to absorb disturbances and re-organize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks"* (Walker, Holling, Carpenter, & Kinzig, 2004, 10). These definitions can be seen representing the second concept of resilience.

However, this definition leaves very little room for system to adapt by changing significantly its structure, identity or the feedbacks because they have to retain. Additionally, it has been criticized that if variables to be measured (leading to resilience) are defined beforehand, the conclusions may be influenced by the initial selection of those variables. (Cumming et al., 2005, 976.) However, the same problem remains if the parameters of identity are measured as indicators of resilience: *"The ability of the system to maintain its identity in the face of internal change and external shocks and disturbances"* (Cumming et al., 2005, 976). The identity of the system is composed by 1) its subsystems or components, 2) connections between subsystem and components and 3) the ability of both to retain over time and space. Lastly, identity is related to 4) capability to innovate and self-organize (ibid.) When looking at the definition closer, it is close to the previous one with an addition of the innovation and self-organizing capabilities, which are characteristic of the third concept of resilience.

Finally, there is a definition especially for social-ecological systems (Adger, Hughes, Folke, Carpenter, & Rockström, 2005, 1036): *"The capacity of a social-ecological systems to absorb recurrent disturbances (…) so as to retain essential structures, processes and feedbacks"*. All in all, the last two definitions have similarities retaining the essential features and they have the ability to self-organize and innovate, just as the third concept of resilience states.

All the definitions mentioned above provide new insights and are useful in certain situations and research. However, in this thesis these definitions seem to be rather theoretical and difficult to apply. Earlier in this chapter, resilience engineering was shortly mentioned. Resilience engineering is an approach to safety management and it focuses on how to cope with complexity also under high pressure. This approach is applicable to organizations, which core value is safety and which are also proactive and anticipating in their nature. (Hollnagel, 2014.)

Resilience engineering defines resilience (Hollnagel, 2011, xxxvi): *"The intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions"*

This definition brings the unexpected conditions clearly under consideration. The system sustains required operations, but it is not defined how or what kind those functions should be (should the system maintain its “identity”?). This definition appears to be functional allowing more freedom for system to adapt and change, but the system should still be able to sustain its critical operations such as food production. There are possibilities for the system to self-organize and change its structures. This definition is used in this work as the definition of resilience.

In addition, there is a wealth of literature and discussion about national, state or international security policies and resilience. A novel governance approach, which connects resilience with preparedness, confronts unexpected risks and living in uncertainty. United Kingdom is the model country and has applied resilience in its national strategies at least since 2010. International organizations such as UN (United Nations) and EU have taken resilience into their policy agendas. (Juntunen, 2014, 4.) In this thesis, this kind of literature is not thoroughly reviewed. However, few interesting points could be raised in connection to resilience, governance and communities. According to Juntunen, it appears that national government is responsible for enabling the conditions for individual and smaller scale community resilience (strategies), and communities and individuals are actually responsible for building their own resilience (Juntunen, 2014, 17). This seems to transfer the responsibility from the “higher” level i.e. governing organizations to the “lower” level i.e. to communities and individuals – to practical level. If this kind of thinking was applied to food systems or food supply chains, it might change the whole thinking of how to increase the resilience of a food system.

In addition to state and civil society, the environment should be included into the equation. Theory of social-ecological systems does that and it is presented in the next chapter.

2.1.3 Social-ecological systems

The important factor in the resilience theory is the integrated concept of ecology and social or human aspect – social-ecological systems (SES). This framework combines both “human systems”, ecological systems and governance systems enabling better understanding of the complex systems and interactions and processes between and among the “components”. There are several frameworks for analyzing social-ecological systems (Binder, Hinkel, Bots, & Pahl-Wostl, 2013). For the purposes of this thesis, a simple framework was sufficient – just to be able to place the food system into a framework. The SES framework presented here initially emerged from the need to build common vocabulary and logical linguistic structure to facilitate communication between researchers from different scientific disciplines such as ecology and sociology (McGinnis & Ostrom, 2014).

What distinguishes social system (anthropogenic) from ecological (biophysical)? In ecosystems, important dimensions are mainly spatial and temporal. In social systems, we have an additional dimension, which is symbolic. In human systems, there are three unique features: capability of foresight, rich communication between its members (written, verbal and body language) and technology. (Holling, 2001, 401.) Even though organisms and ecosystems transfer, test and store information, humans do that much more effectively. In addition, human systems are capable of learning, teaching and developing knowledge and innovation. These features increase the complexity of SES compared to the ecological system, but, on the other hand, provide opportunities to influence the SES and its futures.

SES has multiple integrated anthropogenic and biophysical elements such as cultural, political, economic, ecological, technological and others, which interact and influence each other by feedbacks in complex ways. Through these interactions SES can self-organize, adapt to changing conditions or emerge to novel configuration i.e. transform. In the SES, there can be separated slow-changing and fast-changing components, which affects social and ecological subsystems and vice versa (Resilience Alliance, 2010).

McGinnis and Ostrom present an interesting approach where four key subsystems are interlinked to social, economic and political settings and related ecosystems (Figure 3) (2014). The subsystems are: Resource Systems (e.g. water system), Resource Units (amount of water), Governance Systems and Actors. In the middle, there is Focal Action Situation (interaction -> outcome). These are so called first-tier variables. Additionally, there are second-tier variables for each of the first-tier components. For example, Resource Systems have a second-tier variable “human constructed facilities” and Focal Action Situations “self-organizing activities”. Furthermore, it is notable that the first-tier components can exist in multiple forms, depending on the application. (McGinnis & Ostrom, 2014.) For example, in the Finnish food system, different actors (primary production or food industry) produce different types of resource units and use different kinds of resource systems. In addition, their actions are guided by at least partly different and partly overlapping governance systems. The latter fact causes that it has to be analyzed how the first-tier components are related to each other (e.g. feedbacks) (ibid.). There are some same features to panarchy i.e. hierarchical structures and feedbacks between “levels” (see chapter 2.4), but this is more developed framework for research purposes having more defined internal structure (the first- and the second-tier variables).

During the thousands of years, the survival of SESs has become more a question of resilience of their social systems as opposed to purely a question of resilience of their ecological systems as before. This is a result from replacing the external (environmental) complexity by internal complexity (societal). (Young, Berkhout, Gallopin, Janssen, Ostrom, & van der Leeuw, 2006, 306-307.) This means that environmental resilience is important, but also importance and complexity of societal resilience has increased significantly and societal complexity has enormous influence on ecosystems. In societal resilience, one could include governance systems and other interconnections and rules between different levels of society. In addition, globalization brings societal impacts and feedbacks from far away to unpredictable places as discussed in the next chapter.

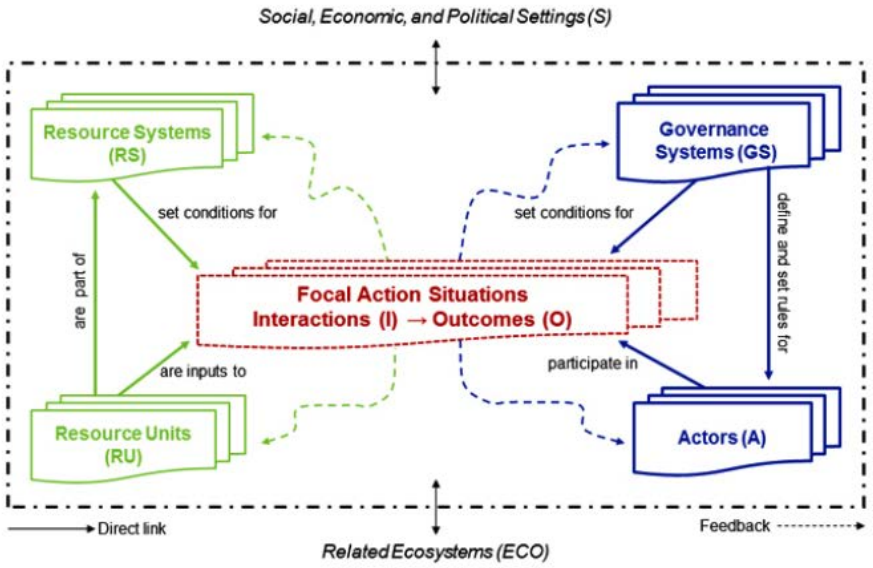


Figure 3 Conceptual model of a social-ecological system (McGinnis & Ostrom, 2014).

2.1.4 Resilience assessment

Food systems are definitely very complex examples of socio-ecological system (SES). There has been wealth of attempts to operationalize the measurement of resilience of SESs but only with some success, which is often connected to the systems having a very well defined spatial and temporal scale (Walker & Salt, 2006). Measurement of resilience is difficult because it actually requires measuring the thresholds or boundaries between different regimes (bifurcation points, discussed more in the section 2.2). That is why resilience of a SES is not observable or measurable directly. However, there are some approaches to develop indicators (Carpenter, Westley, & Turner, 2005) (or surrogates. In this thesis, the term indicator will be used, even if it is not directly measuring resilience itself):

1. Aspects of resilience of a SES are identified by using stakeholder assessment.
2. Models (such as scenarios or computer simulations) are explored and used to examine the potential thresholds.

3. Historical profiling. Different SESs are compared and regime shifts are looked for to be evaluated from resilience point of view.

4. Case study comparison. For example, similar SESs are examined and especially observable properties, which may be related to resilience, are researched.

Each approach has its own weakness and strengths, so combination of them would secure more robust indicators.

Interesting approach to sustainability and to resilience is to combine the two (and robustness) to address global change policy challenges (Anderies et al., 2013). It is critical to design participatory decision process to select collectively performance measures that are accepted by all the stakeholders. Resilience and robustness could be used to address issues regarding three types of challenges, divided into three time categories (Anderies et al., 2013):

1) Uncertainty and disruption in present state of social-ecological system (SES) – a goal is maintaining the present functions. The time scale would be short from months to years. The concept used would be the specified resilience or robustness.

2) Adapting SES incrementally to new types of uncertainties. The time scale would be from years to decades. Robustness framework could help here to see robustness-fragility trade-offs when navigating through short-term decisions to gain intermediate term adaptation.

3) Transition or transformation towards new SES. Transformation may be needed i.e. to fulfill the sustainability requirements and performance measures defined earlier in the process. The time scale in this case is longer from decades even to centuries.

Even though this concept is interesting and certainly broadens the sustainability to include robustness and resilience as well, and extends the time frame from few years up to centuries, the challenge of general resilience still remains. To focus only on present situation, intermediate adaptation and long-term transformation leaves the unlikely events and also the general resilience out of the scope. In addition, there were no clear assessment tools.

There are some practical tools for defining resilience developed by Resilience Alliance. Resilience Alliance’s workbooks for practitioners and for scientists (2007; 2010) are tools to define the resilience of a system, which is well defined both spatially and temporarily – leading to specific resilience. However, in this thesis more general indicators or parameters are needed.

In their book, Walker and Salt (2006, 121, 145-148) define key resilience parameters of a system. These have interestingly close connection to identity defined by Cumming et al. (mentioned in brackets) (2005).

a. Tightness of feedbacks; responsiveness (connections)

b. Modularity (subsystems or components)

c. Diversity

d. Self-organizing behavior – innovation and experimentation (self-organizing)

Tightness of feedbacks refers to the speed how quickly and strongly a change in one part of a system is felt in other parts of the system. This refers also to connections between subsystems or parts of the system. On the other hand, centralized systems and globalization weaken the feedbacks. That creates a risk that thresholds are crossed before noticed. For example, excess use of pesticides or unethical working conditions in Thailand are not directly seen or felt here in Finland - what we see here is cheap pineapple juice or other food products imported from Thailand (Finnwatch, 2014).

Modularity refers to the separate components and links between those components of a system. Less modularity more vulnerable the system is because it is dependent on fewer functioning units. Modularity and connectedness have similar features.

Diversity refers to the number of different actors that makes a system (people, species, business and food supplies). The resilience of a system consists of the number of e.g. species and the connections between them. Diversity may also mean diversity of land use (opposite of monocultures).

Meadows defines self-organization as a system’s capability to make its own structure more complex. Like resilience, self-organization in the system is often sacrificed for the purpose of short-term productivity, profits and stability. (Meadows, 2008, 79-80.) This phenomenon can too often be seen in management of production processes. Long-term sustainability or resilience is forgotten or at least pushed aside. Self-organization produces heterogeneity and unpredictability and, on the other hand, requires freedom and some disorder to occur (Meadows, 2008, 80). The concept of self-organization is discussed further in the next chapter.

Wide-ranging nature of earlier mentioned general resilience makes it difficult to define specific measures or ways to develop it. Instead, there are some conditions that appear to enable the development of general resilience and some of them are the same as above mentioned resilience parameters. The enabling conditions for general resilience include nine system properties (Carpenter et al., 2012):

1. diversity (species, functional and response diversity)
2. modularity (independent and similar systems or functions to secure functioning even if one module fails)
3. openness (strength of connections; tradeoff of modularity)
4. reserves (regeneration of key components or redundancy)
5. feedbacks (linkages of control and response variables)
6. nestedness (turning of challenges into natural scale e.g. community or local level)
7. monitoring (understanding of vital measures of the life supporting systems),
8. leadership (network building and enabling)
9. trust (effective collaboration, trust is developed in repeated interactions).

Openness, leadership and trust can be seen as enabling features for self-organization or later discussed self-renewal and self-referential system. Many of these are similar or the same to the above discussed resilience parameters and these are very close to later on discussed behavioral resilience indicators of Cabell and Oelofse (2012).

Time and rate of changes are also important factors of resilience. Resilience is usually seen as system's capability to cope with rapid changes as well as its ability to adapt to slower changes i.e. climate change. Resilience opens up various interactions between social and ecological systems and is suitable for capturing complex interconnections in a system. (Engle, de Bremond, Malone, & Moss, 2013.) Engle et al. have constructed preliminary categories of "hybrid" resilience framework in connection to the climate change. They identified five groups of indicators: 1. Governance and security, 2. Natural resources, 3. Social systems, 4. Economic systems and 5. Infrastructure. In each, there is short-time coping and long-term adaptation perspective. In addition, there are different spatial scales taken into account. Within each group the indicators show normative outputs, and finer the spatial scale becomes more subjective the indicators are. That is why participative methods are necessary to secure desirable outcomes in relation to resilience and community. This approach is suitable, for example, when building community resilience and when it is possible to use these participatory methods in practice.

A more complex approach to the indicator development is to define critical resilience dimensions and capitals or assets to organize the indicators in logical groups. In this approach, resilience dimensions are 1. Factors undermining resilience, 2. Slow variables, 3. Fast variables, 4. Feedbacks, 5. Likelihood to cross-critical thresholds (tipping points), 6. Response to uncertainty and surprise, 7. Openness to resilience thinking and 8. Potential to reorganize. In addition to dimensions, asset classes are defined as ecological, social, economic, institutional and infrastructural. (Davidson, van Putten, Leith, Nursey-Bray, Madin, & Holbrook, 2013.) The combination of these two creates rather complex but informative indicator framework with abstract indicators and suggestions for concrete indicators. The work of Davidson et al. is from the marine sector, but it is certainly something to be developed further and to other systems and sectors as well. However, for this thesis the indicator framework was still too preliminary to be useful.

It follows from the discussion above that there are several general "parameters", which could be used to define the general resilience. The parameters of Walker and Salt (2006) are fundamental and, in addition, Carpenter et al. mention few important ones (2012):

1. Tightness of feedbacks; responsiveness, openness (connectedness)
2. Modularity; independent functioning modules, subsystems
3. Diversity in a system (at many levels)

4. The amount of change a system can withstand and maintain its main functions and structure (sometimes defined as identity) (reserves and redundancy)

5. The ability of a system to develop the capacity for learning and adaptation (e.g. trust, cultural capital, leadership)

6. Capability of self-organizing behavior – resulting innovation and experimentation

Finally, when these fundamental parameters have been defined, it is necessary to find actual indicators, which could be used to measure these parameters.

All above discussed indicators or parameters are difficult to apply directly into practice, especially to complex systems such as food systems. However, the behavior-based indicator framework of Cabell and Oelofse (2012) for assessing the resilience of agroecosystems is further developed concept and collects and groups 13 indicators, which other authors have identified in their work. These resilience indicators for agroecosystems are used in this thesis. If the indicators of Cabell and Oelofse are explored in more detail, the general parameters discussed above can be identified (Table1).

Table 1 General parameters for general resilience can be identified from the indicators of Cabell and Oelofse.

Indicators (Cabell & Oelofse, 2012)	**General parameters for general resilience**
1. Socially self-organized	Self-organizing behavior
2. Ecologically self-regulated	Connectedness and feedbacks, self-organizing
3. Appropriately connected	Connectedness and feedbacks
4. Functional and response diversity	Diversity
5. Optimally redundant	Modularity, reserves and redundancy
6. Spatial and temporal heterogeneity	Diversity
7. Exposed to small-scale disturbances	"Practicing" self-organizing behavior, capacity of learning
8. Coupled with local natural capital	Modularity, self-organizing behavior and connectedness
9. Reflected and shared learning	Capacity of learning
10. Globally autonomous and locally interdependent	Modularity, self-organizing behavior and connectedness
11. Honors legacy	Capacity of learning, trust
12. Builds human capital	Capacity of learning, trust
13. Reasonably profitable	Capacity of self-organizing behavior

These 13 indicators appear to measure, at some level, the general resilience parameters defined above but in the more comprehensive format.

There appears to be a great deal of research in progress around resilience indicators and measurement of resilience. Nevertheless, as we have seen, there is no agreed upon a set of indicators for specific resilience, not to mention the general resilience. Even more difficult it is to define resilience of certain complex systems such as food systems. A certain set of indicators was chosen for this work. Even if the selection may not be perfect, it most probably gives some indications of resilience useful for further analysis. Resilience is systemic in nature, so it is very difficult to have perfect or "a full set" of indicators to cover the whole system and its complex feedbacks. To appreciate and to better understand the systemic nature of resilience, it is worth visiting briefly the history and the theories of systems thinking.

2.2 Systems thinking

2.2.1 Three paradigms of systems thinking

Systems theory is also the premise for resilience thinking. To understand systems thinking, it is important to understand how it has evolved – one could say that through paradigm changes. These systems thinking paradigms were originally constructed by Ståhle (Ståhle, 1998).

The scalability of systems thinking makes it highly useful in very different contexts. An organism is a system, as well as a global food system is a system. A system can be defined as a complex network of interrelationships between a set of elements that are organized in a way that achieves something or, in other words, have a goal or purpose (e.g. production of food). A social-ecological system is a system as discussed above. The systemic view emphasizes interconnections and communication among the elements, rather than elements itself. (Ståhle, Pöyhönen, & Ståhle, 2003, 30.) System thinking is interested in a flow of information or material between the elements and how those influence the whole system. It is not so much interested in exact structure or quality of those elements itself.

In the late 1940s, systems theories had two main schools: general systems theory and cybernetics. Cybernetics applied Newtonian paradigm, meaning that systems were mainly seen as machines. This thinking led to the conclusion that the systems were closed, predictable and controllable. According to Ståhle, the "first paradigm" in the development of systems thinking refers to systems that obey predetermined laws. (Ståhle, 2008, 3.) However, cybernetics has developed its rather mechanistic worldview more actor-oriented and observer-dependent worldview. For example, sociocybernetics implies feedback loops from the social sciences to cybernetics theory. In spite of these approaches, there is strong emphasis on governance and how to plan and regulate social systems if it is possible and feasible at all. (Geyer & van der Zouwen, 1986.)

The general systems theory and the "second paradigm", as Ståhle defines it, were founded by Ludwig von Bertalanffy. He transferred the systems research from physical sciences to the field of biology. He saw the systems as open and living organisms that communicate and interact with their environment. To define exact spatial boundaries of an organism or a cell is vague because there is a constant flow of molecules in and out. In the end, he defines boundaries being dynamic instead of spatial and "*object (and in particular a system) is definable only by its cohesion in a broad sense, that is, the interactions of the component elements*" (Bertalanffy, 1972, 422). The process could be described as chains of inputs, throughputs and outputs, controlled by continuous feedback cycles. The systems are constantly evolving and striving to achieve equilibrium. (Bertalanffy, 1972, 419.) According to Ståhle, this paradigm is also called “organic systems paradigm” (Ståhle et al., 2003, 36).

Other remarkable researchers in the field are Peter Checkland with his soft systems methodology (1995), Peter Senge with learning organizations (Senge & Sterman, 1992) and Jay Forrester with systems dynamics (Forrester, 1994) – all having some features leading the way to the “third paradigm” (Ståhle et al., 2003, 37).

According to Ståhle, the “third paradigm” (also called “dynamic systems paradigm”) focuses on system’s complexity, uncontrollability, far from equilibrium features and autonomous dynamics (Ståhle, 1998, 63; Ståhle, 2008, 5). A system can also be seen as a highly complex and it can be in a state of disequilibrium and chaos. The third paradigm focuses on the non-linear behavior of systems. Main interests are in the system’s self-renewal, self-organization, discontinuity and non-determinism, and in its potential for radical change. (ibid.)

The nineteenth century was the century of accepting and understanding complexity. Earlier irreversible processes were looked at exceptions, not worth studying. Today we know that in far-from-equilibrium conditions new innovative structures may originate, we may have a transformation from disorder into order. Those new structures are called dissipative structures to emphasize the dissipative process in their creation. (Prigogine & Stengers, 1984, 12.) As Prigogine states, “*order out of chaos*” was revolutionary new thinking and even the beginning of a new paradigm.

These new perspectives grew from complexity and chaos research by Lorenz, Feigenbaum and Mandelbrot; Prigogine’s self-organizing systems research and from research about autopoietic systems conducted by Maturana and Varela (Ståhle, 2008, 4). The third paradigm sees non-stability and chaos as sources for change and innovations and recognizes the possibility and advantages of random connections among elements in the system (Ståhle et al., 2003, 40).

If we consider these three paradigms as dimensions of an organization or even larger system, all three systemic modes – mechanistic, organic and dynamic – can be present in different degrees (Ståhle et al., 2003, 47). It would be interesting to analyze if food systems go through similar phases. If a food system is divided into different hierarchies or levels, each level could be analyzed separately. Is there any level or section in the Finnish food system that could be said to be in the dynamic paradigm – in the innovation phase? If not, how the movement could be helped towards that phase. All in all, innovation is a product of some degree of self-organizing behavior and that will be discussed next.

2.2.2 Self-organizing systems

Systems can self-organize without any external interference or guidance and it is quite common systemic feature according to Prigogine. That claim was revolutionary. Prigogine and Nicolis researched mainly chemical and physical systems, but extended claims to biological and social systems. (Nicolis & Prigogine, 1989.) Claims can be applied to social-ecological systems (SES) as well because general parameters of general resilience include self-organizing behavior (see chapter 2.1.4). Food systems can be defined as social-ecological systems.

According to Ståhle, there are five key concepts in Prigogine’s work regarding self-organization: 1) far-from-equilibrium, 2) entropy, 3) iteration, 4) bifurcation and 5) time (Ståhle, 1998, 71). Self-organization is possible if system is able to stay far-from-equilibrium (Nicolis & Prigogine, 1989, 8). For example, different, even opposing opinions in the social systems, create far-from-equilibrium conditions. Apparently, tension between opinions and people create internal energy, which enables self-organization. (Ståhle, 1998, 72.)

However, self-organizing capability is not in all systems. System’s stabilization is prevented by its internal entropy, which is vital for self-organization. Entropy is excess of energy or information in a system. Instead of collapsing, system reorganizes. Self-organizing systems move between the chaos or far-from-equilibrium and order. (Nicolis & Prigogine, 1989, 12-13)

Iteration means continual feedback (resonance) process throughout the entire system (Ståhle, 1998, 78). Self-organizing systems are always balanced: no part of the system has monopoly over the information – the whole system controls the information. That also causes any change to occur suddenly within the whole system (presumably after the iteration process) (Ståhle, 1998, 80-81). Information and models can be copied from micro to macro level and vice versa, giving the system more capacity for self-renewal. This does not require that micro and macro level function by the same principles. The system dynamics is nonlinear, hence the so called “butterfly effect”. At first, something is having very small impact at micro level of a system, but later the impact increases due to iteration when macro levels of the system are reached. (Nicolis & Prigogine, 1989, 124.)

Bifurcation means that a system, at a certain point, can make choices and these choices cannot be predicted i.e. a choice is free and the choice is irreversible. At the bifurcation point, a system discards a lot of information (entropy) and builds a new order or new state of equilibrium and that change is irreversible. (Nicolis & Prigogine, 1989, 72; Prigogine & Stengers, 1984, 167-170.) A system can produce a whole new structure or solution, which may also be an innovation in case of human system. The constant increase of entropy forces systems to develop and move forward and that takes time. The iterative process takes time and bifurcation has its own timing, so time has a crucial role. (Ståhle, 2008, 9.) Foregoing description reminds reorganization phase of the adaptive cycle when potential/wealth or (in this case) entropy is discarded and new order or new regime is created. Bifurcation point and regime shift are the same phenomena having different terminology. The first terminology originates from physical sciences and the latter is often utilized in resilience literature when e.g. ecological system changes and perturbation causes it to shift to another state or regime (Walker et al., 2004, 68).

This and previous chapter introduced how scientists, mainly from natural sciences, have developed systems theory. The following chapter will take the systems theory also to social systems.

2.2.3 Social systems

Niklas Luhmann expanded autopoiesis theory to social systems because he views them to be autopoietic – self-reproducing. According to Luhmann, the system needs only one type of operation in case of social system. That operation is communication, and social systems use communication as a means of autopoietic renewal. (Luhmann, 1990, 145-146; Luhmann, 2013, 53-54.) Communication can finally create bifurcation points, which can lead to different futures. Luhmann sees that the most important factor in the self-renewal is control of system's complexity from within. This leads to a new category of systems: (in addition to open, closed and far-from-equilibrium systems) self-referential systems. These systems can regulate their boundaries by opening and closing them autonomously, and are thus at once both open and closed. (Luhmann, 1990, 145-147.) In addition, Luhmann defines complexity as follows: "*We will call an interconnected collection of elements complex when, because of immanent constraints in the elements' connective capacity, it is no longer possible at any moment to connect every element with every other element*" (Luhmann, 1995, 24). Complexity also indicates that there are always more possibilities of actions or experience (Luhmann, 1990, 26).

Luhmann also brings interesting viewpoints to a concept of adaptation. According to Luhmann, complex systems must adapt to their environments and, furthermore, to their own internal complexities. That is why complex systems cannot seamlessly follow the changes in their environments; they must simultaneously cope with their internal inadequacies. (Luhmann, 1995, 31-32.) That point seems to describe well how large and complex organizations seem to be slower in their changes and actions (partly due to the bureaucracy) compared to smaller ones. This has the same characteristics as adaptive cycle's conservation phase where connectedness (internal controllability) and potential are accumulated and a system becomes increasingly rigid in its control.

System and its change can be reduced to relationships (in social system between two people) – without relationships (communication in social systems) there would be no system or its change. According to Luhmann, a key element to change is system's relationships and interdependencies between people i.e. connectivity, which Luhmann calls double contingency. These kinds of relationships are always symmetrical and based on voluntariness: both parties understand the nature of the interdependency and accept that. There is an imperative precondition for double contingency: trust. (Luhmann, 1995, 108.) Trust enables a system to develop further and enables even riskier options to develop (Luhmann, 1995, 127-128).

According to Luhmann, meaning is generated during the communication processes and a social system develops towards its true potential when seeking for meanings. Most importantly, "meaningful" information changes the system and it is actually more like a true experience in the end, leading the system to a change (Ståhle, 1998, 108-109). From Luhmann's writing, Ståhle identified following criteria for self-renewal and those are based on self-referential functioning of the system (Ståhle, 1998, 111):

1) Connections with other systems (as reference points) - feedbacks
2) Double contingency (power balance and trust)
3) Information as an event and as a power enabling a change
4) Creation of meanings within a system

Both Prigogine and Luhmann argue that the opportunity for self-renewal is boiled down to communication. The system's ability to communicate will determine its capacity to renewal. (Ståhle, 2008, 21.)

Interesting remark from social psychology, when talking about groups and group performance, is so called "group thinking". Group thinking occurs in a highly cohesive group, which has consensus as its main goal rather than critical and realistic analysis of a situation. To avoid group thinking and foster critical thinking, one should reduce cohesiveness of the group. (Pennington, Gillen, & Hill, 2004, 383.) This interesting point is in line with Luhmann's and Prigogine's thinking: meaningful communication enables a renewal process of a system. In a very cohesive group, too much is assumed and too little is challenged or questioned (i.e. communicated). That is why argumentation and questioning leading to communication is important in forming groups and enabling them to create a change. In the process, some kind of momentary chaos is created and possibly a new order may appear from it.

In addition, the value of information and its meaningfulness is rather difficult to define because information might be meaningless today, but the situation might change tomorrow, and suddenly that same information might be very meaningful and lead to a renewal process. Or a piece of information is useless to one, but the same information is valuable to another. Earlier discussed entropy is also interesting in this context because it is also related to excess information (or energy) in a system. However, any discussion of what kind or how meaningful that information should be to produce entropy was not found. According to Prigogine, equal exchange of information is prerequisite for self-organization. On the other hand, Luhmann emphasizes equality and trust as prerequisites for development of meanings and renewal process (Luhmann, 1995, 127-128).

2.2.4 Resilience concepts and the paradigms of systems thinking

The definition of resilience has gone through similar developments as systems thinking, which has three paradigms developed by Ståhle (Ståhle, 1998). The first paradigm is called closed systems paradigm and systems are defined as static and mechanical, and the objective is stability by prediction and control of the systems. Systems could be controlled by certain laws e.g. classical Newtonian approach (Ståhle, 2008, 5). The first resilience concept is defined as engineering resilience and its characteristics are system's return time after a shock and its efficiency. The focus is on recovery and constancy. (Folke, 2006a, 259.) Both approaches concentrate on static features of the system and the aim is to control the system.

The second systems paradigm is open systems paradigm and systems are defined as balanced and near equilibrium, and the objectives are maintenance, development and controlled change (new state of equilibrium). Continuous disequilibrium would mean system's collapse. (Ståhle, 2008, 5.) The second resilience concept is defined as ecosystem resilience or social resilience and its characteristics are system's buffer capacity to withstand a shock and maintain functions. The focus is on persistence and robustness. (Folke, 2006a, 259.) If food systems are considered, majority of modern food production chains (primary production – food industry – retail – consumption) could be seen as examples of mechanical or open systems paradigm, where prediction (though sophisticated) and control are the main goals to increase the efficiency in a chain. In addition, development is strived in a controlled manner, not to cause disruptions in the chain or production, and the main goal is to increase efficiency. Similarly, the first resilience concept seems to apply well to modern food production chains, which appears to consider mainly how quickly the system can return to its original state after a disturbance to resume its normal functions and efficient production capacity. It would be interesting to evaluate, how much buffer capacity there is in modern and efficient food production chains. Probably some parts or subsystems have buffering capacity or redundancy, but how the whole chain as a system would cope with an unlikely event (or even well-defined sudden disturbance), is rather unclear and this work tries to answer this question to some extent.

The third systems paradigm is dynamic system paradigm and it is defined as far-from-equilibrium, uncontrollable, complex and chaotic, and the objectives are understanding and exploiting the systems dynamics, radical change and innovation (Ståhle, 2008, 6). The third resilience concept is defined as a social-ecological resilience and its characteristics are interplay between disturbance and reorganization, sustaining and developing. The focus is on adaptive capacity, transformability, learning and innovation. (Folke, 2006a, 259.)

It appears that, in general, mechanical and open system paradigms and ecological or social resilience can be applied to systems, which produce goods for human requirements in connection to natural environment (e.g. food systems) i.e. systems are closely controlled and the aim is stability, robustness, maintenance, controlled development, efficiency and growth. Purely social systems (depending on the temporal and spatial scale) seem to be more difficult to control by human efforts and there appears to be more self-organizing examples i.e. movements originating from social media. One aspect, not much discussed here, is the governance of the systems – how that affects the systems paradigms and resilience concepts. Social systems often have strong governance e.g. in large organizations or they are guiding overall behavior such as traffic rules or social norms. In general, governance systems prevent chaos and maintain order, however, simultaneously preventing major transformations (into different governance systems).

From these descriptions it can be seen that both systems thinking paradigms and resilience concepts have gone through similar developments and the third concept and paradigm define systems as very dynamic and the focus is on change and innovation. The understanding of systems has evolved from steady-state or mechanical view to complex adaptive systems.

In the next chapter systems are described as evolving and continuously changing entities going through certain phases as described by the adaptive cycle framework.

2.3 Adaptive cycle

According to the resilience thinking, systems can evolve and move through four phases: rapid growth (exploitation), conservation, release and reorganization (Holling, 2001, 394-395).

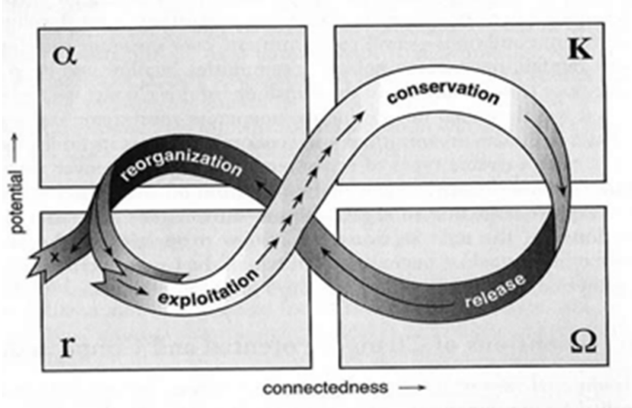


Figure 4 Representation of an adaptive cycle showing the four phases: exploitation, conservation, release and reorganization. The cycle reflects developments of two measures: x-axis showing the connectedness and y-axis showing the potential. (Holling, 2001, 394.)

In his article ”Understanding the Complexity of the Economic, Ecological, and Social Systems”, C. S. Holling (2001, 394) states that three properties of a system – connectedness, potential and resilience – shape the future of that system whether being economic, ecologic or social system. Potential (wealth), defines the system's limits and number of options for the futures. Connectedness, or controllability, defines how much the system has control over its own futures. Resilience, or adaptive capacity, defines the vulnerability of a system to different disturbances. (ibid.)

Adaptive cycle of a system is described in details in Figure 4. The cycle is like number eight lying on its side, flowing through four-fields or phases: exploitation, conservation, release and reorganization (r, K, Ω and α). Two of the properties are shown in the Figure 4: X-axis defines the connectedness and y-axis the potential of a system. (Holling, 2001, 394.)

When the cycle proceeds from exploitation to conservation, connectedness and stability increases and simultaneously wealth and capital is accumulated in the system. Because of high connectedness, system becomes increasingly rigid – finally too rigid to sustain and it may move to release phase. (Holling, 2001, 396.) The final trigger may be, for example, environmental or external disturbance, which forces the system from conservation to release phase. It is time for fast reorganization and during this phase it is also possible to see new innovations. This phase is highly unpredictable and may produce unexpected combinations. It may be defined as a phase, which maximizes invention, and previous phase (exploitation – conservation) maximizes production (whatever that is in a system). (Holling, 2001, 396.)

The third dimension of the adaptive cycle is resilience, which can be seen in Figure 5. Resilience is high during the release phase when connectedness is low opening the opportunities to new combinations. This phase is time for either crisis or innovation. (Holling, 2001, 395.)

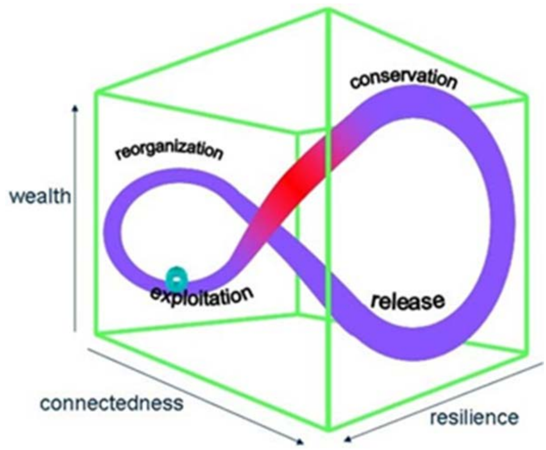


Figure 5 Resilience is the third dimension of the adaptive cycle and evolves during the cycle and being at the minimum at the end of conservation phase. (Holling, 2001, 395)

An adaptive cycle can be divided into "front loop" and into "back loop". The first being development loop characterized by accumulation of potential or capital and the latter being invention loop characterized by change and experimentation. These loops have different objectives: front loop growth and stability, and back loop change and variety. If we compare the duration of the loops, the back loop is brief. (Holling, 2001, 395; Walker & Salt, 2006, 81-82.)

However, not all systems behave similarly or follow the adaptive cycle similarly. For example, human systems have foresight capacity, adaptive capabilities and are also able to take advantage of emerging opportunities. (Holling, 2001, 396.) That way the system may, for example, prevent or postpone release phase.

There are people who dislike adaptive cycle concept because it appears to be deterministic, and others who see the concept as inspiring and leading to new thinking – seeing the world as a dynamic process (Folke, 2006b, 258). It is said that adaptive cycle is heuristic model, developed from long-term observations of ecosystems and their development. There are those who use adaptive cycle as an analytical tool and others who understand it more as a heuristic concept. (ibid.) The author of this paper sees the adaptive cycle more as a heuristic concept and a helpful tool to understand the changing systems, including the complex food systems.

2.3.1 Adaptive cycle and self-organizing systems

Description of self-organizing systems has some resemblance to an adaptive cycle model. If wealth/potential is replaced (Figure 4, "y-axis") with entropy, the adaptive cycle model could describe a self-organizing-system evolving between chaos (release and reorganization) and order (exploitation and conservation) (Holling, 2001, 394).

Entropy is needed to induce the self-organizing capability and if the adaptive cycle analogy is used, entropy increases during the conservation phase and, finally, when there is excess of information or entropy (y-axis, wealth/potential in the Figure 4), imbalance is created and release phase may begin and reorganization may occur. During that phase, excess information is decreased by making choices (bifurcation points) and by categorizing some of the abundant information (Ståhle, 1998, 77). Prigogine and Strengers write about knowledge as follows: "C*ommunication is at the base of what probably is the most irreversible process accessible to human mind, the progressive increase of knowledge*". (Prigogine & Stengers, 1984, 295.) Knowledge could be seen here as a developed, processed, tested and communicated form of information. When pure information is processed and finally communicated, and part of it is discarded and/or combined with other information, also entropy in that system is lowered. Could a system avoid release and reorganization phases or postpone them by increasing communication and information processing? On the other hand, communication could also increase connections (connectedness, internal controllability) and that way increase rigidity of the system. (Holling, 2001, 394.) The key appears to be the bifurcation points when the excess information (entropy) is discarded.

Going back to Holling, he describes a concept of panarchy, which seems to be somewhat functionally analogous to iteration (Holling, 2001, 398). Panarchy will be discussed more in chapter 2.4. Panarchy is a hierarchical structure of adaptive cycles. Panarchical connections create and sustain adaptive capacity in a panarchy. These connections can go towards upper levels of a structure (from micro level to macro level – "revolt" – critical change) or from upper levels to lower levels (from macro level to micro level – "remember" – renewal by using macro level potential). (ibid.) This is an interesting aspect if thinking about how micro level innovations can proceed to higher level and potentially change their functional principles. For example, micro level food system innovation may change the functioning of higher levels. This will be discussed further in connection to panarchy scenarios in chapter 2.5.

Social-ecological systems (SES) are in focus in this work, so the social context is important. Luhmann expanded systems theory to social systems and defined self-referential systems. He emphasizes system's ability to control its own internal complexity. How does that work with adaptive cycle? The parameter for internal controllability is the connectedness. The system can control its internal (and external) connectedness, so in that way the system can control its internal complexity. At the conservation phase, the connectedness increases, which increases internal complexity (entropy) and, on the other hand, finally also system's rigidity possibly leading to the release and reorganization (new self-organization) phases. The question is how to find the optimum of connectivity i.e. internal control causing also rigidity. Probably that is not possible because the system and its environment is changing all the time and the optimum is also changing.

2.4 Panarchy

In the process creating complexity, self-organizing systems generate hierarchies. Hierarchies reduce the amount of information at each level and, in the end, entropy as well. Each level or subsystem has denser relationships within than between levels or subsystems. (Meadows, 2008, 82-83.) That could be seen as a manifestation of self-referential closure.

Systems are not closed entities existing in vacuum; they are connected to other systems horizontally, but also vertically below and above their own level. C. S. Holling defines (Holling, 2001, 396): "*A panarchy is a representation of a hierarchy as a nested set of adaptive cycles*."

Three adaptive cycles are presented in Figure 6. At different levels, adaptive cycles are having connections between them. However, each level is able to operate independently. Above slower and larger level is not slowing down lower and faster levels of adaptive cycles. Still each level is connected to the lower and upper levels if they exist. That is why lower and faster level can invigorate upper level with innovation (revolt) and upper level can supply lower level with information or materials (remember). The panarchy is therefore both innovative (revolt) and conserving (remember). (Holling, 2001, 398.)

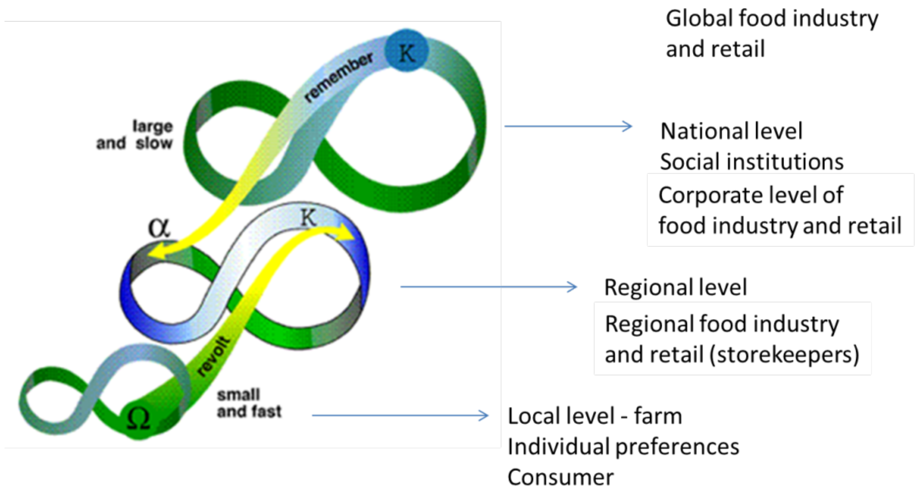


Figure 6 Panarchy. Three levels are connected to each other and that way are sustaining and creating adaptive capacity of the system. “Revolt” can induce critical change at the upper level, which is at a vulnerable stage. “Remember” makes renewal possible by drawing potential from upper slower level, for example, after losing part of the biodiversity. Modified from: (Holling, 2001, 398)

“Revolt” and “remember” connections across the scales are examples of developing the resilience of the total system or the panarchy (Folke, 2006a, 259).

The growth phase or the conservation phase proceeds usually to the release phase, but it may, through smaller interferences, also move backwards back to the growth phase. It seems to be possible (at least in some cases) to organize the release or the reorganization phases at lower levels of panarchy to avoid the release or major regime change at the higher level. (Walker & Salt, 2006, 82.)

These panarchy levels and adaptive cycles inspired the author to produce “panarchy scenarios”. These scenarios could also be seen as evolutionary scenarios because they can be produced in temporal sequence.

2.5 Adaptive cycle operationalized - Panarchy scenarios

2.5.1 Scenario typologies

Scenario technique is an effective way of organizing knowledge and understanding of futures. Scenarios produce information and insights for strategic decisions, for example, in business organizations or in a policy making in governmental organizations. In addition, scenarios are often used tool in research context as in this thesis.

There have been several suggestions of different scenario topologies trying to capture the diversity of scenario types. Scenarios can be constructed around possible, probable and preferable futures (Amara, 1981). Scenarios can be classified by thinking about project goal (exploration or decision support), process design (intuitive or formal) and scenario content (complex or simple) (van Notten, Rotmans, van Asselt, & Rothman, 2003, 426). Scenarios can also be divided into predictive, explorative and normative scenarios. (Börjeson, Höjer, Dreborg, Ekvall, & Finnveden, 2006, 731.) Normative scenarios describe desirable futures and work towards some kind of goals. A normative scenario can be either preserving or transformative in its nature. Explorative scenarios describe events and trends as they could evolve and influence the future and there are two types, external and strategic, scenarios. The first one describes what can happen to the external factors in the future and focuses only on factors that cannot be directly influenced by the actors (i.e. climate change). The latter describes what can happen to the internal or strategic factors in the future. The actors of course can influence those. Predictive scenarios aim to produce forecasts and answer "what-if" questions. (Börjeson et al., 2006, 726-727.)

In this work, the approach is explorative and the focus is more on the external factors influencing the food system. However, there are also "internal" factors taken into account such as homogenization of food production and concentration of industries. These stem from the resilience parameters discussed earlier. Sometimes it is difficult to clearly define external and internal factors because all are interconnected and influence each other by feedback mechanisms. For example, globalization influences Finnish food system, and force concentration and homogenization to produce efficiency and competitiveness. Globalization has not been taken into the driving forces separately because it has such manifold and complex ways to influence.

2.5.2 Futures table and scenario construction process

Futures table using PESTE categorization (political, economic, social, technological and environmental factors) is used to include the relevant drivers affecting the Finnish food system. The futures table is based on the field anomaly relaxation (FAR) method. The FAR involves multidisciplinary approach to create themes of a system under research and then describes futures states of the themes in a table format. The final scenarios are constructed by combining the futures states, which form logical and coherent wholes or narratives. (Rhyne, 1995.)

The scenario process in this study follows roughly the process described by Peter Schwartz (Schwartz, 1996, 241-248):

1. Identification of focal issues or decisions. Schwartz's process is designed for organizations and for business environment, so this phase may not be clear in case of food system, where the system is large and complex. In this study, the interest is more on structural changes and how different levels of food system may interact and drive major transformations. Of course, there might be issues in relation to food security or self-sufficiency, which are critical to any food system.
2. Key factors influencing focal issues in the environment are identified. In this context, they are related to resilience and are collected into the futures table.
3. Driving forces are identified; listing the driving forces from macro level, which influence the key factors listed above. These matters were already discussed in the introduction.
4. Ranking those by importance and uncertainty. Because the theoretical framework is complex, it was possible to take only a limited number of factors or driving forces into the futures table. In the end, only the most important once were selected and the uncertainty of those had only secondary importance.
5. Fine tuning the scenario logics. In this work, the adaptive cycle and panarchy frameworks were used as frames for the final scenarios.
6. Fleshing out the scenarios.

The scenario construction was commenced by thinking of focal issues (Schwartz, 1996, 241). Already in the introduction, it was discussed that the main objective of food systems is food security, to provide quality food for everyone (Ericksen, 2008b, 16). Another focal issue could be self-sufficiency at least when some critical food items are considered. Even though during normal circumstances Finnish food system is able to provide Finnish population with food products, Finnish food system (like all modern food systems) is very dependent on imported inputs such as oil and chemicals. Another critical food security factor is energy supplies during possible crisis or a power failure. That is why the oil dependency was taken into the futures table: exploitation of natural resources, including oil.

Key factors or factors in microenvironment were identified more from the resilience perspective (Schwartz, 1996, 242). Microenvironment was defined as environmental factors inside Finland and caused by Finnish people, institutions or organizations. Even though some of the factors are global and driven by forces of globalization, they are allowed, enforced and supported by national policies and actions. The first factor identified was homogenization and specialization of the food production (monocultures, larger production units). This is related to diversity and modularity (usually decreasing them), two of the resilience parameters.

The second factor identified was concentration of industries (e.g. retail and input industries), which is also related to diversity and modularity (decreasing them) and in addition to tightness of feedbacks (decreasing them).

There are, on the other hand, appearing number of optional food distribution and production practices (farmers markets, food circles, city farming, small-scale farming etc.). Parameters associated with resilience in this case are diversity, modularity and self-organization (increasing them) and, on the other hand, these optional channels are increasing the tightness of feedbacks.

Another important factor included in the futures table is investments in R&D as a measure of enabling innovations.

The number of transformative consumers, NGOs or other movements is an important factor as well and it is in connection to self-organization, modularity and diversity.

Furthermore, the volume of food imports was also considered important having impacts on self-sufficiency and national food production. Parameters of resilience are mainly tightness of feedbacks. When the modern food systems are wealthy, there are possibilities to import and also consumers require more options and larger selection. Importing foods often requires high-level connectedness and there may be long and complex routes to import food products.

The amount of agricultural subsidies affects the tightness of feedbacks possibly causing them to be less tight and as a result distorting them. On the other hand, subsidies make agriculture possible in the areas where it would otherwise be difficult and that way have positive impact on self-sufficiency and local livelihoods. In Finland, farming has been traditionally subsidized. In the global context, it is difficult to compete against cheap imports. In the future, Finland's self-sufficiency and national food production is vital if all the global drivers are considered.

The last factor selected was existence of redundancy at different parts of food system securing some level of flexibility. This can be seen providing diversity of options in the crisis situation and, on the other hand, increasing resilience.

Driving forces or forces from macro environment (Schwartz, 1996, 242-243) were limited to the climate change and to the population growth because those were seen as the major ones from the food system perspective and having the major impacts by 2050. In addition, a major trend of control and surveillance was added because it has implications to resilience causing bureaucracy and stiffening of structures.

Table 2 Futures table for panarchy scenarios.

PESTE	Variables	Exploitation or Growth	Conservation	Release	Reorganization
Economic and Technology	Investments on R&D, innovations (e.g. 3D printing)	+	--	-	++
Environmental	Exploitation of natural resources (including oil)	++	+	+	++
Social	Population growth (urbanization)	++	+	--	-
Economic	Homogenization and specialization of the food production (monocultures, larger units)	++	+	--	-
Economic	Concentration (e.g. retail, input industry)	++	+	--	-
Social	Optional food distribution (farmers markets, food circles) or production (small scale farming,)	++	+	--	+
Social	Number of transformative consumers/NGOs movements	++	+	--	+
Political	Command, control, surveillance (WikiLeaks, bureaucracy, policies)	+	++	--	-
Economic	Importing inputs and foods	++	+	--	-
Political	Agricultural subsidies	+	++	--	-
Economic	Existence of "redundancy", providing diversity and flexibility	-	--	+	++

Additionally, the phases of adaptive cycle were added to the futures table: growth, conservation, release and reorganization. Each variable or factor behaves differently at different phases of the adaptive cycle. For example, concentration increases strongly (++) during the growth phase and continues (+) during the conservation phase. During the release and the reorganization phase the concentration is not possible (-- and -). Another example is existence of redundancy. There is little redundancy during the growth phase (-) and even less during the conservation phase (--). But when release and reorganization phases occur, there is more redundancy available (+ and ++).

The process of building the futures table was somewhat heuristic. After futures table was constructed, different hierarchies or "panarchial" structures were considered. The electronic survey to the experts was divided into primary production, food industry, retail and consumption sections, so it is logical to use the same structure here. In fact, each level – national, regional and local – has own actors as described in the Table 3.

2.5.3 Three panarchy scenarios of the Finnish food system

The panarchy of the Finnish food system is presented in the Figure 6. The panarchy of the Finnish food system combined with the adaptive cycle framework and futures table was used to produce the final panarchy scenarios.

To help framing the scenarios, a table format was developed (see Table 3). The panarchy level is described on the left hand side, and the phase of the adaptive cycle after that. Then the panarchy level is divided into retail, food industry, farm and consumer sections when applicable. The upper row shows the variables from the futures table and the table is fulfilled by the plus and minus signs (+ and -) to show how each variable behaves in the panarchy depending on the adaptive cycle phase. To make the exercise little bit simpler and because the national level concerns mainly corporates having primarily strategic role, the national and regional levels were combined. That means that they follow the same adaptive cycle phase in the following scenario construction.

In the first scenario, *Seeds of Transformation* (Table 3), national and regional levels have conservation phase: minimal R&D investments, exploitation of natural resources continues (raw materials). Homogenization and concentration are still proceeding. Control and bureaucracy increase strongly (increasing connectedness) and there is no redundancy (because of efficiency demands).

On the other hand, the local level has reorganization phase meaning that resources are available in the form of renewables and human capital. This, of course, postulates that the development of renewable techniques has been possible and favorable for farmers. The old structures are broken; there is no more or at least less of homogenization, concentration or bureaucracy both for farms and for local food distribution (retail). New transformative movements spread and gain momentum. Such movements could be permaculture or organic farming supporting ecological self-regulation, avoiding chemical inputs such as pesticides and fertilizer. In addition, farms are able to produce value added products by networking and using new mobile and communication technologies. The major change can be seen on profitability. Healthy profitability enables farmers to invest and research new and better (ecological) ways to farm their land and grow their animals. One major driver for better profitability is the new innovative distribution systems and closer contact with the actual consumers. That way the farmers are better able to control their products' pricing and logistics.

Usually, in the adaptive cycle the change proceeds from the lower and faster levels to the upper and slower levels, via so called revolt (Holling, 2001, 398). That may be the case here as well and this scenario may proceed to the following "phase".

Table 3 Panarchy scenario: *Seeds of Transformation*

	Phase of the adaptive cycle		R&D investment, innovation	Exploitation of natural resources	Population growth urbanization	Homogenization	Concentration	Opt. food distribution	Transformative movements	Control, surveillance	Imports	Agri subsidies	Redundancy
National, corporate	Conservation	Retail	- -	+		+	+			++	+		- -
		Food industry	- -	+		+	+			++	+		- -
Regional	Conservation	Food industry	- -	+		+	+			++	+		- -
Local	Reorganization	Farm	++	++		-	-	+		-	-	-	++
		Consumer			-			+	+	-	-		
		Retail	++	++		-	-	+		-	-		++

Initial system structure and variables chosen can also limit the construction of the scenarios. Variables may not be valid as such after certain time. Assumption of major changes (reorganization) is needed to produce radically different scenarios. By 2050 there may not be similar food system, as we know it today. The whole organization or logic may have changed. That is why the second "step" is needed. This kind of "steps" could produce different end result depending on the variables and adaptive cycle phase chosen or conditions, which are assumed to be valid at each time point.

At this second "step", *Successful Transformation* (Table 4), national and regional levels have reorganization phase: big corporations have been divided into smaller units or even disappeared, new and more local ones have emerged. The main driver has been the previous reorganization of the lower i.e. local level. R&D investments and exploitation of natural resources are high (in the form of renewables and human capital). On the other hand, the local level has growth phase now: resources are available (renewables and human capital). From the previous phase, the best transformative production and distribution methods and businesses are now evolving further.

The second step produces new kind of food system businesses run based on sustainability, resilience and consumer well-being. The human capital is fully exploited, so that practically there is no unemployment. There is something to do for everyone, everyone can feel productive and be active part of the community. Children are involved in different food production systems from the young age, so they grow up appreciating land, environment and food.

Larger communities such as cities have been divided into smaller ones to be able to organize the food production, logistics and labor. In cities, there are small-scale farming and domestic production in every home by utilizing new technologies for vegetable and protein production. However, part of the food products (fresh and manufactured) are still delivered from outside the cities, but there are no more huge supermarkets, instead food products are distributed via smaller scale markets and other innovative distribution systems. Even insects are grown to produce protein powder to be used, for example, in 3D printing (McEachran, 2015).

Table 4 Panarchy scenario: *Successful Transformation*

	Phase of the adaptive cycle		R&D investment, innovation	Exploitation of natural resources	Population growth	Homogenization	Concentration	Opt. food distribution	Transformative movements	Control, surveillance	Imports	Agri subsidies	Redundancy
National, corporate	Reorganization	Retail	++	++		-	-			-	-		++
		Food industry	++	++		-	-			-	-		++
Regional	Reorganization	Food industry	++	++		-	-			-	-		++
Local	Growth	Farm	+	++		++	++	+		+	++	+	-
		Consumer		++	++			+	+				
		Retail	+	++		++	++			+	++		-

On the other hand, there might also be less bright futures, *Missed Opportunities* (Table 5). The higher levels of panarchy may end up to the release phase where all the present structures are, one way or the other, paralyzed and that leads to disruption and failure. The reasons, which could lead to this scenario, are the ever-increasing efficiency demands leading to very low resilience and, finally, disruption caused by the climate change or global market failure (for example, unavailability of inputs or fossil fuels).

On the other hand, the lower level i.e. local level has the growth phase, following the previous phase of reorganization: resources are available (renewables and human capital). From the previous phase, the best transformative production and distribution methods and businesses are now evolving further. In this scenario, the future of the whole Finnish food system (and consumer well-being) depends on the ability of local level to take advantage of the new transformative movements and optional food distribution systems to secure food availability for consumers.

Table 5 Panarchy scenario: *Missed Opportunities*.

	Phase of the adaptive cycle		R&D investment, innovation	Exploitation of natural resources	Population growth urbanization	Homogenization	Concentration	Opt. food distribution	Transformative moves	Control, surveillance	Imports	Agri subsidies	Redundancy
National, corporate	Release	Retail	-	+		--	--			--	--		-
		Food industry	-	+		--	--			--	--		-
Regional	Release	Food industry	-	+		--	--			--	--		-
Local	Growth	Farm	+	++		++	++	+		+	++	+	-
		Consumer		++	++			+	+				
		Retail	+	++		++	++			+	++		-

Different scenarios above follow well defined logics described in the particular tables. The variables change in relation to each other and the scenario follows the phases of the adaptive cycle. That makes the scenario construction easy and different scenarios are easy to compare, and they are transparent. There is still some freedom to interpret the changes of the variables allowing some creativity. However, too rigid a structure can be a weakness – how to involve radical interruptions, which mainly but not solely come through release phase. All in all, this tool may be useful when well-structured and very transparent scenario process is needed.

3 MATERIALS AND METHODS

Materials and methods chapter discusses the Delphi method and the data analysis methods utilized in this work. Both rounds of Delphi are discussed including the structure of the expert panel, the structure of questionnaires and questions or claims used in this work.

3.1 Delphi method

The Delphi method is much applied research method in futures research. The Delphi method was originally developed during the 1950s by RAND Corporation's famous think tank based in California, USA. Key persons were Olaf Helmer, Norman Dalkey and Nicholas Rescher. That time the major questions were concerned with military issues and potential future political issues. (Gordon, 2009, 1; Linstone & Turoff, 2002, 10.)

Delphi usually involves an expert panel that answers questionnaires on paper or electronically. The Delphi method has some characteristic features such as anonymity, feedback and iteration – meaning several rounds collecting the feedbacks from experts. The basic idea of Delphi is to use the panel of experts to address the futures issue/s at hand. It is assumed that experts would be more accurate answering questions related to their own specific field. If experts meet face-to-face group dynamics such as power plays, hierarchies, loudest voice wins or difficulties to change opinion, may cause major negative impact in the end results. Such dynamics may prevent the expert group to end up with the best or soundest "solution". All these issues mentioned are prevented when the Delphi method is applied correctly. Delphi is designed to enable a fruitful debate independently from social structures or personalities. (Gordon, 2009, 1.)

The traditional structure of Delphi could be described as sequential rounds where experts answer questions, comment or give feedback to the results from the previous rounds. The Delphi method could be described as a controlled and documented debate about certain issues. (Gordon, 2009, 4.)

As discussed above, Delphi is usually conducted in two or more rounds. Anonymity of the participants is a part of the process, making the commenting and disagreeing easier. In addition to answering ready structured questions, experts are encouraged to add their own comments and explain their answers and views in more detail. In traditional Delphi, the answers of the panel usually start to approach each other during the rounds. On the other hand, in disaggregative Delphi the goal is to find different views of the panelists, which could be used later on, for example, in building scenarios. (Tapio, 2002.)

The benefits of the Delphi method in terms of conducting a research are manifold, including: anonymity, iteration, possibility to collect experts from different fields to contribute, saving time and money, possibility to use different formats like paper or electronic, interviews, workshops and the possibility of combining quantitative and qualitative methods. On the other hand, the possible risks of the Delphi method have mainly to do with the preparation phase of the study. First of all, the structure and expertise of the panel is very important. In addition, the questions have to be formed very carefully to gain the maximum results. Having several rounds in the study may discourage some of the panelists, which may lead to a low response rate during the successive rounds. (Linstone & Turoff, 2002, 4, 6-7.) Delphi is also suitable for broad and complex problems when experts from various fields are needed to give their input (Linstone & Turoff, 2002, 4).

The Delphi method has been used in a lot of research and in many different ways. Especially, combination of qualitative and quantitative information in scenario process is an interesting aspect, though difficult and challenging to implement. (Tapio, Paloniemi, Varho, & Vinnari, 2011.) An interesting approach was applied in the study to construct four alternative futures food consumption scenarios. In this study, in addition to expert views also consumer views were collected both by survey and by workshops (Kirveennummi, Mäkelä, & Saarimaa, 2013). An example of a very sophisticated method is Q_2 scenario technique where the Delphi study is combined with interviews and the futures table method. The quantitative data is analyzed with cluster analysis, interviews are analyzed with content analysis and, finally, the futures table method is applied. (Varho & Tapio, 2013.) In their study, Landeta, Barrutia and Lertxundi used so called "Hybrid Delphi" combining methods having face-to-face contacts and methods having anonymous argumentation (i.e. traditional Delphi method) (Landeta, Barrutia, & Lertxundi, 2011). These examples show that there are many ways the Delphi method could be applied and combined with other methods such as futures table or scenario techniques.

In this study, both rounds are anonymous expert surveys. Both rounds are arranged as electronic expert surveys where participants from different parts of Finnish food system are invited to participate. During the second round, experts, who responded during the first round, comment and express opinions about the future images constructed based on the first round data.

3.1.1 The first round of Delphi

The target groups of the study are the experts of primary production, food industry, retail and consumer attitudes and behavior. The survey was conducted in Finnish (translated questionnaire, see Appendix 1). The behavior-based indicator framework for assessing the resilience of agroecosystems was utilized when constructing the questions (Table 7) (Cabell & Oelofse, 2012). The questions were in the form of claims.

The first round of Delphi was executed with Webropol survey software. The link to the survey was sent to the recipients by email (see Appendix 2) with a short explanation: the purpose of the research and from where the contacts of the survey were acquired.

In general, the selection of panelists or experts is very critical and greatly impacts the final Delphi results. In this survey, the participants were mainly selected from the database of MTT (Agrifood Research Finland, a governmental research institute) and the goal was to include experts having knowledge of each section or subsystem of food system i.e. primary production, food industry, retail and consumer attitudes and behavior. In addition to MTT database, also ProAgria[1] contacts were collected from their web pages.

The first email was send to 602 recipients. Only one email was erroneous and did not reach the recipient. The contacts were from the following groups:

Table 6 Contacts of the expert survey

Type or name of the organizations	**Number of contacts**
ProAgria	123
Food industry	220
Retail	48
Unions and associations related to the food production	50
Research institutes, universities and NGOs	151
Ministry of Agriculture and Forestry	10
Sum	602

In the expert survey, there were claims about primary production, food industry, retail, consumer behavior and attitudes and common claims/question at the end. Most of the claims asked respondent to evaluate the present situation and the situation by 2050. After each and every claim, there was also space for comments and explanations why the respondent answered the way he or she did. At first, a respondent had to select which section he or she wanted to answer. After finalizing that particular section, the survey returned to the selection page and the respondent could select another section or go on answering the common questions and complete the survey.

[1] ProAgria is a Finnish counseling organization for farmers. ProAgria provides knowledge, services and guidance related to agricultural practices and entrepreneurship.

Table 7 Structure of the first round questionnaire (see also Appendix 1).

Indicator s by Cabell and Oelofse	Definition of the indicator	Sections having related questions	# of question s in the survey
1.Socially self-organized	The social components are able to form own configurations based on their needs and desires.	Primary production Consumer	Q3, Q4 Q62, Q63
2.Ecologically self-regulated	Ecological components self-regulate via stabilizing feedback mechanisms that send info back to controlling elements.	Primary production	Q5, Q6
3.Appropriately connected	Connectedness describes the quantity and quality of relationships between system elements.	Primary production Food industry Retail	Q7, Q8 Q29, Q30 Q47, Q48
4.Functional and response diversity (FD and RD)	FD is variety of ecosystem services and RD is range of responses to the environmental change.	Primary production Food industry	Q9, Q10 Q31, Q32
5.Optimally redundant	Critical components and relationships are duplicated in case of failure.	Primary production Food industry Retail	Q11, Q12 Q33, Q34 Q49, Q50
6.Spatial and temporal heterogeneity	Patchiness across the landscape and changes through time.	Primary production	Q13, Q14
7.Exposed to disturbances	The system is exposed to low-level events that cause disruptions without pushing beyond critical threshold.	Primary production	Q17, Q18
8.Coupled with local natural capital	The system functions mainly within regionally available natural resource base and ecosystem services.	Primary production Food industry Retail	Q15, Q16 Q35, Q36 Q53, Q54
9.Reflected and shared learning	Individuals and institutions learn from past and present experimentation to anticipate change and create desirable futures.	Primary production Food industry Retail (Consumer)	Q19, Q20 Q37, Q38 Q51,Q52 (Q60, Q61)
10.Globally autonomous and locally interdependent	The systems has relative autonomy from global control, high level more local cooperation .	Primary production Food industry Retail Consumer	Q21 Q39, Q40 Q45, Q46 Q58, Q59
11.Honors legacy	The current configuration and future trajectories of system are influenced by past conditions and experiences.	Primary production	Q22, Q23
12.Builds human capital	The system takes advantage of and builds social relationships and memberships in social networks.	Primary production Food industry Retail	Q24, Q25, Q27, Q28 Q43, Q44 Q56, Q57
13.Reasonably profitable	The segments of society involved in agriculture are able to make a livelihood from the work they do without relying too heavily on subsidies or secondary employment.	Primary production	Q26

The primary production section had 28 questions (see Table 8 and Appendix 1, Q1-Q28). The question about “being reasonably profitable” and “dependence of imported inputs from global markets” had only future perspective because there are statistics and previous research available showing that average Finnish farms are not very profitable and most of the inputs needed in farms are imported (Niemi & Rikkonen, 2010).

The questions for food industry, retail and consumer behavior and attitudes were also constructed mainly based on the above indicators. However, some of the questions were not suitable for business or consumer context and, therefore, there were fewer questions in these sections. On the other hand, few additional questions were constructed to increase the credibility in otherwise rather limited sections.

The food industry section had 16 questions (see Table 8 and Appendix 1, Q29-Q44). There was one additional question (for the present and the future) about the food industry's responsibility of consumers' well-being; if they genuinely produce products, which enhance consumer well-being, and if the products are clearly labeled to inform about possible unhealthy qualities of the product.

The retail section had 13 questions (see Table 8 and Appendix 1, Q45-Q57). There was only one additional question in this section (only the future aspect). The question was about the future concentration of retail in Finland and the question had only the future aspect because it is a well-known fact that two major chains, S-group and K-group, dominate the market. S-group's market share is 45.7 %, K-group's is 34 %, Suomen Lähikauppa has 7 %, Lidl has 6.6 % and the rest has 6.8 % (Peltola, 2014, 9).

The consumer behavior and attitude section had eight questions (see Table 8 and Appendix 1, Q58-Q65). From Table 8, it can be seen that consumption of local foods and possibilities for self-organization were adapted to consumer context. There were two additional questions in this section (both asking views of the present and the future situation). The first question asked how aware consumers are of their consumption impacts on health and environment. This could loosely be seen representing reflective and shared learning. Another question was about diminishing food waste. Waste is a critical issue when future of food is discussed. It is claimed that even one third of the food produced in the world is wasted or lost during the supply chain and consumption, so it is very important to educate consumers to minimize the food waste (Gustavsson, Cederberg, Sonesson, van Otterdijk, & Meybeck, 2011, v).

In the end of the survey, there were *common questions* for everyone to answer. The first common question asked the respondents view how important it is to understand and to develop resilience (either for primary production, food industry, retail or for research) now and 2050. The third and the final question asked the respondent's own view about his/her professional status (leading expert, professional or novice).

All the questions were in the form of claims and the answers were given into matrixes having Likert scale (1. Strongly disagree, 2. Disagree, 3. Don't know, 4. Agree and 5. Strongly agree) to estimate how much respondent agrees or disagrees in relation to different alternatives.

In the section of primary production, alternatives varied according to the farm sizes and farm types. The farm sizes were small, medium and large and the types of the farms were organic, plant production or livestock farms (total six options). The size of the farm was defined according to the farm's arable land (small: 0-29,99; medium: 30-149,99 and large 150 hectares and over). The indicator about building human capital had only three alternatives asking where the human capital is built: in villages, in municipalities or in cities. Mainly, the purpose was to see if the size of the community is reflected in the results.

In the food industry section, the alternatives were small business, medium size business or large business (having national level operations) and *in retail section* the alternatives were local, national or international player. In consumer section, there were no alternatives; the respondents just selected how much they agree with the claims.

Table 8 Questions or claims of the first round of the expert survey (see Appendix 1). Future (the year 2050) claims followed the same structure.

Indicators	Claims – the present
1. Socially self-organized	**Farmers** are able to act locally or regionally on their own initiative based on their own needs and hopes. **Consumers** are able to make choices and even organize based on their needs and hopes, for example, to support ethical or ideological food choices (such as organic, local, non-gmo, vegan etc. foods).
2. Ecologically self-regulated	**Farmers** exploit ecosystem services, local conditions and natural resources in a way that ecological regulation is possible. This way the need of external inputs decreases (fertilizers, water, pesticides and energy).
3. Appropriately connected	**Farmers** pay attention to diverse stakeholder connections, for example, to minimize risks. They may have several input suppliers, buyers or distributors/channels to their own products. Social contacts to other actors on the field have also been taken care of. **Food companies** have taken into account the importance of diversified connections to their stakeholders, for example, to minimize risks. They have e.g. several suppliers, buyers, target groups or distributors for their products. **Retail companies** have taken into account the importance of diversified connections to their stakeholders, for example, to minimize risks. They have e.g. several suppliers, sales channels or target groups.
4. Functional and response diversity	**Farms** have taken diversity into account in their different functions, for example, with inputs, products (crop diversification) and income sources or even with landscape values. **Food companies** have taken into account diversity in their different functions, for example, in their raw material supplies (several suppliers and several different kinds of raw materials), in their products, distribution and customers.
5. Optimally redundant	**Farms** / **Food companies / Retail companies** have "flexibility" to handle problems or even crisis. They have, for example, spare parts, reserve power, new varieties or additional manpower available. Flexible resources ensure the continuation of the operations in spite of surprises.
6. Spatial and temporal heterogeneity	**Farms** have taken into account the diversity of landscape and land use such as variation of cultivated and uncultivated land, pasture and usage of different cultivation techniques or crop rotation.
7. Exposed to disturbances	**Farms** use "tolerization", for example, by utilizing natural selection and this way adapting species to different conditions. For example, when talking about pest control a small number of pests is used and afterwards the plants showing resistant features are selected. .
8. Coupled with local natural capital	**Farms** operate respecting natural resources and environment. For example, farms do not deplete soil organic matter, do not deplete or contaminate ground or other water resources, use moderately commercial fertilizers or other chemicals and produce only little waste to be taken away. **Food companies** operate respecting natural resources and environment. Food companies do not deplete or contaminate natural resources, water resources and produce only little amounts of waste. **Retail companies** operate respecting natural resources and environment. Retail companies do not deplete or contaminate natural resources, water resources and produce only little amounts of waste.
9. Reflected and shared learning	Learning, active search and sharing of information are essential parts of the **farm** operations. Farms also test new (and old) solutions. Learning, active search and sharing of information and innovative product development and testing are essential parts of the **food company** operations. Learning, active search and sharing of information and innovative solutions and testing are essential parts of the **retail company** operations. Most of the **consumers** are very aware how their choices impact their health and environment.
10. Globally autonomous and locally interdependent	**Farms** are very dependent on inputs such as imported energy, protein feed and chemicals (e.g. pesticides). How about the future: **the year 2050**? Finland is almost self-sufficient with regard to above inputs. Especially, share of imported energy has significantly decreased and it has been replaced by renewable energy sources. **Food companies** are more locally or nationally dependent than dependent on global markets or players to have their raw material or other supplies. **Retail companies** purchase their food supplies more locally or nationally than from global markets. **Consumers** purchase more local or national food supplies than imported food supplies (when possible).
11. Honors legacy	**Farmers** respect traditional knowledge, traditions and honors legacy. They know how to apply old methods to the present situations. Knowhow and experience from the previous generations is appreciated and utilized when the future is thought of.
12. Builds human capital	**Farming communities** / **Food companies / Retail companies** build and develop their different "capitals". Capital comprises e.g. built (technology and infrastructure), culture (knowledge and capabilities of individuals) and social (official and unofficial networks) capital.
13. Reasonably profitable	The average profitability of **farms** is low. How about the future: **the year 2050**? Farms are reasonably profitable. Farms succeed with their work (if they want) without being overly dependent on subsidizes or on work outside the farm (another employer). Farms are neither heavily indebted.

3.1.2 Discussion of the first round of Delphi

Expert survey is a very useful method also in the futures research and could be used in many ways. How successful the research is, depends mainly on the selection and activity of recipients and the quality of questions.

The survey was open for two weeks and two reminders were sent during that time. Final and total number of replies was 63 and the survey was opened by 135 persons in total. The final response rate was 10.5% and from persons who opened the survey the response rate was 46.7%.

The actual final response rate was rather low, but considering the busy target groups and the nature of the survey (there were no direct personal benefits), it is not surprising. The questions/claims were also somewhat difficult being broad, abstract and ambiguous. Because the claims were broad in nature, few respondents commented that it made the answering to some of the claims difficult. One respondent wrote that individual questions had too many separate claims and could not reply because of that.

There were few comments that respondents found it difficult to distinguish between indicator 3, appropriately connected, and indicator 4, functional and response diversity. Both are some way related to connections, but the first (indicator 3) is all about connections and the latter (indicator 4) more about diversity of functions. Seeing the questions afterwards, the framing of the questions could have been clearer.

Some of the questions had high number of "I don't know" replies, which indicates the difficulty of those questions. Such questions were in primary production section – the question about "are farms exposed to small-scale disturbances" and education of farmers. In food production section, such questions were about food businesses' appropriate connections, functional and response diversity and optimal redundancy. In retail section, such questions were about retailers' ability to build human capital, and their optimal redundancy. In general, questions about the future had more "I don't know" replies.

The claims of the survey were constructed so that agreeing with the claim means agreeing with optimum resilience. However, indicator 3 (appropriately connected) could produce "too many" connections, meaning that system becomes too rigid and unable to handle the complex connections properly. It could be said that increasing diversity (indicator 4) for its own sake is not building resilience. However, it was difficult to include any threshold into the claims/questions, especially, when such thresholds are not known, so in the end the claims were left as simple as possible.

3.1.3 The second round of Delphi

The second round of Delphi was organized after the future images were constructed. The second round was also organized as an electronic expert survey by using Webropol software. The link to the survey was sent to the recipients by email with a short explanation (see Appendix 5). The survey was sent to all the experts who had replied during the first round, altogether 63 recipients.

The second round had altogether only 13 questions: six in the primary production section and six in the food industry section. Three future images of primary production and three future images of food industry were presented to the experts. The experts were able to choose whether they wanted to answer only the primary production section or the food industry section. It was also possible to answer both of the sections. The experts were asked to evaluate both probability and desirability of each future image (Likert scale 1-5). In addition, they had an opportunity to explain verbally why they made their choices. Additionally, in the end of the survey the experts were asked how familiar they are with the term “resilience”.

3.1.4 Discussion of the second round of Delphi

The respond rate was rather good probably because the survey was sent to people who had already replied and shown interest. The survey was open for two weeks and one reminder was sent during that time. Altogether there were 23 replies and the final response rate was 36.5%. From persons who opened the survey (41) the response rate was 56%.

The second round was easier and much shorter, so the amount of “I don’t know” answers was low, except for the *agile food industry* future image and its probability question (23%). It appeared to be difficult to evaluate. In the open comments, the respondents wrote that this kind of future is not possible at all and Finland is and will be dependent on global markets. On the other hand, in this particular question no one regarded this future image to be “not at all desirable or probable”, which is in conflict with the written comments.

From the open comments, it seems that some of the respondents didn’t remember or understand that the future images are based on the first round replies and wondered why there are such peculiar future images. In addition, the section of food industry had some defensive comments about food industry’s actions and dependency on global markets. It might be that the respondent thought that the author presented purely her own ideas in the future images.

3.2 Data analysis methods

The data from the first round of Delphi was analyzed by using several methods. First, the present resilience was analyzed by studying average answers. The same was done for the future resilience by the year 2050. In addition, the present and the future resilience change was studied relatively. Finally, to develop futures images the cluster analysis method was utilized.

In general, based on frequencies of future resilience, it can be said that the majority of experts have very positive view of the future. It is difficult to say whether it is realistic or “wishful thinking”. On the other hand, the present resilience had more variation when evaluating resilience indicators (i.e. agreement or disagreement with the claims). Strongest disagreements appeared in food industry and retail sections (meaning lack of resilience). That is why the present resilience estimations could be seen rather reliable or realistic, especially in these sections. In addition, at the end of the survey the respondents reported the length of their career and the average was 21.6 years (from 4 years up to 45 years). It could be said that the survey had very experienced professionals answering the questions.

The present and the future resilience estimations of the experts were analyzed by comparing the average answers of the expert survey. Because of the Likert scale used in the questionnaire, it was reasonable to produce intervals for analyzing and presentation of the answers. In the result tables, green indicates resilience (average of the expert answers in between 3.4-5), yellow less resilience (average in between 2.7-3.3) and red lack of resilience (average in between 0-2.6).

Relative percentage change was calculated by subtracting an average of present value answered by the experts from an average of future value and the result was divided with the present value and multiplied with 100 giving the percentage values. It was possible to analyze where the experts foresee the major relative changes from the present status to the future by 2050.

To develop futures images, the cluster analysis method was utilized. SPSS software was used for cluster analysis and more specifically “Hierarchical” cluster analysis. Both “Furthest neighbor” and “Ward’s” methods were tested and, in the end, both gave similar results showing same individuals in the dendrograms (see dendrograms in Appendix 3 and 4). A dendrogram is a “tree diagram” illustrating the arrangement of the clusters produced by hierarchical clustering. The hierarchical clustering method builds the hierarchy from the individual answers by progressively merging closely related clusters or answers. Usually, two closest elements are chosen at first. Then the process is continued until all the elements or individuals are clustered.

After the dendrograms were analyzed, the cluster centers were calculated in Excel. To help visualization and analysis also graphical representations were produced (see Figure 12) and finally placed into table (Table 18).

The second round was analyzed simply by using % distribution of respondents' answers. That was directly obtained from Webropol and graphical illustrations were produced.

4 RESULTS

This chapter discusses the results of both Delphi rounds. First, the experts' views of the present resilience are presented and then the views about the future state by the year 2050 are presented. Then the relative change of resilience is shown to investigate where the experts view major changes to be occurring by the year 2050. In addition, the first round results are analyzed with cluster analysis and future images are constructed based on the results. The second round results of Delphi, the probability and the desirability of the future images are presented at the end of this chapter.

4.1 Present resilience of the Finnish food system

4.1.1 Primary production

On average, 26 respondents answered the expert survey section of the primary production. The number of replies varied between 24 and 30 depending on a question. The results were analyzed by Webropol analytics. Figures 7 and 8 below show the results of questions 5 and 6 respectively as examples. Even if informative, it is difficult to have any deeper analysis or definite conclusions. Therefore, the results were exported to Excel and analyzed further.

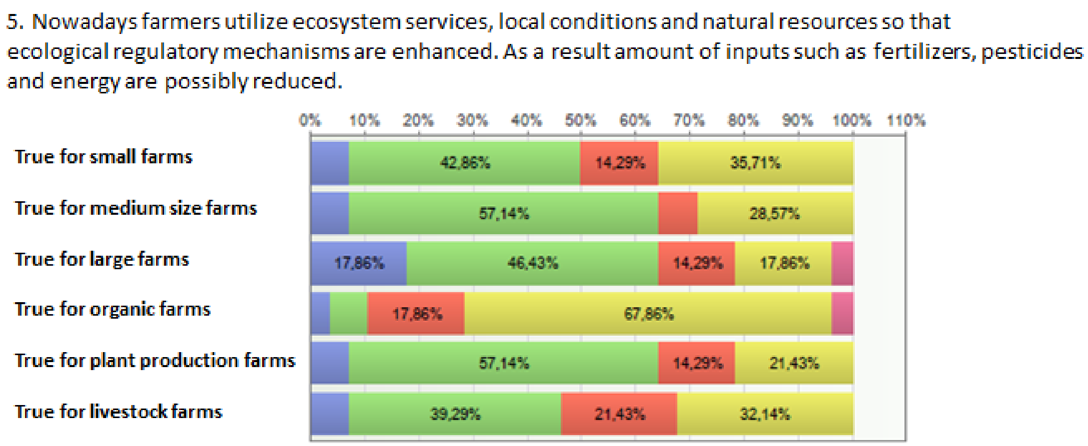


Figure 7 An example question/claim and answers from the expert survey: Q5 ecological self-regulation – present status. Purple and yellow colors indicate strong agreement and agreement. Red indicates "I don't know". Blue and green colors indicate strong disagreement and disagreement.

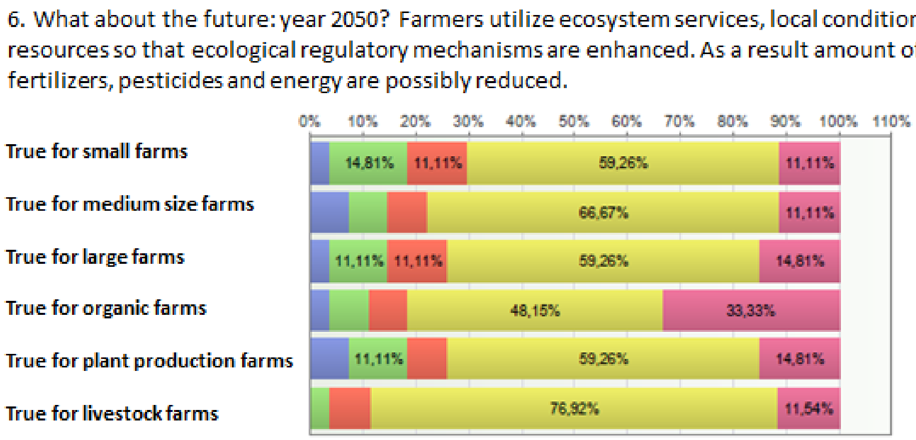


Figure 8 An example question/claim and answers from the expert survey: Q6 ecological self-regulation - future state by 2050. Purple and yellow colors present strong agreement and agreement. Red color indicates “I don’t know”. Blue and green colors indicate strong disagreement and disagreement.

In the result tables below, green color indicates resilience (average of expert answers in between 3.5-5), yellow color less resilience (average of the expert answers in between 2.6-3.4) and red color lack of resilience (average of the expert answers in between 0-2.5). The scale used in the questionnaire was the Likert scale (1-5). Unfortunately, this analysis is not very sophisticated because the elimination of “I don’t know” answers from the original data was not possible. It is problematic because there were quite many “I don’t know” answers in some of the questions (see the sub-chapter 3.1.2), so that distracts the averages and makes them less reliable. However, the summary tables below give some idea how the experts see the present status of resilience and where there is room for improvement.

In Table 9, there are the results of the expert views for primary production presented (except indicator 12, which has a different scale and could not be placed in the table and indicators 10 and 13, which only had future perspective in the survey).

If the expert views are examined for resilience, especially the indicator for reflected and shared learning is noteworthy; all farm types, except the small ones, are seen operating resiliently. The experts see medium, large and organic farms socially self-organizing. In addition, small, medium and organic farms honor legacy and show resilience in that respective.

The question about the education level of farmers shows resilience for all farm types, except for the small and medium size farms. According to the experts’ view, the indicator for building human capital in different communities showed resilient behaviors only for municipalities (not for cities or villages).

As a conclusion, it can be said that experts see farmers at some degree able to self-organize, well educated, able and willing to share their learnings and know-how, which means they are having the capabilities to develop their livelihoods and possibly originate new behaviors or structures even transformations. Municipalities are seen the most supportive for building human capital (build infrastructure, technology, culture and social capital).

On the other hand, if the expert views are examined for the lack of resilience ecological self-regulation in connection with medium, large and plant production farms is notable. In addition, functional and response diversity in connection with large farms, plant production and livestock farms show lack of resilience according to the experts. Especially, coupling with local natural capital shows lack of resilience. Only exception is organic farms showing relatively better resilience. It can be said that, according to the expert views, farms are not very well coupled to the local environment and do not utilize local natural resources, ecosystem services or diversity the way they could to be able to reduce the inputs such as fertilizers, pesticides or energy and that way to enhance their independence and resilience.

Furthermore, the farms appear to function efficiently and have little redundancy to cope with unexpected situations. Some respondents commented that farms have prepared for some common unusual situations such as power failure, but there are no possibilities to have much redundancy because of the very tight financial situation.

Additionally, the results can be analyzed to see if there are any farm types, which behave more resiliently than the others. According to the experts' view, the organic farms are most resilient.

Table 9 The present status of resilience of primary production according to average responses in the expert survey. Green indicates resilience (average 3.4-5), yellow less resilience (2.7-3.3) and red lack of resilience (0-2.6).

Indicator	**True for small farms**	**True for medium size farms**	**True for large farms**	**True for organic farms**	**True for plant production farms**	**True for livestock farms**	**In total**
1. Socially self-organized	3,33	3,44	3,41	3,59	3,3	3,11	3,36
2. Ecologically self-regulated	2,79	2,57	2,43	3,61	2,5	2,79	2,78
3. Appropriately connected	2,38	2,67	3,13	3,04	3,04	2,71	2,83
4. Functional and response diversity	3,08	2,85	2,5	3,65	2,5	2,46	2,84
5. Optimally redundant	2,88	2,80	2,76	2,96	2,88	2,72	2,83
6. Spatial and temporal heterogeneity	2,96	2,88	3,00	4,08	2,69	3,31	3,15
7. Exposed to low-level disturbances	3,30	3,41	3,22	3,93	3,37	3,22	3,41
8. Coupled with local natural capital	2,2	2,27	2,23	2,76	2,23	2,15	2,31
9. Reflected and shared learning	3,23	3,48	4,12	4,00	3,80	3,96	3,77
11. Honors legacy	3,52	3,37	3,00	3,85	3,26	3,30	3,38
Farmers have middle level or higher education	3,08	3,31	3,85	3,65	3,46	3,54	3,48
In total	2,98	3,02	3,12	3,52	3,00	3,09	

4.1.2 Food industry

The food industry section of the expert survey had between 20 and 22 respondents, depending on a question, which is little bit less than in the primary production section.

The experts' views of the present resilience of food industry are analyzed in Table 10. If indicators showing resilience are analyzed, it can be seen that for all business types only coupled with local natural capital or environmental responsibility indicator shows resilience, except for the small businesses. The experts see food industry taking responsibility of its environment and respect natural resources. That also included water resources and efficient waste management. On the other hand, optimal redundancy indicator shows lack of resilience for small and medium businesses, meaning that experts consider that currently food industry operates very efficiently and do not have much redundancy available. The large businesses have more redundancy or access to additional capacity or resources. Written comments confirm this conclusion. In addition, the question about the food industry's responsibility towards consumers' well-being shows less resilience according to the experts.

Furthermore, the expert views can be analyzed to see if there is any food industry business type, which operates more resiliently than the others. It seems that large businesses are more resilient and have better average value in total than the other two types of businesses. However, even if small businesses do not show resilience for indicators such as appropriately connected, functional and response diversity or optimally redundant probably because of limited resources, they show resilience for indicators such as globally autonomous and locally interdependent and building local human capital, which seems to be logical small business being locally influential and active.

Table 10 The present status of resilience of food industry according to the average responses in the expert survey. Green indicates resilience (average 3.4-5), yellow less resilience (2.7-3.3) and red lack of resilience (0-2.6).

Indicator	**True for small businesses**	**True for medium size businesses**	**True for large businesses**	**In total**
3. Appropriately connected	2,55	3,36	3,82	3,24
4. Functional and response diversity	2,45	3,09	3,59	3,05
5. Optimally redundant	2,19	2,62	2,90	2,57
8. Coupled with local natural capital / environmental responsibility	3,05	3,36	3,36	3,26
9. Reflected and shared learning, innovation	2,86	3,19	3,95	3,33
10. Globally autonomous and locally interdependent	3,43	3,10	2,38	2,97
12. Builds local human capital	3,43	3,29	2,90	3,21
Food industry takes responsibility of consumer well-being	2,90	2,95	2,95	2,94
In total	2,9	3,12	3,23	

4.1.3 Retail

The retail section of the expert survey had between 13 and 14 respondents, which is less than in previous sections. There were also less retail contacts in the original mailing list.

The present resilience of retail is presented in Table 11. In general, the experts responding to the retail section see the retail actors not being resilient; the lack of resilience clearly dominates the expert views. The experts see only appropriately connected and reflected and shared learning indicators showing resilience for national and international actors, meaning that presently those retail actors have appropriate connections to their stakeholders to minimize risks e.g. enough connections to suppliers, several sales channels and customer groups. This is logical, also seen from the efficiency point of view. According to the comments, these connections are not seen as a tradeoff to maintain flexibility but necessity to minimize the risks. Additionally, these actors perform shared learning and innovation practices at least with their stakeholders. On the other hand, local and national actors are seen more globally autonomous and locally interdependent.

Optimal redundancy, coupled with local natural capital or environmental responsibility, and building of local human capital indicators are showing lack of resilience according to the experts. These indicators could be seen as tradeoffs of efficiency. Present business models do not support or value this kind of activities.

Table 11 The present status of resilience of retail according to the average responses in the expert survey. Green indicates resilience (average 3.4-5), yellow less resilience (2.7-3.3) and red lack of resilience (0-2.6).

Indicator	**True for local actors**	**True for national actors**	**True for international actors**	**In total**
3. Appropriately connected	3,07	3,64	3,86	3,52
5. Optimally redundant	2,57	2,5	2,93	2,67
8. Coupled with local natural capital / environmental responsibility	2,92	2,54	2,23	2,56
9. Reflected and shared learning, innovation	2,77	3,38	3,83	3,33
10. Globally autonomous and locally interdependent	3,31	2,92	1,69	2,64
12. Builds local human capital	2,46	2,62	2,31	2,46
In total	2,85	2,93	2,80	

4.1.4 Consumer behavior and consumption

Many respondents replied this section in addition to some other section/s in the expert survey (N= 36…37). In consumer section, the respondent just had to decide how much to agree or disagree with the claims. There were just four questions, which reflect current resilience of consumer behaviors.

According to the experts, two indicators were seen showing less resilience (yellow color): consumption of local foods and possibilities for self-organization. These questions were directly applied from the original indicators into consumer context. On the other hand, awareness of consumers i.e. knowledge how food affects health and environment was seen currently representing lack of resilient behavior. This question could be seen representing reflective and shared learning indicator because to be able to understand all the impacts of personal consumption, it requires extensive learning and ability to see desirable futures. In addition, the experts viewed indicators current awareness of food waste and activities to diminish the waste showing lack of resilience as well. All in all, there were no resilient behaviors, according to the experts, in this section. However, there were only four questions, which is not enough to make any further conclusions about the current resilience of consumer behavior.

4.2 Resilience of the Finnish food system by 2050

4.2.1 Primary production 2050

Table 12 shows how the experts view the future resilience of primary production by the year 2050. It is clear that they strongly believe in positive developments and majority of the indicators are green meaning resilient operations and behaviors prevail by 2050.

Only the indicator for optimal redundancy shows not that resilient behavior for all the farm types. Similarly, the indicator for reasonable profitability shows less resilience for all farm types except for large farms. It appears that the experts believe that large farms may have the best opportunities to have profitable business (efficiency demands). Furthermore, the indicator for globally autonomous and locally interdependent farming shows less resilience for large and plant production farms. It might be that the experts think large and plant production farms being more dependent on imports such as feeds, fertilizers and pesticides.

Table 12 Resilience of the primary production by 2050 according to the average responses in the expert survey. Green indicates resilience (average 3.4-5), yellow less resilience (2.7-3.3) and red lack of resilience (0-2.6).

Indicator	**True for small farms**	**True for medium size farms**	**True for large farms**	**True for organic farms**	**True for plant production farms**	**True for livestock farms**	**In total**
1. Socially self-organized	3,74	3,63	3,52	3,89	3,59	3,44	3,64
2. Ecologically self-regulated	3,59	3,67	3,7	4,00	3,63	3,96	3,76
3. Appropriately connected	3,56	3,79	3,88	3,96	3,92	3,72	3,81
4. Functional and response diversity	3,73	3,73	3,54	3,92	3,65	3,35	3,65
5. Optimally redundant	2,96	3,08	3,00	3,20	3,16	3,00	3,07
6. Spatial and temporal heterogeneity	3,50	3,69	3,96	4,24	3,68	3,88	3,83
7. Exposed to low-level disturbances	3,38	3,35	3,31	3,58	3,38	3,38	3,40
8. Coupled with local natural capital	3,96	4,23	4,24	4,38	4,19	4,23	4,21
9. Reflected and shared learning	4,16	4,24	4,40	4,36	4,32	4,36	4,31
10. Globally autonomous and locally interdependent	3,42	3,35	3,31	3,54	3,31	3,58	3,42
11. Honors legacy	3,7	3,56	3,37	3,78	3,59	3,59	3,60
13.Reasonably profitable	2,62	2,85	3,42	3,15	3,12	3,31	3,08
Farmers have middle level or higher education	3.81	4,04	4,27	4,19	4,08	4,19	4,10
In total	3,55	3,63	3,67	3,86	3,66	3,55	

4.2.2 Food industry 2050

Table 13 shows how the experts view the future resilience of Finnish food industry by 2050. The development is clearly positive and the table shows more resilient behaviors when compared to the present status. Especially, indicator coupled with local natural capital or environmental responsibility and indicator reflected and shared learning, innovation show resilience for all business sizes. In addition, the experts foresee food industry taking responsibility of consumer well-being and, accordingly, developing resilient operations for all business sizes.

On the other hand, the indicators optimally redundant and globally autonomous and locally interdependent show yellow or red, indicating not that resilient operation. The experts foresee also that for small businesses the indicator appropriately connected shows lack of resilience and for large businesses the indicator globally autonomous and locally interdependent shows lack of resilience in the future.

Table 13 Resilience of the food industry by 2050 according to the average responses in the expert survey. Green indicates resilience (average 3.4-5), yellow less resilience (2.7-3.3) and red lack of resilience (0-2.6).

Indicator	**True for small businesses**	**True for medium size businesses**	**True for large businesses**	**In total**
3. Appropriately connected	2,45	3,09	3,59	3,05
4. Functional and response diversity	3,33	3,71	4,05	3,70
5. Optimally redundant	2,81	2,90	3,00	2,90
8. Coupled with local natural capital / environmental responsibility	4,00	4,14	4,05	4,06
9. Reflected and shared learning, innovation	3,81	3,95	4,10	3,95
10. Globally autonomous and locally interdependent	3,10	2,76	2,14	2,67
12. Builds local human capital	3,9	3,85	3,67	3,81
Food industry takes responsibility of consumer well-being	3,95	3,90	3,75	3,87
In total	3,42	3,53	3,54	

4.2.3 Retail 2050

Table 14 presents how the experts view the future resilience of retail actors by 2050. The development is clearly positive. Especially, the indicators appropriately connected, coupled with local natural capital or environmental responsibility and reflected and shared learning, innovation show all green meaning resilience by 2050.

On the other hand, the indicators optimally redundant and globally autonomous and locally interdependent, and the extra question about reduced concentration show mainly yellow meaning less resilient operations. Additionally, the experts foresee that international actors of retail business would be dependent on global markets. International retail would still acquire products from global markets. That is logical if present systems and business models persist. For local actors, the experts foresee more autonomy from the global markets and less concentration.

Table 14 Future resilience of the retail actors according to the average responses in the expert survey. Green indicates resilience (average 3.4-5), yellow less resilience (2.7-3.3) and red lack of resilience (0-2.6).

Indicator	**True for local actors**	**True for national actors**	**True for international actors**	**In total**
3. Appropriately connected	3,85	4,15	3,85	3,95
5. Optimally redundant	2,75	2,85	3,15	2,92
8. Coupled with local natural capital / environmental responsibility	4,38	4,08	3,69	4,05
9. Reflected and shared learning, innovation	4,00	4,08	4,25	4,11
10. Globally autonomous and locally interdependent	3,85	3,33	2,15	3,11
12. Builds local human capital	4,00	3,62	3,31	3,64
Reduced concentration	3,92	3,23	3,08	3,41
In total	3,82	3,62	3,35	

4.2.4 Consumer behavior and consumption 2050

Four questions and indicators of consumer behavior are all green meaning that consumer behavior, according to the experts, would be resilient by 2050. Consumers are foreseen to consume mainly local and national food products (indicator 10; average value 3.65) and consumers are aware of the health and the environmental impacts of their consumer choices (average value 3.84). In addition, consumers are foreseen to be able to self-organize according to their specific preferences or needs (indicator 1; average value 4.08), which may enable different transformational movements. Moreover, consumers are foreseen to be aware of environmental impacts of food waste and they are actively reducing their waste (average value 4.00).

4.3 Relative change of resilience of the Finnish food system by 2050

This section presents the future views of the experts about the indicators' relative percentage change by 2050. Relative percentage change is used because resilience has no absolute values, but relative change indicates where major changes of resilience occur according to the experts.

4.3.1 Primary production

The largest relative changes can be seen for the following indicators for primary production (see Table 11): ecologically self-regulated, appropriately connected, and exposed to small-scale disturbances. However, the last one is not a reliable result because there were on average over 30% "I don't know" replies. Written comments related to ecologically self-regulated emphasized the well-known problem in Finland; separation between livestock farms and plant production farms, meaning that manure produced by livestock is not exploited efficiently (often because of logistics). The respondents also commented that there is a long way for farmers to really understand and exploit ecosystem services and local natural resources. However, organic farms were seen as positive exceptions. Relative change for the organic farms appeared to be smaller than to the other farm types because they are seen already behaving resiliently. The comments also emphasized that it is critical and necessary for future sustainability (and resilience) to learn and exploit sustainably ecosystem services and local natural resources. Some respondents also commented that when prices of inputs (oil, fertilizers and pesticides) will rise only then other options are searched and evaluated seriously.

On the other hand, the smallest relative changes can be seen for the following indicators: socially self-organized, optimally redundant, honors legacy, and building human capital.

In addition, indicators globally autonomous and locally interdependent and reasonably profitable had only future aspect, so they only have averages and no relative percentage changes.

Table 15 Primary production, relative percentage change.

Primary production	Q4-Q3	Q6-Q5	Q8-Q7	Q10-Q9	Q12-Q11	Q14-Q13	Q18-Q17	Q16-Q15
Indicator	1. Socially self-organizing	2. Ecologically self-regulated	3. Appropriately connected	4. Functional and response diversity	5. Optimally reduntant	6. Spatial and temporal heterogenity	7. Exposed to small scale disturbances	8. Coupled with local natural capital
				Relative change %				
True for small farms	12	29	50	21	3	18	54	20
True for medium size farms	6	43	42	31	10	28	48	24
True for large farms	3	52	24	42	9	32	48	32
True for organic farms	8	11	30	7	8	4	30	11
True for plant production farms	9	45	29	46	10	37	52	24
True for livestock farms	11	42	37	36	10	17	57	31
All together	8	35	35	29	8	22	47	23

Primary production	Q20-Q19	Q21	Q23-Q22	Q26	Q28-Q27
Indicator	9. Reflective and shared learning	10. Globally autonomous and locally interdependent	11. Honors legacy	12. Reasonably profitable	Education of the farmer
	Relative change %	Mean (only future aspect)	Relative change %	Mean (only future aspect)	Relative change %
True for small farms	29	3,42	5	2,62	24
True for medium size farms	22	3,35	6	2,85	22
True for large farms	7	3,31	12	3,42	11
True for organic farms	9	3,54	-2	3,15	15
True for plant production farms	14	3,31	10	3,12	18
True for livestock farms	10	3,58	9	3,31	18
All together	14	3,42	7	3,08	18

Primary production	Q25-Q24
Indicator	13.Community builds capital
	Relative change %
True for villages	2
True for municipalities	-2
True for cities	5
All together	1

4.3.2 Food industry

Unlike primary production responders, food industry experts foresee also negative developments for some of the indicators. Indicators appropriately connected and globally autonomous and locally interdependent both show clear negative change from the present status compared to the year 2050. On the other hand, clear positive developments are foreseen for some indicators such as coupled with local natural capital and functional and response diversity.

Interestingly, the additional question about the food industry's responsibility of consumer well-being showed the most positive developments, indicating that experts foresee some major changes how food industry takes responsibility of the effects their products have on consumer health. That may also indicate major changes in the future legislation guiding the food industry.

According to the experts, the small food industry businesses show more positive behavior and future developments compared to the other business sizes. Especially, functional and response diversity showed most positive values for small businesses.

Table 16 Food industry, relative percentage change.

Food industry (future - present)	Q30-Q29	Q32-Q31	Q34-Q33	Q36-Q35	Q38-Q37	Q40-Q39	Q44-Q43	Q42-Q41
Indicator	1.Appropriately connected	4.Functional and response diversity	5.Optimally reduntant	8.Coupled with local natural capital	9.Reflective and shared learning, innovation	10.Globally autonomous and locally interdepende	12.Builds local capital	Responsibility of consumer well-being
			Relative change %					
True for small businesses	-4	36	28	31	33	-10	14	36
True for medium size businesses	-8	20	11	23	24	-11	17	32
True for large businesses (national)	-6	13	3	21	4	-10	27	27
All together	-6	21	13	25	19	-10	19	32

4.3.3 Retail

The experts of retail foresee only positive developments and no negative relative changes from the present to the future. The most significant changes are for indicators coupled with local natural capital and builds local human capital. The experts foresee major developments for these indicators in the future. On the other hand, the smallest changes are foreseen for indicators optimally redundant and appropriately connected. Indicator appropriately connected was seen resilient already at present state, so it is logical not to have large developments for this indicator.

Table 17 Retail, relative percentage change.

Retail	Q48-Q47	Q50-Q49	Q54-Q53	Q52-Q51	Q46-Q45	Q57-Q56	Q55
Indicator	1. Appropriately connected	5. Optimally reduntant	8. Coupled with local natural capital	9. Reflective and shared learning, innovation	10. Globally autonomous and locally interdependent	12. Builds local capital	Consentration will be reduced
			Relative change %				Mean, only future
True for local actors	25	7	50	44	16	63	3,92
True for national actors	14	14	61	21	14	38	3,23
True for international actors	0	8	65	11	27	43	3,08
All together	12	9	58	23	18	48	3,41

4.3.4 Consumer behavior and consumption

The experts of consumer behavior foresee only positive developments and no negative relative changes from the present to the future (Figure 9). The most significant changes are for the diminishing the food waste and the consumption awareness. These two can be seen related because when the awareness increases also the role of waste is probably better understood.

On the other hand, the relative change of "consumption of local foods" changes only slightly (10%) and "possibilities for self-organization" increases also (26%). Compared to the present values in the previous section, the ones, which had the most positive values, have changed relatively less (consumption of local foods and possibilities to self-organization). That makes sense because if those are seen possessing rather resilient behavior already at the moment, the future change is not necessarily large.

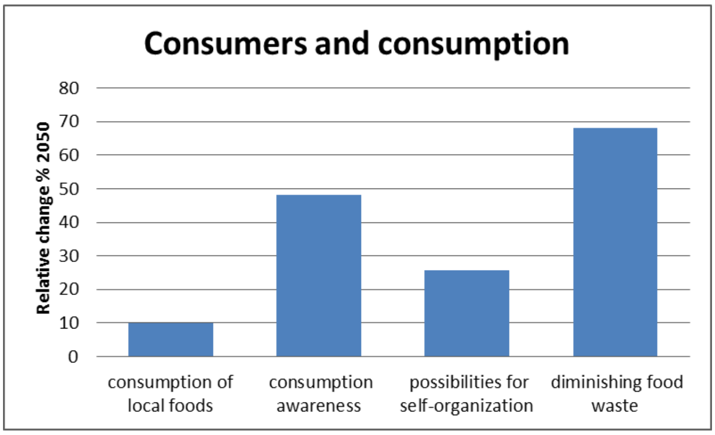


Figure 9 Consumers; relative percentage change of indicators by 2050

4.4 Cluster analysis and images of the probable futures

Cluster analysis was performed in order to construct the future images. The analysis was conducted to "future average values minus present average values" to have greater emphasis in the actual change between the present and the future status.

Primary production section had 20 valid cases, food industry section 18 valid cases and consumer section 36 valid cases for cluster analysis. Retail section had only 10 valid cases and cluster analysis did not produce usable clusters and, therefore, the future images were not produced either. The consumer section had too few questions (only 4) to produce really interesting future images. Therefore, the future images were produced for primary production and for food industry.

Figure 10 shows two of the indicators with the clusters (one for primary production and one for food industry) and also how the figures were used to "quantify" the differences between the clusters. Because there was no significant differences or only few deviations between farm types (primary production) or business sized (food industry), it was decided that only variations between clusters are taken into account. Each indicator was analyzed by marking each cluster between +++ and - - depending their relative positions to each other. This was a rather heuristic method, but produced accurate enough results to make the clusters "visible". In Table 18 the clusters and their analysis are presented in more detail. It must be mentioned that the term 'future images' is used here to differentiate it from the scenarios. In this case, the future images are not fully developed or entirely logical (like scenarios usually are).

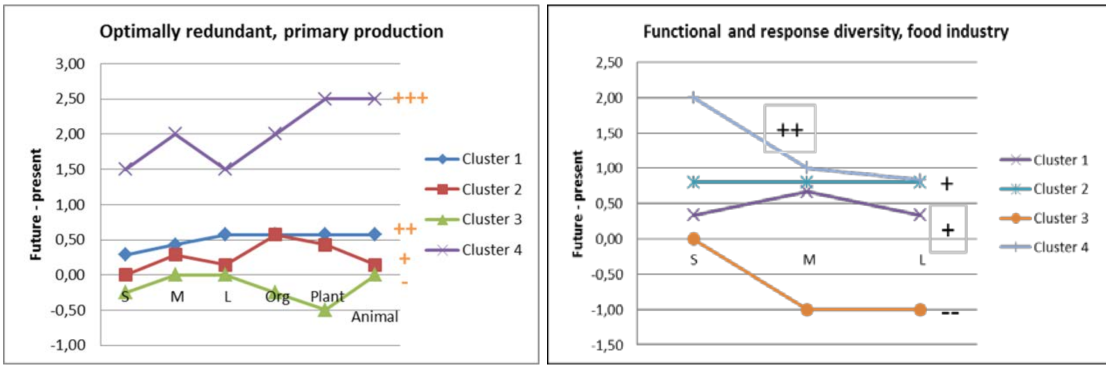


Figure 10 The results of cluster analysis of the responses from the expert survey by two exemplary indicators. Figures above are examples of indicators from primary production and food industry. The average of the present value was deducted from the average of the future value; Y-axis shows the relative change. X-axis displays variables (primary production: small, medium, large farm size, organic, plant or livestock farms; food industry: small, medium, large businesses). Plus and minus signs indicate clusters' relative position to each other (see summary in Table 18).

Based on the Table 18, the images of the probable futures by the experts were constructed. For the primary production, the most "optimistic" future is called *"Resilient agriculture"*, cluster 4, which foresees the probable future to be very resilient. On the other hand, *"Externally controlled agriculture"* could be formed from cluster 3, which is the most "pessimistic". Somewhere between the previous ones is *"Technological agriculture"*, which is formed from clusters 1 and 2 (because they are very close to each other).

Exactly the same can be done for the clusters of food industry. Cluster 4, *"Resilient and innovative food industry"*, is the most "optimistic" and foresees the probable future to be very resilient. On the other hand, the future image *"Food industry depending on global markets"* could be formed from cluster 3, which is the most "pessimistic". Somewhere between the previous ones is *"Agile food industry"*, which is formed from clusters 1 and 2.

Table 18 Comparison of the clusters in relation to each other – the summary table.

	Primary production				Food industry			
Indicators below / Future images on the right	Technological agriculture (clusters 1 and 2)		Externally controlled agriculture (cluster 3)	Resilient agriculture (cluster 4)	Agile food industry (clusters 1 and 2)		Food industry depending on global markets (cluster 3)	Resilient and innovative food industry (cluster 4)
1. Socially self-organized	+	+	-	+				
2. Ecologically self-regulated	++	+	+	+++				
3. Appropriately connected	+	+	+	++	+	+	- -	++
4. Functional and response diversity	+	+	+	++	+	+	-	++
5. Optimally redundant	+	++	-	+++	+	-	0	++
6. Spatial and temporal heterogeneity	+	+	+	+++				
7. Exposed to low level disturbances	++	+	-	+++				
8. Coupled with local natural capital	++	+	-	+++	+	+	+	++
9. Reflected and shared learning	+	+	+	++	+	0	+	++
10. Globally autonomous and locally interdependent	++	+	++	+++	0	+	- -	-
11. Honors legacy	- -	+	+	++				
12. Builds local human capital	-	- -	+	++	+	0	0	+
13. Reasonably profitable	+++	+	+	+++				
Total	**14**	**11**	**6**	**32**	**6**	**3**	**-3**	**10**

4.4.1 Future images of the primary production

"Resilient agriculture" (cluster 4) is a future image foreseeing all the indicators having positive values, meaning that the future will develop towards more resilient operations. Farmers make use of ecosystem services, local conditions and natural resources in ways, which enables ecological regulation. The need of external inputs has decreased (e.g. fertilizers, water, pesticides and energy). Farms have redundancy or "flexibility" including strong networks to handle sudden problems or even crisis. Farmers are able and they want to form networks to develop their livelihoods and knowhow. In addition, the knowhow of the previous generations is highly appreciated and it is extensively utilized and again transferred to the new generation. Farmers pay attention to diverse stakeholder connections and they have several input suppliers, buyers or distributors/channels to their products. Social contacts to colleagues are important. All connections enhance networking and transfer of knowledge. National agriculture is not dependent on global markets. Instead, it is almost self-sufficient in terms of e.g. inputs and energy (renewable). All in all, agriculture is profitable and national agriculture is highly appreciated.

“*Technological agriculture*” (clusters 1 and 2) is a future image foreseeing the primary production developing towards more resilient operations. This is especially reflected in a respect and appreciation for natural resources also because of factors such as natural catastrophes and legislative changes. New technologies have also advanced sustainable use of natural resources. Farmers have only few connections to their stakeholders and the main motivation being financial benefits. Human capital is not appreciated and it is not developed in different forms such as social contacts or networks. The legacy from the previous generations is not appreciated either. Because of that, new technologies rapidly gain ground without a long-term view of their feasibility to specific circumstances or environments. Primary production is reasonably profitable because of technological developments and innovations in the field of energy production.

“*Externally controlled agriculture*” (cluster 3) is a future image foreseeing that processes and operations of primary production have not developed towards resiliency and the short-term efficiency and economy are the main drivers. Farmers do not have opportunities to self-organize (no time or resources). That means they have limited opportunities to build networks and develop their competencies. This may be one reason for low profitability. Farms rarely act ecologically or exploit sustainably ecosystem services or natural resources. Long-term sustainability is sacrificed in the name of profits. Farms have limited connections to their stakeholders such as customers and input industry. That leads to the dependency on these few connections. Farms have no redundancy either, which causes further dependency on external resources.

4.4.2 Future images of the food industry

“*Resilient and innovative food industry*” (cluster 4) is a future image foreseeing that industry respects natural resources and environment. Food industry companies do not pollute or impoverish their environment. They have acknowledged the importance of versatile connections (to their stakeholders) and functions (compensatory operations). Many food companies are also active members of local communities taking part into community development (when activities support company values). Learning, acquiring and sharing knowledge, in addition to innovative product development, are essential to food industry. End results can be seen all the way to consumer well-being. In other words, the food industry also takes responsibility of consumer well-being. The food industry is dependent on global markets, but utilizes national and local raw materials when convenient and economical.

“*Agile food industry*” (clusters 1 and 2) is a future image foreseeing the food industry aiming to be independent from the volatile global markets and it is actively co-developing national and local food production. Fierce competition causes adverse effects on the environment, even though the goal is to reduce these impacts. Diversity has been taken into account in raw material procurements and in modes of operation. There are several suppliers and new compensatory modes of operation are actively looked for. Diverse connections to stakeholders such as retail, producers, distributors, decision makers and consumers are actively maintained. However, the long-term vision and the development of the networks are still missing.

"Food industry depending on global markets" (cluster 3) is a future image foreseeing the food industry being heavily dependent on global markets. Because of that, connections to local and national stakeholders are weak and connections to global actors are mainly based on economic factors. Raw material and product purchases from the global markets are the main focuses. Because of volatile prices and changing availabilities, the resource intensity of procurement increases. The Finnish food industry is very sensitive to the global market forces and it has no resources to prepare for potential crises. This is reflected in price fluctuations and availability problems all the way to the consumers.

4.4.3 The probability and the desirability of the future images of the primary production

Primary production experts (N=13) regarded the *resilient agriculture* future image to be either highly desirable or desirable (100%) (Figure 11). However, there was more variability when probability of this future image was considered by the experts. Most of them thought that this future image is not probable (54%) and 38% thought that it is probable.

In the written comments, a respondent wrote that this future image is not probable at all until major changes in production systems and consumption happens (paradigm change). In addition, one respondent commented that it is highly improbable that profitability would increase.

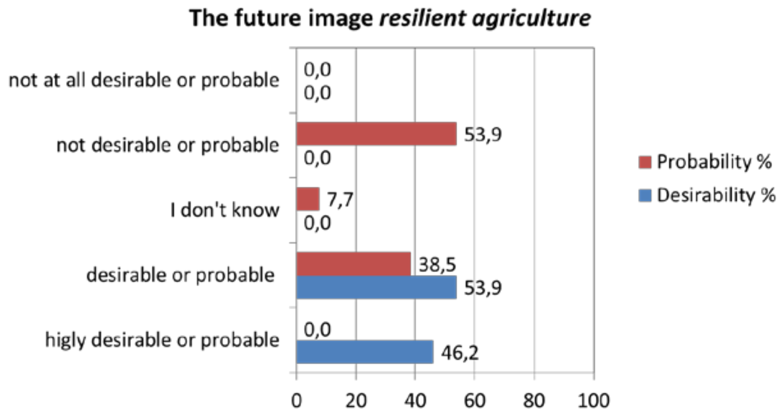


Figure 11 The future image *resilient agriculture*. The desirability and the probability of the future image are estimated by the respondents.

The *technological agriculture* future image was not seen very desirable by most of the respondents. Minority regarded it as desirable (Figure 12). When probability was considered, opinions were divided equally between the future image being probable and not being probable.

In the comments, a respondent wrote that there probably are no other options and this future is the most probable if viable agriculture, in general, is maintained in Finland.

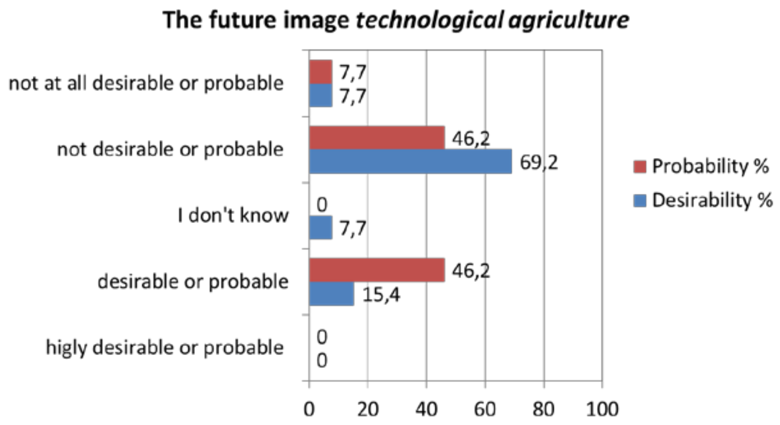


Figure 12 The future image *technological agriculture*. The desirability and the probability of the future image are estimated by the respondents.

The *externally controlled agriculture* future image was not desirable (Figure 13). However, the probability of this future image clearly divided opinions. No one considered this future image to be highly probable, but many respondents considered this as a probable future image. On the other hand, many considered this future image to be either not probable or not at all probable. This future image had also some “I don’t know” replies, which implies the difficulties to estimate the probability of this future image.

In the comments, respondents wrote that this future image seems to be “business as usual” and for some of the farms this image will probably be the reality by 2050.

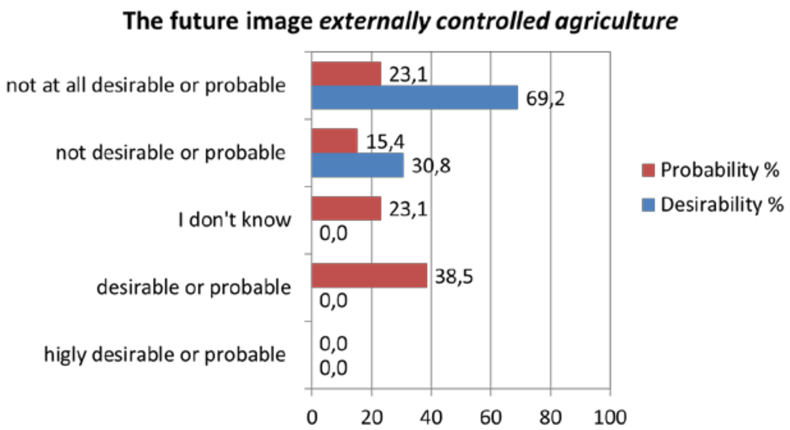


Figure 13 The future image *externally controlled agriculture*. The desirability and the probability of the future image are estimated by the respondents.

4.4.4 The probability and the desirability of the future images of the food industry

The future image of the food industry *resilient and innovative food industry* (N=14) was considered either desirable or highly desirable by all the respondents. On the other hand, the probability of the future image had more disunity; majority regarded the image to be probable and many not to be probable. In addition, some responded “I don’t know” (Figure 14).

In written comments, a respondent wrote that food industry is never responsible for the well-being of consumers. According to the respondent, the food industry could develop very healthy and responsible products, but it is a decision of a consumer to buy or not to buy the “better” products in the end. Unfortunately, too often the only driving force seems to be the price. In the end, the consumer decisions depend on education and financial capacity. One may argue that the availability and access may influence as well.

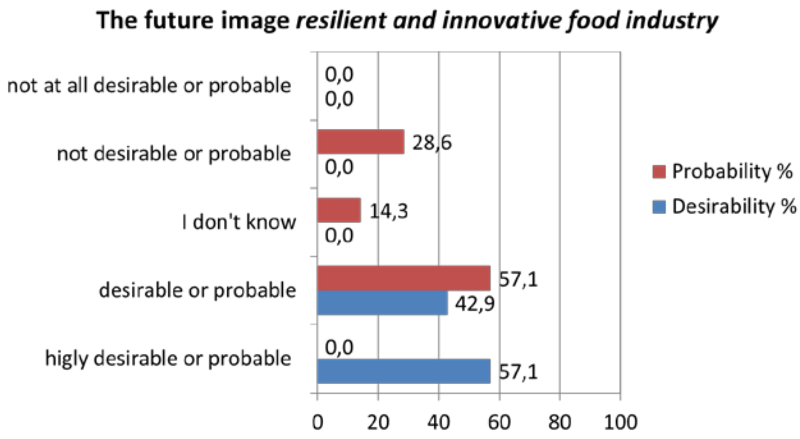


Figure 14 The future image *resilient and innovative food industry*. The desirability and the probability of the future image are estimated by the respondents.

The future image of *agile food industry* was interestingly regarded to be desirable by majority of experts. Again, the probability of this future image divided the opinions; slightly more regarded it not to be probable than to be probable. In addition, many replied "I don’t know”, which indicates the difficulties in deciding the probability of this future image (Figure 15). No one regarded this future image to be “not at all probable”.

In written comments, respondents wrote that it is not probable that food industry would be independent from global markets, on the contrary. One respondent got somewhat annoyed by this future image and commented that it is unrealistic and there are no economic realities taken into account meaning that work, energy and raw materials are cheaper in other countries, which makes it impossible to be independent from global markets.

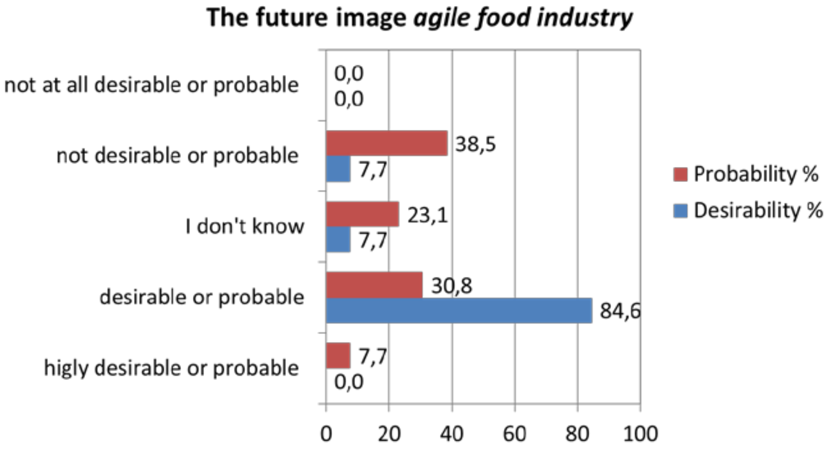


Figure 15 The future image *agile food industry*. The desirability and the probability of the future image are estimated by the respondents.

The undesirability of the future image *food industry depending on global markets* was uniform. Again, the probability estimations had more variation: most regarded this future image to be probable and many not to be probable (Figure 16).

All in all, it appears from these answers and written comments that the experts foresee the food industry to be dependent from the global markets. However, there were also comments stating that the Finnish food industry is still dependent on national primary production and it is vital to support and facilitate Finnish primary production also in the future.

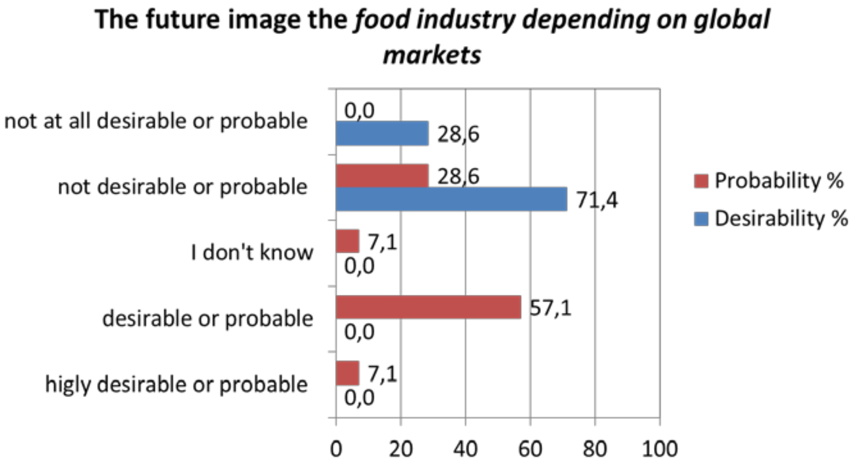


Figure 16 The future image *food industry depending on global markets*. The desirability and the probability of the future image are estimated by the respondents.

5 DISCUSSION

In this chapter, the reliability of the methodology and the results are reflected. This chapter also summarizes and interprets different approaches utilized researching the futures of the Finnish food system. The future images were constructed utilizing the insights of the food system experts and, on the other hand, the panarchy scenarios were constructed solely by the author based on the adaptive cycle model. Different approaches produced somewhat different end results. However, also interesting similarities can be identified.

5.1 Reflections on results and methodology

The indicators used in this work are important foundation for the whole work. That is why it is critical to reflect on reliability of the actual indicators. The indicators used here are not precise and do not measure exact numbers. These indicators identify behaviors that may produce resilience and if absent may signal increased risk for vulnerability. In addition, the indicators are heavily focused on environmental aspects or behaviors indicating impacts on environmental resilience. Qualities of the actors are included such as reflective and shared learning and honoring of legacy. Furthermore, the education level was added to the sub-section of primary production by the author. All thirteen indicators are based on wide literature and analysis by the Cabell and Oelofse (2012). However, it is possible that some significant points of views are missing. One such perspective could be the governance of the agroecosystems. Even if there are indicators such as socially self-organized and appropriately connected, which indicate the ability of the system actors to form own configurations and quality and quantity of networks, they do not indicate precisely how the governance system influence the agroecosystems as a whole. Another aspect is the structure of the agroecosystems. That was added to some extent in the questions as options of farm size and type of production, but not systematically, and it was not possible to draw any conclusions about the structural aspects to resilience itself. The discussed points are developed further in the following "Conclusions" chapter (see also Table 20).

The reliability of the questionnaire and the questions has been already discussed. The major problem seemed to be the amount of "I don't know" answers, which may have distorted the results. In addition, it appears that some of the questions were more difficult that the others even causing confusion. Especially, the question about the small-scale disturbances (indicator 7) was difficult and that is why the results around that indicator are not very reliable.

The Delphi method itself carries some inherent risks. In this work utilized complex electronic questionnaire has a risk to produce incoherent answers by the experts. The risk that panelists are not able to build coherent answers to all the required dimensions of the questions is rather high. Sometimes that leads to inconsistent and illogical answers, which cause problems when cluster analysis and the final future images are constructed. Furthermore, the structure of the panel and the distribution of the final replies are critical and, in this work, more replies were received from the researchers representing the research organizations than from the rest of the organizations such as food industry, ProAgria and retail. It is difficult to assess if this has caused any bias in the answers or in the final future images, but it definitely have caused different results compared to the situation where replies are equally distributed from all the panel organizations.

The future images had some internal inconsistencies and, on the other hand, conflicting similarities. The combining of clusters 1 and 2 (the future images of primary production and food industry, see Table 18) produced a potential risk for internal inconsistencies. For example, cluster 1; primary production, showed high profitability (+++) and cluster 2 only fair profitability (+). The future image *Technological agriculture* is described to be reasonably profitable.

The future images *Resilient agriculture* (cluster 4) and *Resilient and innovative food industry* (cluster 4) clearly had distinct features and were easy to construct. On the contrary, for example, future images *Technological agriculture* (combined clusters 1 and 2) and *Externally controlled agriculture* (cluster 3) were rather challenging because there were not that clear differences, and the future images had to be constructed partly underlining some features more than the others. For example, the latter future image was built based on low scores (pluses or minuses in Table 18) in many indicators and not so much based on individual scores.

The future images seem to lack the “worst case scenario”, even if the *Externally controlled agriculture* and *Food industry depending on global markets* may be interpreted to be the negatively nuanced future images. If compared to panarchy scenarios, the future images produced by the experts are somewhat more incremental and do not have that much major “negative” features. The panarchy scenarios are solely produced by the author based on adaptive cycle framework, which provides a good “evolutionary” structure for the construction work. However, being based on only one person’s work, the reliability could have been increased, for example, by presenting the scenarios to the experts and collecting their views and feedback. These scenarios could have been included into the second round of the Delphi questionnaire. Again, this could have produced too complicated a questionnaire, and because of the time constrains, this could not be done.

5.2 Interpretation of experts' future images and panarchy scenarios

Successful Transformation scenario appears to be a combination of the desirable future images *Resilient agriculture* and *Resilient and innovative food industry*. In addition, parts of the *Agile food industry* could be seen in line with this scenario such as food industry's active role in the development of local and national food production. These features could be described to be a part of a very desirable future image or a scenario. However, *Successful Transformation* requires the *Seeds of Transformation* to occur first – a reorganization phase is needed at local level to enable the old structures to be broken and the new ones to emerge. This scenario does not take a stand how exactly that reorganization would take place: "peacefully" or through some more or less violent chaos. The author believes that the Finnish food system has the potential for orderly reorganization if the planning and actions are started on time – meaning immediately. There are lots of signs of more sustainable and resilient behaviors, but they are still at low level and small-scale.

On the other hand, the scenario of *Missed opportunities* has features of *Food industry depending on global markets*, especially, if the availability of food products is considered. Higher levels of panarchy are going through release phase, which means they are partly unable to deliver or produce food products. Consumers are heavily dependent on local production and small-scale distribution systems, which hampers the availability and accessibility.

As a conclusion from above, it appears that all the scenarios and the future images imply that the Finnish food system should prepare itself for the changing operational environment and coming global challenges. Key concerns are the ability to produce food when availability of raw materials or energy from global markets is hampered or national delivery or logistic system for some reason is not functioning properly. One important dependency is the dependency from the fossil fuels and the changes in the price and availability affecting also the food system – from local level to global and vice versa. Discussions about decentralization or centralization of different systems such as energy systems are ongoing and one simple truth or solution is not probably reachable or practical. One solution does not suit all levels (from local to global) or systems. However, it appears, also from these scenarios and future images, that simple centralization and focusing only on efficiency do not produce resilient or sustainable solutions on the long run. For example, further centralization of modern large-scale food production is a risk viewed from the context of resilience. On the other hand, personal or small-scale self-sufficiency would not probably be a solution either, not now or in the future (by 2050). Balance between the two would produce resiliency and, on the other hand, some efficiency and economies of scale where it is necessary.

In addition, the panarchy scenarios and the future images can be analyzed from the perspective of the three systems paradigms and the resilience concepts (see Table 19). The more innovation, learning, complexity, uncontrollability, self-organization and radical change the scenario or the future image involve, the more it represents the third systems paradigm and the resilience concept. However, it has to be emphasized that even if one systems paradigm or resilience concept seem to be prevalent, all the others are also there, though not so prominent.

The *Resilient agriculture* and *Resilient and innovative food industry* future images are mainly representations of the third systems paradigm and the third resilience concept (dynamicity and radical change have been a part of the process to develop these future images) and, according to the third resilience concept, learning and innovation are the key success factors. The *Seeds of Transformation* scenario represents the third systems paradigm (reorganization phase) at the local level, but the national and the regional levels still remain at the first systems paradigm and the resilience concept (objective is the stability and efficiency) (conservation phase). *Successful Transformation* represents the third systems paradigm at the national and the regional levels, and the third resilience concept (reorganization) and the local level (growth phase) has moved to the second systems paradigm and the resilience concept (focus on robustness and persistence). The *Missed Opportunities* scenario, the *Externally controlled agriculture* and *Food industry depending on global markets* future images have less features of the third systems paradigm or the third resilience concept. However, chaos of release phase (at national and regional level) of the *Missed Opportunities* scenario may produce elements for self-organization and transformation, especially, if the national and the regional levels proceed towards the next phase of the adaptive cycle, namely reorganization. That option could be studied if one more scenario was constructed.

Table 19 Scenarios and future images of this work analyzed in relation to systems paradigms, resilience concepts and Dator's categories.

	Adaptive cycle phases			
Theoretical frames	**Release**	**Reorganization**	**Growth**	**Conservation**
The first / closed systems paradigm	*Missed Opportunities, Externally controlled agriculture, Food industry depending on global markets*		*Technological agriculture, Agile food industry*	*Seeds of Transformation*
The second / organic systems paradigm			*Successful Transformation*	
The third / dynamic systems paradigm		*Resilient agriculture, Resilient and innovative food industry, Seeds of Transformation, Successful Transformation*		
The first / engineering resilience concept	*Missed Opportunities, Externally controlled agriculture, Food industry depending on global markets*			*Seeds of Transformation*
The second / ecosystem or social resilience concept			*Successful Transformation*	
The third / social-ecological resilience concept		*Resilient agriculture, Resilient and innovative food industry, Seeds of Transformation, Successful Transformation*		
Dator's "continued economic growth"				*Externally controlled agriculture, Food industry depending on global markets*
Dator's "collapse"				
Dator's "disciplined society"			*Technological agriculture, Agile food industry*	
Dator's "transformation society"		*Resilient agriculture, Resilient and innovative food industry*		

Dator claims that all the future images can be categorized into the following four groups: 1) continued economic growth (business as usual), 2) collapse, 3) disciplined society (society has comprehensive values, usually traditional values) and 4) transformation society (high tech or high spirit society where instead of traditional solutions emerge new ones). (Dator, 1998.)

When the panarchy scenarios and adaptive cycle framework are considered, the *reorganization phase* could be seen as a representation of the third systems paradigm, the third resilience concept and Dator's "transformation society". The *release phase* could also be considered as a representation of the third systems paradigm, the third resilience concept and Dator's "collapse" category. The *exploitation phase* could be seen as a representation of the first or the second systems paradigms, the second or the first resilience concepts and from Dator's categories "disciplined society". The *conservation phase* could be seen as a representation of the first or the second systems paradigms, the second or the first resilience concepts and from Dator's categories "continued economic growth".

If the future images are also analyzed according to Dator's categories (see Table 19), *Resilient agriculture* and *Resilient and innovative food industry* represent "transformation society". *Technological agriculture* and *Agile food industry* could be placed into Dator's "disciplined society" category. Finally, *Externally controlled agriculture* and *Food industry depending on global markets* could be placed into Dator's "continued economic growth" category. It seems that all the scenarios and the futures images of this thesis can be placed into Dator's categories.

As a conclusion, none of these – adaptive cycle phases, systems paradigms or resilience concepts – is any more preferable than the other, but they are needed at different phases of the systems development. A larger complex system at the third systems paradigm would not probably be able to thrive forever. There also seems to be a need for other systems paradigms and resilience concepts to balance the development and allow the systems to develop between the system paradigms and the resilience concepts. However, it appears that the system is not able to profoundly transform without the third systems paradigm or the reorganization phase and the third resilience concept is the one to produce the best resilience for the complex adaptive systems.

5.3 Conclusions

Neither sustainability nor resilience has one clear definition or assessment tool. Both frameworks are very dependent on how well they are used and how well the user is aware of or able to foresee the long-term consequences. There is also an issue of ethics: from whose point of view the system is seen, to whose benefit it is developed and by which means.

It is necessary to understand the system dynamics when system's sustainability or resilience is managed. Today's complex systems such as global food system, trade systems and economic systems are so complex that decision makers have problems making good decisions in a longer term because the consequences of their decisions cannot be forecasted. The sustainability assessment tools at their best should take into account the systemic challenges, far enough future consequences also for future generations. However, weak sustainability seems to be the most common way of thinking sustainability. Interestingly, according to resilience and portfolio theory, most resilient systems in the long term are not always the most productive in the short term. (Perrings, 2006.) That is the most difficult challenge for all kinds of decision makers because it is so much easier to go for the quick profits and solutions, and leave the unpleasant consequences for the next government or even for the future generations to solve.

A true sustainable or resilience development program is an indefinite process. Sustainable development or resilience of a system is a constantly moving target because the conditions and environment is constantly changing. (Newman, 2006, 635.) The same solution or practice is not suitable to all or at all times. In addition, different parts of a system (subsystems) may require different solutions. For example, food systems' have subsystems such as primary production, food industry, retail and consumption each being totally different.

The results of this study reflect the present and the future views of the experts on resilience of the Finnish food system. There are various strengths in the Finnish food system for building resilience. Organic farms and larger farms are perceived as socially self-organized, which can promote innovations and new experimentations for adaptation to changing circumstances. In addition, organic farms are currently seen as the most ecologically self-regulated farms. Innovations in terms of taking advantage of new circumstances, is a crucial component of resilience (Beermann, 2011). Moreover, Lehtola and Ståhle define societal innovation and claim that such an innovation occurs at the interface of the state and civil society (2014). According to them, societal innovation improves people's everyday life and brings systemic change to society. It appears that there ought to be more communication between civil society (NGOs, companies and research institutes) and state. (ibid.) Societal innovations could also increase resilience of a food system, especially, if the primary production is seen as a critical part of the civil society.

There are also weaknesses in the Finnish food system restricting resilience building. Optimal redundancy is a measure, which is not currently associated with the Finnish food system in the expert survey. It is important to reach optimal redundancy, in which efficiency and resilience are in balance. In addition, retail sector and food industry, except for small businesses, are not particularly associated with building local human capital. In the future, however, the experts believe that both sectors will improve their performance in this sense. In the whole food system, retail sector will probably face the most dramatic changes in the future, especially, if the scenarios and the future images are reflected. Hence, retailers must reconsider their values, purpose and mission in the food system. Especially, the *Missed opportunities* scenario brings visible the risks of continuous concentration and constantly increasing efficiency demands. In addition, the future image of *Food industry depending on global markets* foresees how dependency on global markets may lead to food availability problems.

Naturally, small businesses and local retailers demonstrate higher degree of resilience in terms of global autonomy and local interdependency compared to large businesses and international actors. According to the experts, this will be the case also in the future and they even see negative developments in terms of appropriate supply chain relationships, global autonomy and local interdependency. Due to concentration and consolidation in the food industry and food retail, large businesses and international retailers may face risks of disruptions in their global supplier networks. Again, the future image of *Food industry depending on global markets* foresees how dependency on global markets may lead to supply problems.

The profitability of farms is and will be a critical cornerstone of the overall resilience in primary production. For ensuring food security and adequate supply of food, economic, social and environmental dimensions of sustainability of the food system must be carefully assessed. Sustainable farm livelihood of family farms is certainly among the key vulnerabilities in Finland as well as globally.

All in all, the food system experts have very positive views concerning the resilience development of the Finnish food system in the future. Sometimes small and local is beautiful, sometimes large and international is more resilient. The positive future images and scenarios also support the possibility of positive, resilient futures. However, depending on the resilience indicator, the critical phases of the food system can be found in primary production, in food industry, in retail sector or in consumption. Along the whole supply chain, nonetheless, the food system experts consider organic farms as the most resilient actor. Maybe other actors in the food supply chain could learn something from the principles of organic farming in their process of resilience building.

However, comparison between the resilient behaviors of different subsystems should be made with caution, as the corresponding measures are partly different. Resilience is a systemic, multi-dimensional and multidisciplinary phenomenon. There's no single indicator measuring resilience, but a comprehensive set of resilience indicators are needed. This study utilized an indicator framework made for assessing resilience of agroecosystems, but similar frameworks and sets of indicators could be developed also for food industry, retail and consumption. In addition, the role of different institutions, research organizations, governance or leadership should be taken into account.

According to resilience engineering, a resilient system is able to adjust and sustain its core operations under both expected and unexpected conditions (Hollnagel, 2011, xxxvi). The requirement of unexpected events is especially challenging because unexpected events may vary from natural catastrophes such as floods or storms, to human induced such as financial crisis or extensive strikes. Above all, there are events we cannot even imagine and therefore there is no way to be prepared. That is why the understanding of general resilience is so critical in the future. However, the desired state has to be carefully evaluated, also on the longer term and even between generations. For example, food systems may function at the moment, but concentrated and large production and distribution systems are more vulnerable than modular and decentralized units. In addition, sustainability of modern food system is questionable, especially, in light of nutrient cycles (nitrogen and phosphorus), not to mention its impact on climate change and biodiversity (Rockström et al., 2009). This implies that there are needs for re-evaluate our modern food systems also from the perspective of resilience. There might be need for some self-renewal.

Ståhle (1998, 111) identified criteria for self-renewal in social systems as follows: connections with other systems and feedbacks, power balance and trust, information as an event and as a power enabling a change, and creation of meanings within a system. Both Prigogine and Luhmann argue that the opportunity for self-renewal is boiled down to communication. The system’s ability to communicate will determine its capacity to renewal (Ståhle, 2008, 21). This is important conclusion also when system’s general resilience is considered. When a system reaches the point of release phase, the “destructive” reorganization of the system could be prevented by meaningful communication. The prerequisite for that is trust in the system. According to Luhmann, a key element to change is system’s relationships and interdependencies between people i.e. connectivity. In addition, release phase could be prevented by releasing some entropy (information) in the system, as discussed earlier, and that could be done by rejecting excess information or combining it to create new knowledge or creating new meaning within the system.

Going back to the future images, interestingly, the experts assessed the future images' desirability rather consistently favouring resilience and sustainability, whereas probability estimates varied considerably.. The question remains: how to facilitate the materialization of the desirable future despite of possible conflicts of interests between different sections of food system? The author believes that futures research has a key role in facilitating the communication and building trust by using participatory methods and enabling different groups of food system to agree upon and build a common way towards the desirable future.

There is need for future research in the area of general resilience. One framework for approaching social-ecological systems (SES) is McGinnis's and Ostrom's work (McGinnis & Ostrom, 2014). According to them, four main categories in any SES are relevant: Resource Systems, Resource Units, Governance Systems and Actors, as already discussed on pages 22-23. Panarchy model could bring different "levels" to this framework and, that way it might enable better conceptualization of different feedbacks and interconnections. In addition, some of the so-called second-tier variables are interesting from the resilience perspective, e.g. resource systems: human constructed facilities; actors: leadership, norms/social capital, knowledge; and focal action situations such as self-organizing activities (McGinnis & Ostrom, 2014). Further research is required and wider literature research to confirm if this framework could be used for research purposes of general resilience of SES. However, some preliminary constructions are below. It appears that for the research purposes three main "categories" are essential:

Structure of the system – depends on what the system "produces" from inputs to outputs. The structure of the system depends on its "identity" or the purpose of the system i.e. infrastructure or, on the other hand, natural structure such as forest, farmland or lake (resource systems). It could also be an organizational structure, a structure of a city or a structure of the food system having certain kind and number of farms, food businesses or retail actors. Furthermore, the structure of a distribution system (logistics) between hierarchies and inside one level is probably interesting and should be understood better from the resilience point of view. According to resilience theory, it is important to have diversity and modularity also in the structure, but for each and every resource system (if McGinnis and Ostrom analogy is used) these parameters mean different things.

Behavior of the actors in the system – communication, trust, knowledge, self-organizing behavior, learning capacity, equality and, finally, innovation and even futures consciousness are all components influencing resilience (at personal level, at community level, at organizational level or at systems level). Trust enables a system to develop further and enables even riskier or more innovative options to develop (Luhmann, 1995, 127-128). In society, there could be more emphasis on enabling conditions of innovation and self-organizing behavior. Important social elements such as values and ethics have crucial role in this category and it would be interesting to investigate further how values and change of values impacts resilience (at local level and even higher levels). In addition, also qualities of the actors itself such as socioeconomic attributes and norms/social capital (McGinnis & Ostrom, 2014) may influence the resilience of the system by influencing, for example, the learning capacity and futures knowledge in the system.

Governance and policy institutions – so called institutional category, which produces rules and policies to regulate both the structure of the system and the behavior of its actors. In this category, also NGOs and research organizations produce their impact into the system. This category could be divided into structural and behavioral subcategories because both points of views produce important insights into resilience of governance system. In Table 20, categories and suggested new indicators are presented.

Table 20 General resilience parameters and social-ecological system “categories” and suggested new indicators.

“Categories” of the social ecological systems				
General resilience parameters	**Structure (for each hierarchical level)**	**Behaviors of the key actors (for each hierarchical level)**	**Governance and policy institutions (for each hierarchical level)**	
			Structure	**Behavior of the actors**
Tightness of feedbacks	Number of connections between units	Trust, leadership and cultural capital	Number of connections between units	Number of connections between actors and trust
Modularity	Number of optional modules	Number of optional actors and behaviors	Number of optional governance modules and policy institutions	Number of optional actors and behaviors
Diversity	Diversity of structures	Diversity of actors and behaviors	Diversity of governance and policy institutions	Diversity of actors and behaviors
The amount of change a system can withstand (redundancy)	Redundancy/ resilience in the structures	Resilience of the actors	Redundancy / resilience in the structures	Resilience of the actors
The capacity for learning	-	Leadership, cultural capital and appreciation of learning and knowhow	-	Leadership, cultural capital and appreciation of learning and knowhow
Self-organizing behavior	Ability and possibilities of structures to self-organize	Ability and possibilities of actors to self-organize, innovation	Ability and possibilities of governance and policy institutions to self-organize, innovation	Ability and possibilities of actors to self-organize, innovation

According to Juntunen, it appears that national government is responsible for enabling the conditions for individual and smaller scale community resilience (strategies), and communities and individuals are actually responsible for building their own resilience (Juntunen, 2014, 17). This seems to transfer the operative responsibility from the "higher" level i.e. governing organizations to the "lower" level i.e. to communities and individuals – to practical level. If this kind of thinking was applied to food systems or food supply chains, it might change the whole thinking of how to increase the resilience of a food system.

Scientists and policy makers are increasingly interested in the processes towards sustainability – sustainability transformations. It appears that there are research areas where combined perspectives from different disciplines would produce new insights about transformations processes. For example, innovation (being technological or social) and better understanding of agency seem to be some of the research areas needing more transdisciplinary efforts. (Olsson, Galaz, & Boonstra, 2014.) In addition, power and its distribution in the system is a very valid question and how it is related to resilience.

General resilience forms a foundation for all kinds of resilience. Tightness of feedbacks (connectedness), modularity, diversity, the amount of change a system can withstand and maintain its main functions, the ability of a system to develop the capacity for learning and adaptation and self-organizing behavior are all fundamental components of resilience in any kind of system. It would be interesting to use general resilience parameters and combine them with these three categories of resilience to construct specific indicators to different subsystems of the Finnish food system (see Table 20). In addition, the process should be participatory to enable the learning and shearing of knowledge from the actors covering the different parts of the Finnish food system. The process should produce futures knowledge and that way also enable process towards desirable futures. During the process, also trust would be created among the participants. That would enable self-organizing behavior and even innovation, and that way resilience.

BIBLIOGRAPHY

Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R., & Rockström, J. (2005). Social-ecological resilience to coastal disasters. *Science, 309*(5737), 1036-1039.

Amara, A. (1981). The futures field: searching for definitions and boundaries. *The Futurist, 15*(1), 25-29.

Anderies, J. M., Folke, C., Walker, B., & Ostrom, E. (2013). Aligning Key Concepts for Global Change Policy: Robustness, Resilience, and Sustainability. *Ecology and Society, 18*(2), 8.

Bartos, S., Balmford, M., Karolis, A., Swansson, J., & Davey, A. (2012). *Resilience in the Australian food supply chain*. Australian Government, Department of Agriculture, Fisheries and Forestry.

Beermann, M. (2011). Linking corporate climate adaptation strategies with resilience thinking. *Journal of Cleaner Production, 19*, 836-842.

Bell, W. (2003). *Foundations of Futures Studies, Volume 1: Human Science for a New Era* (sixth ed.). USA: Transaction Publishers.

Bertalanffy, L. (1972). History and Status of General Systems Theory. *Academy of Management Journal, 15*(4), 407-426.

Binder, C., Hinkel, J., Bots, P., & Pahl-Wostl, C. (2013). Comparison of frameworks for analyzing social-ecological systems. *Ecology and Society, 18*(4), 26.

Blaikie, P., Cannon, T., Davis, I., & Wisner, B. (1994). *At risk: Natural hazards, people's vulnerability and disasters*. New York, NY: Routledge.

Bomford, M. (2010). Getting fossil fuels off the plate. In R. Heinberg, & D. Lerch (Eds.), *Post Carbon Reader – Managing the 21st century's sustainability crisis* (pp. 119-127). USA: Watershed Media in collaboration with Post Carbon Institute.

Börjeson, L., Höjer, M., Dreborg, K., Ekvall, T., & Finnveden, G. (2006). Scenario types and techniques: Towards a user's guide. *Futures, 38*(7), 723-739.

Cabell, J. F., & Oelofse, M. (2012). An Indicator Framework for Assessing Agroecosystem Resilience. *Ecology and Society, 17*(1), 18.

Carpenter, S. R., Westley, F., & Turner, M. G. (2005). Surrogates for resilience of social–ecological systems. *Ecosystems, 8*(8), 941-944.

Carpenter, S. R., Arrow, K. J., Barrett, S., Biggs, R., Brock, W. A., Crepin, A., . . . de Zeeuw, A. (2012). General Resilience to Cope with Extreme Events. *Sustainability, 4*(12), 3248-3259.

Casti, J., Ilmola, L., Rouvinen, P., & Wilenius, M. (2011). *Extreme events*. Helsinki: Taloustieto Oy.

Checkland, P. (1995). Model Validation in Soft Systems Practice. *Systems Research, 12*(1), 47-54.

Ching, L. L., Edwards, S., & El-Hage Scialabba, N. (Eds.). (2011). *Climate Change and Food Systems Resilience in Sub-Saharan Africa*. Rome: Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/docrep/014/i2230e/i2230e00.htm. Accessed 22.11.2014

Cumming, G. S., Barnes, G., Perz, S., Schmink, M., Sieving, K. E., Southworth, J., . . . Van Holt, T. (2005). An exploratory framework for the empirical measurement of resilience. *Ecosystems, 8*(8), 975-987.

Dator, J. (1998). The Future lies Behind! Thirty Years of Teaching Futures Studies. *The American Behavioral Scientist, 42*(3), 298.

Davidson, J. L., van Putten, I. E., Leith, P., Nursey-Bray, M., Madin, E. M., & Holbrook, N. J. (2013). Toward Operationalizing Resilience Concepts in Australian Marine Sectors Coping with Climate Change. *Ecology and Society, 18*(3).

Derissen, S., Quaas, M. F., & Baumgaertner, S. (2011). The relationship between resilience and sustainability of ecological-economic systems. *Ecological Economics, 70*(6), 1121-1128.

Engle, N. L., de Bremond, A., Malone, E. L., & Moss, R. H. (2013). Towards a resilience indicator framework for making climate-change adaptation decisions. *Mitigation and Adaptation Strategies for Global Change,* 1-18.

Ericksen, P. J. (2008a). Conceptualizing food systems for global environmental change research. *Global Environmental Change, 18*(1), 234-245.

Ericksen, P. J. (2008b). What is the vulnerability of a food system to global environmental change? *Ecology and Society, 13*(2)

FAO. (2014). *SAFA Sustainability Assessment of Food and Agriculture Systems, Guidelines, Version 3.0.* (). Rome: FAO. Retrieved from http://www.fao.org/nr/sustainability/sustainability-assessments-safa/en/. Accessed 17.2.2015

FAO. (November 1996). Rome declaration on world food security and World Food Summit Plan of Action. Paper presented at the Rome, Italy. Retrieved from http://www.fao.org/docrep/003/w3613e/w3613e00.HTM. Accessed 12.9.2014

Finnwatch. (2014). Kaupan ananasmehujen takaa löytyi taas viitteitä ihmiskaupasta ja pakkotyöstä. Retrieved from http://www.finnwatch.org/uutiset/122-kaupan-ananasmehujen-takaa-loeytyi-taas-viitteitae-ihmiskaupasta-ja-pakkotyoestae. Accessed 20.12.2014.

Folke, C. (2006a). Resilience: The emergence of a perspective for social-ecological systems analyses. *Global Environmental Change-Human and Policy Dimensions, 16*(3), 253-267.

Folke, C. (2006b). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global Environmental Change, 16*(3), 253-267.

Forrester, J. W. (1994). System dynamics, systems thinking, and soft OR. *System Dynamics Review (Wiley), 10*(2), 245-256.

Gasparatos, A., El-Haram, M., & Horner, M. (2008). A critical review of reductionist approaches for assessing the progress towards sustainability. *Environmental Impact Assessment Review, 28*(4–5), 286-311.

Geyer, F., & van der Zouwen, J. (1986). In Geyer F., van der Zouwen J. (Eds.), *Sociocybernetic Paradoxes: observation, control and evolution of self-steering systems* Sage.

Goodland, R., & Daly, H. (1996). Environmental sustainability: Universal and non-negotiable. *Ecological Applications, 6*(4), 1002-1017.

Gordon, T. J. (2009). The Delphi Method. *Futures Research Methodology, Version 3.0. The Millennium Project, CD-ROM.*

Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R., & Meybeck, A. (2011). *Global food losses and food waste - extent causes and prevention*. Rome: FAO.

Holling, C. S. (1973). Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics, 4,* 1-23.

Holling, C. S. (2001). Understanding the complexity of economic, ecological, and social systems. *Ecosystems, 4*(5), 390-405.

Hollnagel, E. (2011). RAG - The resilience analysis grid. In E. Hollnagel, J. Paries, D. D. Woods & J. Wreathall (Eds.), *Resilience engineering in practice: A guidebook*. Farnham, UK: Ashgate.

Hollnagel, E. (2014). Resilience engineering and the built environment. *Building Research and Information, 42*(2), 221-228.

Howell, L. (Ed.). (2013). *Global Risks 2013 - An initiative of the risk response network* (Eighth ed.). Geneva, Switzerland: World Economic Forum.

Huan-Niemi, E., Niemi, J., & Niemi, J. (2010). Global Food Production under Alternative Scenarios. *International Food and Agribusiness Management Review, 13*(4), 117-135.

Hughes, T. P., Baird, A. H., Bellwood, D. R., Card, M., Connolly, S. R., Folke, C., . . . Roughgarden, J. (2003). Climate change, human impacts, and the resilience of coral reefs. *Science, 301*(5635), 929-933.

Janssen, M. A., Schoon, M. L., Ke, W., & Börner, K. (2006). Scholarly networks on resilience, vulnerability and adaptation within the human dimensions of global environmental change. *Global Environmental Change, 16*(3), 240-252.

Juntunen, T. (2014). *Kohti varautumisen ja selviytymisen kulttuuria? Kriittisiä näkökulmia resilienssiin.* (SPEK puheenvuoroja No. 2). Tampere: SPEK.

Kahiluoto, H., & Himanen, S. (2012). *Monimuotoisuudesta sopeutumiskykyä - ruokaketju uusille raiteille?* (No. 43). Jokioinen: MTT.

Kirveennummi, A., Mäkelä, J., & Saarimaa, R. (2013). Beating unsustainability with eating: Four alternative food-consumption scenarios. *Sustainability: Science, Practice, and Policy, 9*(2), 83-91.

Landeta, J., Barrutia, J., & Lertxundi, A. (2011). Hybrid Delphi: A methodology to facilitate contribution from experts in professional contexts. *Technological Forecasting and Social Change, 78*(9), 1629-1641.

Lehtola, V. V., & Ståhle, P. (2014). Societal innovation at the interface of the state and civil society. *Innovation.*

Linstone, H. A., & Turoff, M. (2002). 1. Introduction. In H. A. Linstone, & M. Turoff (Eds.), *The Delphi Method: Technique and Applications* (pp. 1-12)

Luhmann, N. (1990). *Essays on self-reference*. New York: Columbia University Press.

Luhmann, N. (1995). In Lenoir, T. and Gumbrecht, H. (Ed.), *Social systems* (Bednarz J., Jr. with Baecker D. Trans.). Stanford California: Stanford, CA: Stanford University Press.

Luhmann, N. (2013). In Baecker D. (Ed.). *Introduction to systems theory* (P. Gilgen Trans.). Polity.

Mannermaa, M. (1991). *Evolutionaarinen tulevaisuudentutkimus. Tulevaisuudentutkimuksen paradigmojen ja niiden metodologisten ominaisuuksien tarkastelua*. Helsinki: VAPK-kustannus.

McEachran, R. (2015). Breeding flies and edible plastic: the kitchen of the future. *The Guardian.* Accessed 13.1.2015.

McGinnis, M. D., & Ostrom, E. (2014). Social-ecological system framework: initial changes and continuing challenges. *Ecology and Society, 19*(2), 30.

Meadows, D. (2008). *Thinking in systems: A primer* Chelsea Green Publishing.

Miller, F., Osbahr, H., Boyd, E., Thomalla, F., Bharwani, S., Ziervogel, G., . . . Rockström, J. (2010). Resilience and vulnerability: complementary or conflicting concepts. *Ecology and Society, 15*(3), 11.

Misselhorn, A., Aggarwal, P., Ericksen, P., Gregory, P., Horn-Phathanothai, L., Ingram, J., & Wiebe, K. (2012). A vision for attaining food security. *Current Opinion in Environmental Sustainability, 4*(1), 7-17.

Nelson, D. R., Adger, W. N., & Brown, K. (2007). Adaptation to environmental change: contributions of a resilience framework. *Annual Review of Environment and Resources, 32*(1), 395.

Newman, L. (2006). Change, uncertainty, and futures of sustainable development. *Futures, 38*(5), 633-637.

Nicolis, G., & Prigogine, I. (1989). *Exploring complexity*. New York, USA: W. H. Freeman and Company.

Niemi, J., & Rikkonen, P. (2010). *Maatalouspoliittisen toimintaympäristön ennakointi - Miten käy kotimaisen elintarvikeketjun?* (No. 7). Jokioinen: MTT.

Niemi, J., Lehtonen, H., Liesivaara, P., Huan-Niemi, E., Kettunen, L., Kässi, P., & Toikkanen, H. (2014). *EU:n yhteinen maatalouspolitiikka vuosina 2014-2020 ja Suomen maatalous.* (No. 130). Jokioinen: MTT.

Olsson, P., Galaz, V., & Boonstra, W. (2014). Sustainability transformations: a resilience perspective. *Ecology and Society, 19*(4), 1.

Peltola, H. (2014) Kauppa putosi kuoppaan. *Kehittyvä Kauppa, 5/2014*

Pennington, D. C., Gillen, K., & Hill, P. (2004). *Social Psychology*. London: Arnold.

Perrings, C. (2006). Resilience and sustainable development. *Environment and Development Economics, 11*(4), 417.

Pimm, S. L. (1984). The Complexity and Stability of Ecosystems. *Nature, 307*(5949), 321-326.

Prigogine, I., & Stengers, I. (1984). *Order out of chaos: Man's new dialogue with nature*. USA: Bantam Books.

Reilly, M., & Willenbockel, D. (2010). Managing uncertainty: A review of food system scenario analysis and modelling. *Philosophical Transactions of the Royal Society B: Biological Sciences, 365*(1554), 3049-3063.

Resilience Alliance. (2007). *Assessing resilience in social-ecological systems: A workbook for scientists.* (Version 1.1) Resilience Alliance. Retrieved from http://www.resalliance.org/index.php/resilience_assessment. Accessed 24.10.2014

Resilience Alliance. (2010). *Assessing resilience in social-ecological systems: Workbook for practitioners.* (Version 2.0). Resilience Alliance. Retrieved from http://www.resalliance.org/index.php/resilience_assessmen Accessed 22.10.2014

Rhyne, R. (1995). Field Anomaly Relaxation - the Arts of Usage. *Futures, 27*(6), 657-674.

Rikkonen, P. (2005). Scenarios for future agriculture in Finland: a Delphi study among agri-food sector stakeholders. *Agricultural and Food Science, 14*(3), 205-223.

Rockström, J., Steffen, W., Noone, K., Persson, Å, Chapin, F. S., Lambin, E. F., . . . Foley, J. A. (2009). A safe operating space for humanity. *Nature, 461*(7263), 472-475.

Schwartz, P. (1996). *Art of the long view: paths to strategic insight for yourself and your company*. New York: Doubleday.

Senge, P. M., & Sterman, J. D. (1992). Systems thinking and organizational learning: Acting locally and thinking globally in the organization of the future. *European Journal of Operational Research, 59*(1), 137-150.

Stigson, P. (2013). The Resource Nexus: Linkages Between Resource Systems., 1-3.

Ståhle, P. (1998). *Supporting a system's capacity for self-renewal.* Academic dissertation in educational sciences, Department of Teacher Education, University of Helsinki. *Research Report 190*

Ståhle, P. (2008). The dynamics of self-renewal: A systems-thinking to understanding organizational challenges in dynamic environments. In A. Bounfour (Ed.), *Organisational Capital: Modelling, measuring and contextualizing* (pp. 1-26). London: Routledge.

Ståhle, P., Pöyhönen, A., & Ståhle, S. (2003). Analyzing dynamic intellectual capital: System-based theory and application. *Acta Universitatis Lappeenrantaensis.*

Tapio, P. (2002). Disaggregative policy Delphi Using cluster analysis as a tool for systematic scenario formation. *Technological Forecasting and Social Change, 70*(1), 83-101.

Tapio, P., Paloniemi, R., Varho, V., & Vinnari, M. (2011). The unholy marriage? Integrating qualitative and quantitative information in Delphi processes. *Technological Forecasting and Social Change, 78*(9), 1616-1628.

Tilman, D., Balzer, C., Hill, J., & Befort, B. L. (2011). Global food demand and the sustainable intensification of agriculture. *Proceedings of the National Academy of Sciences of the United States of America, 108*(50), 20260-20264.

Toffler, A. (1990). *Power Shift: Knowledge, Wealth, Violence at the Edge of the 21st* Bantam Books, New York.

van Notten, P. W. F., Rotmans, J., van Asselt, M. B. A., & Rothman, D. S. (2003). An updated scenario typology. *Futures, 35*(5), 423-443.

Varho, V., & Tapio, P. (2013). Combining the qualitative and quantitative with the Q(2) scenario technique - The case of transport and climate. *Technological Forecasting and Social Change, 80*(4), 611-630.

Walker, B., Abel, N., Anderies, J. M., & Ryan, P. (2009). Resilience, adaptability, and transformability in the Goulburn-Broken Catchment, Australia. *Ecology and Society, 14*(1), 12.

Walker, B., & Salt, D. (2006). *Resilience thinking: sustaining ecosystems and people in a changing world*. Washington DC: Island Press.

Walker, B., Holling, C. S., Carpenter, S. R., & Kinzig, A. (2004). Resilience, adaptability and transformability in social-ecological systems. *Ecology and Society, 9*(2), 5.

WCED. (1987). *Report of the World Commission on Environment and Development: Our Common Future.* Oxford: Oxford University Press.

Wheeler, T., & von Braun, J. (2013). Climate Change Impacts on Global Food Security. *Science, 341*(6145), 508-513.

Woods, J., Williams, A., Hughes, J. K., Black, M., & Murphy, R. (2010). Energy and the food system. *Philosophical Transactions of the Royal Society B: Biological Sciences, 365*(1554), 2991-3006.

Young, O. R., Berkhout, F., Gallopin, G. C., Janssen, M. A., Ostrom, E., & van der Leeuw, S. (2006). The globalization of socio-ecological systems: An agenda for scientific research. *Global Environmental Change, 16*(3), 304-316.

APPENDICES

Appendix 1 Questionnaire of the first round

	PRIMARY PRODUCTION
Q1	How the climate change will be affecting Finnish average temperature change and primary production by 2030, 2040 and 2050? Mark your view into the graph; average temperature change (x-axis) and its impact (y-axis) (total three answers). Write comments or arguments for your above answers:
Q2	How many farms you estimate to be in 2050? Options: over 40000, about 40000, about 30000, about 20000 under 20000 farms Write comments or arguments for your above answers:
For all Q3-Q28	**Matrix questions having Likert scale: 1. Strongly disagree 2. Disagree 3. Don’t know 4. Agree 5. Strongly agree** **And options: small, medium, large farm size and organic, plant production or livestock farm**
Q3	At the moment, farmers are able to act locally or regionally on their own initiative based on their own needs and hopes. Write comments or arguments for your above answers:
Q4	How about the future: the year 2050? Write comments or arguments for your above answers:
Q5	At the moment, farmers exploit ecosystem services, local conditions and natural resources in a way that ecological regulation is possible. This way the need of external inputs may decrease (fertilizers, water, pesticides and energy). Write comments or arguments for your above answers:
Q6	How about the future: the year 2050? Write comments or arguments for your above answers:
Q7	At the moment, farmers pay attention to diverse stakeholder connections for example to minimize risks. They may have several input suppliers, buyers or distributors/channels to their own products. Social contacts to other actors on the field have also been taken care of. Write comments or arguments for your above answers:
Q8	How about the future: the year 2050? Write comments or arguments for your above answers:
Q9	At the moment, farms have taken diversity into account in their different

	functions, for example, with inputs, products (crop diversification) and income sources or even with landscape values. Write comments or arguments for your above answers:
Q10	How about the future: the year 2050? Write comments or arguments for your above answers:
Q11	At the moment, farms have "flexibility" to handle problems or even crisis. They have, for example, spare parts, reserve power, new varieties or additional manpower available. Flexible resources ensure the continuation of the operations in spite of surprises. Write comments or arguments for your above answers:
Q12	How about the future: the year 2050? Write comments or arguments for your above answers:
Q13	At the moment, farms have taken into account the diversity of landscape and land use such as variation of cultivated and uncultivated land, pasture land and usage of different cultivation techniques or crop rotation. Write comments or arguments for your above answers:
Q14	How about the future: the year 2050? Write comments or arguments for your above answers:
Q15	At the moment, farms operate respecting natural resources and environment. For example, farms do not deplete soil organic matter, do not deplete or contaminate ground or other water resources, use in moderation commercial fertilizers or other chemicals and produce only little waste to be taken away from the farm. Write comments or arguments for your above answers:
Q16	How about the future: the year 2050? Write comments or arguments for your above answers:
Q17	At the moment, farms use "tolerization", for example, by utilizing natural selection and this way adapting species to different conditions. For example, when talking about pest control, a small number of pests are used and afterwards the plants showing resistant features are selected. Write comments or arguments for your above answers:
Q18	How about the future: the year 2050? Write comments or arguments for your above answers:
Q19	At the moment, learning, active search and sharing of information are essential parts of the farm operations. Farms also test new (and old) solutions. Write comments or arguments for your above answers:
Q20	How about the future: the year 2050? Write comments or arguments for your above answers:
Q21	At the moment, farms are very dependent on inputs such as imported energy,

	protein feed and chemicals (e.g. pesticides). How about the future: the year 2050? Finland is almost self-sufficient with regard to above inputs. Especially, share of imported energy has significantly decreased and it has been replaced by renewable energy sources. Write comments or arguments for your above answers:
Q22	At the moment, farmers respect traditional knowledge, traditions and honors legacy. They know how to apply old methods to the present situations. Knowhow and experience from the previous generations is appreciated and utilized when the future is thought of. Write comments or arguments for your above answers:
Q23	How about the future: the year 2050? Write comments or arguments for your above answers:
Q24	At the moment, a community builds and develops its different "capitals". Capital comprises e.g. built (technology and infrastructure), culture (knowledge and capabilities of individuals) and social (official and unofficial networks) capital. Write comments or arguments for your above answers:
Q25	How about the future: the year 2050? Write comments or arguments for your above answers:
Q26	At the moment, the average profitability of farms is low. How about the future: the year 2050? Farms are reasonably profitable. Farms succeed with their work (if they want) without being overly dependent on subsidizes or on work outside the farm (another employer). Farms are neither heavily indebted. Write comments or arguments for your above answers:
Q27	At the moment, a farmer has either secondary or university degree. He or she may also have other working experience. Write comments or arguments for your above answers:
Q28	How about the future: the year 2050? Write comments or arguments for your above answers:
	FOOD INDUSTRY
For all Q29-Q44	**<u>Matrix questions having Likert scale</u>: 1. Strongly disagree 2. Disagree 3. Don’t know 4. Agree 5. Strongly agree** **<u>And options</u>: small, medium and large (national level) food enterprise**
Q29	At the moment, food companies have taken into account the importance of diversified connections to their stakeholders, for example, to minimize risks. They have e.g. several suppliers, buyers, target groups or distributors for their products. Write comments or arguments for your above answers:

Q30	How about the future: the year 2050? Write comments or arguments for your above answers:
Q31	At the moment, food companies have taken into account diversity in their different functions, for example, in their raw material supplies (several suppliers and several different kinds of raw materials), in their products, distribution and customers. Write comments or arguments for your above answers:
Q32	How about the future: the year 2050? Write comments or arguments for your above answers:
Q33	At the moment, food companies have "flexibility" to handle problems or even crisis. They have, for example, spare parts, reserve power, machinery or additional manpower available. Flexible resources ensure the continuation of the operations in spite of surprises. Write comments or arguments for your above answers:
Q34	How about the future: the year 2050? Write comments or arguments for your above answers:
Q35	At the moment, food companies operate respecting natural resources and environment. Food companies do not deplete or contaminate natural resources, water resources and produce only little amounts of waste. Write comments or arguments for your above answers:
Q36	How about the future: the year 2050? Write comments or arguments for your above answers:
Q37	At the moment, learning, active search and sharing of information and innovative product development and testing are essential parts of the food company operations. Write comments or arguments for your above answers:
Q38	How about the future: the year 2050? Write comments or arguments for your above answers:
Q39	At the moment, food companies are more locally or nationally dependent than dependent on global markets or players to have their raw material or other supplies. Write comments or arguments for your above answers:
Q40	How about the future: the year 2050? Write comments or arguments for your above answers:
Q41	At the moment, food companies take responsibility of consumer well-being (in addition to social and environmental responsibility) by bringing to the marker products, which truly promote well-being. Products whose healthiness is questionable (fat or sugar content, no nutritional value or has no fibers) are marked clearly and understandably.

	Write comments or arguments for your above answers:
Q42	How about the future: the year 2050? Write comments or arguments for your above answers:
Q43	At the moment, food companies build and develop different "capitals" of its local community. Capital comprises e.g. built (technology and infrastructure), culture (knowledge and capabilities of individuals) and social (official and unofficial networks) capital. Write comments or arguments for your above answers:
Q44	How about the future: the year 2050? Write comments or arguments for your above answers:
	RETAIL
For all Q45-Q57	**Matrix questions having Likert scale: 1. Strongly disagree 2. Disagree 3. Don't know 4. Agree 5. Strongly agree** **And options: local, national and international level retail actors**
Q45	At the moment, retail companies purchase their food supplies more locally or nationally than from global markets. Write comments or arguments for your above answers:
Q46	How about the future: the year 2050? Write comments or arguments for your above answers:
Q47	At the moment, retail companies have taken into account the importance of diversified connections to their stakeholders, for example, to minimize risks. They have e.g. several suppliers, sales channels or target groups. Write comments or arguments for your above answers:
Q48	How about the future: the year 2050? Write comments or arguments for your above answers:
Q49	At the moment, retail companies have "flexibility" to handle problems or even crisis. They have, for example, spare parts, reserve power, machinery or additional manpower available. Flexible resources ensure the continuation of the operations in spite of surprises. Write comments or arguments for your above answers:
Q50	How about the future: the year 2050? Write comments or arguments for your above answers:
Q51	At the moment, learning, active search and sharing of information and innovative solutions and testing are essential parts of the retail company operations. Write comments or arguments for your above answers:
Q52	How about the future: the year 2050? Write comments or arguments for your above answers:
Q53	At the moment, retail companies operate respecting natural resources and

	environment. Retail companies do not deplete or contaminate natural re-sources, water resources and produce only little amounts of waste. Write comments or arguments for your above answers:
Q54	How about the future: the year 2050? Write comments or arguments for your above answers:
Q55	At the moment, the structure of retail in Finland is concentrated. How about the future: the year 2050? Retail business has additional channels both new and old ones, so the structure is more diversified. Write comments or arguments for your above answers:
Q56	At the moment, retail companies build and develop different "capitals" of its local community. Capital comprises e.g. built (technology and infrastruc-ture), culture (knowledge and capabilities of individuals) and social (official and unofficial networks) capital. Write comments or arguments for your above answers:
Q57	How about the future: the year 2050? Write comments or arguments for your above answers:
	CONSUMPTION
For all Q58-Q65	**<u>Only Likert scale</u>: 1. Strongly disagree 2. Disagree 3. Don't know 4. Agree 5. Strongly agree**
Q58	At the moment, consumers purchase more local or national food supplies than imported food supplies (when possible). Write comments or arguments for your above answers:
Q59	How about the future: the year 2050? Write comments or arguments for your above answers:
Q60	At the moment, most of the consumers are very aware how their choices impact their health and environment. Write comments or arguments for your above answers:
Q61	How about the future: the year 2050? Write comments or arguments for your above answers:
Q62	At the moment, consumers are able to make choices and even organize based on their needs and hopes, for example, to support ethical or ideologi-cal food choices or availability (such as organic, local, non-gmo, vegan etc. foods). Write comments or arguments for your above answers:
Q63	How about the future: the year 2050? Write comments or arguments for your above answers:
Q64	At the moment, majority of consumers are aware of the environmental im-pacts of food waste and are actively acting to reduce the waste.

	Write comments or arguments for your above answers:
Q65	How about the future: the year 2050? Write comments or arguments for your above answers:
	COMMON QUESTIONS
For Q66-Q67	**Matrix questions having Likert scale: 1. Strongly disagree 2. Disagree 3. Don't know 4. Agree 5. Strongly agree** **And options: primary production, food industry, retail, consumption**
Q66	At the moment, to understand and to develop resilience of the food system is an essential part of its operations. Earlier questions in this survey give some idea what resilience concept is about. Write comments or arguments for your above answers:
Q67	How about the future: the year 2050? Write comments or arguments for your above answers:
Q68	What is your area of expertise and how would you define your expertise? Matrix question having options: top expert, expert / professional, novice And options for expertise areas: primary production, food industry, retail, research, consumption Open question: how many years of expertise do you have?

Appendix 2 Email message of the expert survey, the first round

Flexibility and adaptability of the Finnish food system now and in the future 2050

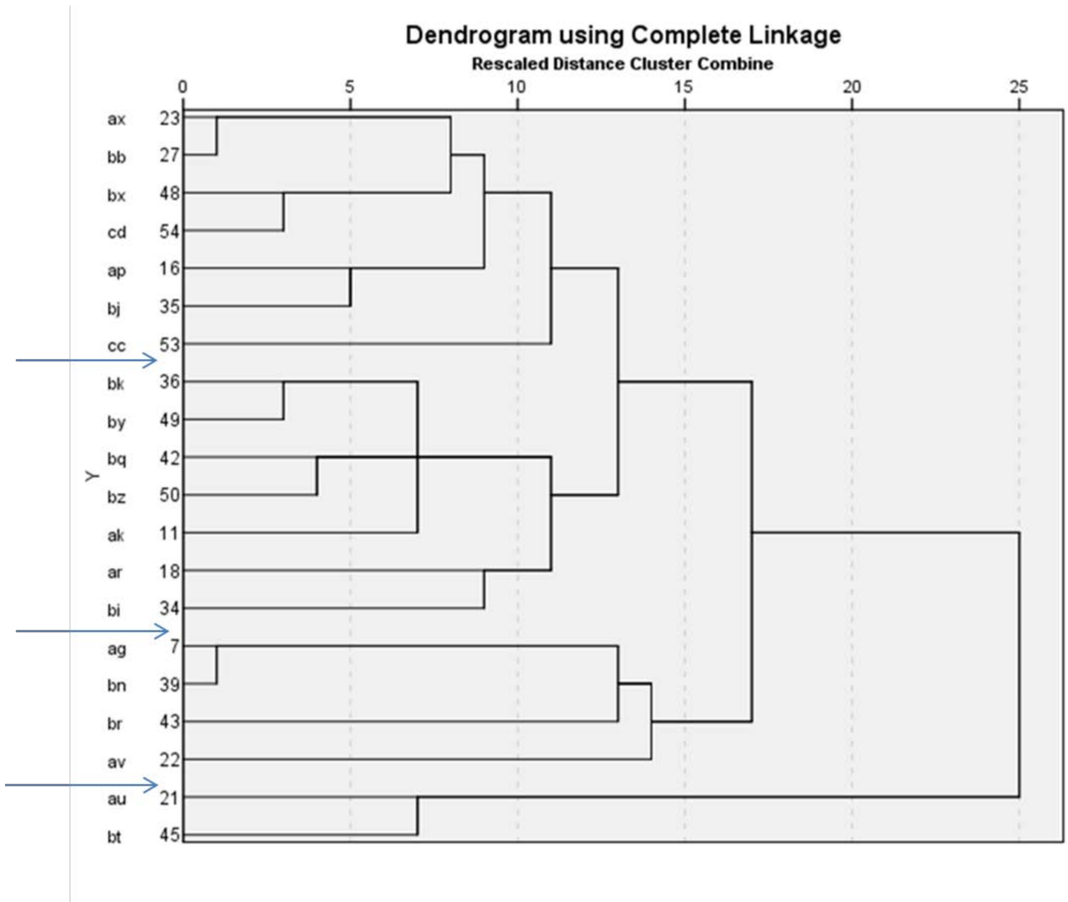
This research is about Finnish food system's flexibility and adaptability. A group of food system experts has been chosen to reply this survey. Contact details were obtained from the customer register of Agrifood Research Finland, MTT.
Every answer (anonymous) is very important. If there are enough replies, the second round will be arranged and that gives the opportunity to see how the other experts have answered.
This survey produces valuable information about the expert views regarding the state of the Finnish food system now and in the future from the perspective of flexibility and adaptability. The views about the future will be used to construct future scenarios.
You are able to access the survey from the link below. It takes about 5-15 minutes to reply, depending on how many sections are answered.

Thank you in advance.

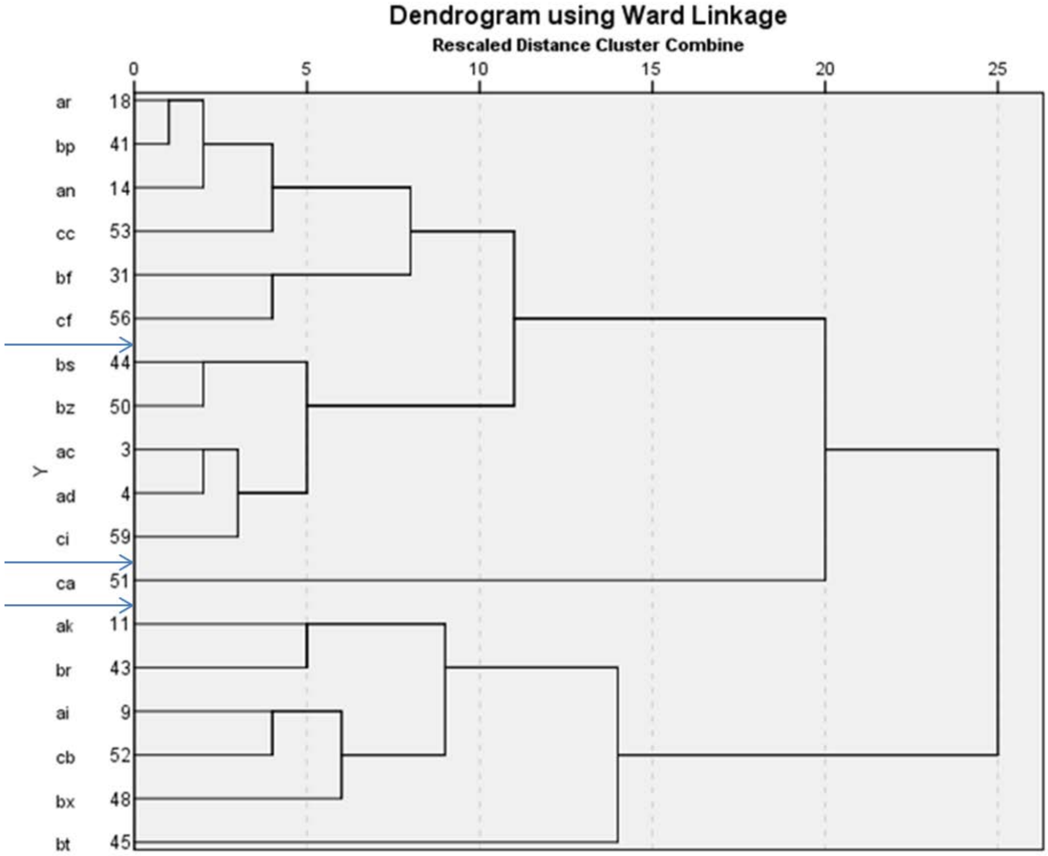
Kind Regards,

Titta Tapiola
Master's Degree Programme in Futures Studies, University of Turku
Telephone:
Email:

Appendix 3 Dendrogram of cluster analysis (primary production)



Appendix 4 Dendrogram of cluster analysis (food industry)



Appendix 5 Email message of the expert survey, the second round

Future images of the Finnish food system 2050

Last April you answered the questionnaire about the Finnish food system's flexibility and adaptability. Based on the replies, the year 2050 future images for primary production and food industry were constructed.
Link below takes you to the questionnaire where we ask your view about the desirability and probability of these future images. It takes about 10 minutes to answer the questions.

Thank you in advance.

Kind regards,

Titta Tapiola
Master's Degree Programme in Futures Studies, University of Turku
Telephone:
Email: