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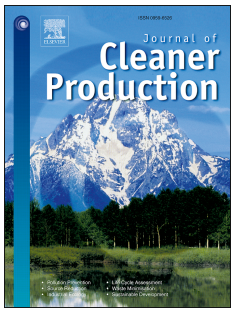

Vulnerability matrix of the food system: Operationalizing vulnerability and addressing food security

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Vulnerability matrix of the food system: operationalizing vulnerability and addressing food security

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Abstract

Food security is the major desired outcome of any food system, but its realization may be prevented by vulnerabilities in a food system. By shifting the focus of their vulnerability analysis from the discrete components of the food system to the food system as a whole, the authors of this article were able to develop a qualitative food system vulnerability matrix. The objective of the research was to make the concept of food system vulnerability operational by identifying vulnerability drivers, vulnerable systems and vulnerable subclasses in light of food security. The vulnerability matrix was set up with five classes of vulnerable systems ('Vulnerability of what?') on the horizontal axis and vulnerability drivers ('Vulnerability to what?') on the vertical axis. The authors analyzed the relationship between vulnerability drivers and vulnerable systems by using qualitative, abductive content analysis within the context of the Finnish food system. The data consists of public documents collected from the web pages of key organizations within the Finnish food system including ministries and their administration, interest groups and non-governmental organizations. It therefore covers various types of content related to food policy and management. Excerpts from the documentation data were coded according to which vulnerable system subclasses they addressed. The key findings of the study highlight the importance of using a systems approach that takes into account social, ecological and technical considerations. Such a framework covers multiple stressors, including exogenous natural drivers and endogenous social drivers, as well as the coalescence of vulnerability and food security discourses. The benefits of the proposed vulnerability framework for public food policy and food supply chain management include the explicit recognition of vulnerability drivers and vulnerable systems, a higher degree of specificity when speaking about food security, and opportunities for the identification of vulnerability-based innovations.

Keywords: Vulnerability matrix, vulnerability drivers, vulnerable systems, food security, operationalization, Finland

1 Introduction

Vulnerability is a central concept in food system research, policy and management, since the negative outcome of food system vulnerability is food insecurity (Eakin 2010, 81). However, the conceptual state-of-the-art of the field of vulnerability is confusing due to the many definitions of the term and the overlapping of similar terms (Hinkel 2011). In addition, Khazai et al. (2014) claim

that there is no knowledge base that focuses explicitly on data, methods and research initiatives to better understand specific approaches to vulnerability assessments. However, a more sophisticated understanding of food system vulnerabilities has begun to emerge. This focuses on both global environmental and societal change, and is based on the consideration of multiple drivers (Ericksen et al. 2010, 72). The identification of vulnerabilities in food systems and the development of means to rectify those vulnerabilities constitute true innovations and provide significant opportunities where public food policy and food supply chain management are concerned. In order to provide the structured representation of food system vulnerability that has been lacking in the research field, we have set up a vulnerability matrix that aims, first and foremost, to operationalize the concept of food system vulnerability. Our discussion centers around food security, which is the major desired outcome of any food system.

Two basic research questions are raised on the basis of the food system vulnerability concept. First, how can the concept of food system vulnerability be made operational? The achievement of this goal requires that the key components of vulnerability be specifically defined and distinguished from one another. This part of the research is conducted by formulating a food system vulnerability matrix, which includes vulnerability drivers in the rows and five classes of vulnerable systems in the columns. Second, how can an operational food system vulnerability framework contribute to the achievement of food security? We illustrate the applicability of a food system vulnerability matrix in the context of the Finnish food system. Addressing food security in this context requires the identification of vulnerability drivers, vulnerable systems and vulnerable subclasses. It is crucial to operationalize the vulnerability concept in order to facilitate the development and implementation of appropriate national food security and food supply chain management policies in light of current and emerging changes. This article thereby also contributes to the methodology of vulnerability assessments.

Vulnerability is a highly contextual and place-based concept (Cutter et al. 2003). It is typically described as a combination of exposure, sensitivity and adaptive capacity. Within a food system, the impact of an exposure, such as climate change, can vary significantly between and even within different countries. Food systems are vulnerable not only to climate and environmental change but also to various social factors, which is highlighted in the concept of double exposure (Leichenko et al. 2010). The multiple stressors to which food systems are exposed also include endogenous social drivers associated with internal factors, which together contribute to vulnerability (Bohle et al.

1994). It is important to note that vulnerability is a theoretical concept and does not denote an observable phenomenon, making it difficult to measure (Hinkel 2011). A framework for vulnerability indicator development and challenges for measuring vulnerability are discussed by the authors of this paper in a previous publication (Paloviita et al. 2015). Food-related vulnerability studies typically adopt a narrow focus on the vulnerability of agriculture instead of a more systemic focus where food processing, manufacturing, distribution and consumption are also considered (Eakin 2010, 79). This deficit partially reflects state policies around the world during the 20th century, as these were more focused on farming than on food systems. Most countries had ministries of Agriculture, not of Food (Lang and Barling 2012).

There is an inherent cycle of inside-out impacts (the impact a food system has on society and the environment) and outside-in impacts (external conditions that may affect a food system and food supply chains), which emphasizes the need for increased systems thinking to understand broader correlations and inter-linkages (Porter and Reinhardt 2007). These impacts are associated with external and internal vulnerabilities occurring within or beyond the system. Moreover, Beermann (2011) suggests that vulnerabilities within the German food industry caused by climate change could be both direct consequences (such as the physical consequences of climate change) and indirect consequences (such as change in transport conditions, risks for supply chain management, rise of production insecurities and changes in demand). The impacts can be multidimensional, including social, ecological, economic and cultural consequences. Hence, understanding these impact cycles is important not only for food system policies but also for food supply chain management. While corporate social responsibility policies mainly aim to make their business cases through sustainability management, we argue that more accurate identification of food system vulnerabilities can help companies to recognize major social or natural factors alongside business cases (e.g. Figge and Hahn 2012). This can be a real step forward in creating shared value in the food supply chain and in redefining productivity in the value chain (Porter and Kramer 2011).

Vulnerability drivers are generally classified into two types: exogenous natural drivers and endogenous social drivers (Khazai et al. 2014). Exogenous drivers such as extreme weather events, climate change and global environmental change are generally unpredictable in terms of their timing, magnitude, location and impact on the vulnerability of a given system (Beermann 2011; Linnenluecke et al. 2012; Misselhorn et al. 2010, 323). On the other hand, endogenous drivers such as anthropogenic impacts, governance and other socio-economic drivers represent a broader societal

perspective, which focuses on the social drivers of vulnerability (Khazai et al. 2014). For example, the vulnerability of children to air pollution around schools demonstrates the impact of human-made (anthropogenic) environmental pollution (Mohai et al. 2011). Essentially, the dual system of food system governance, private and public, generates another source of endogenous vulnerability (Barling 2007). State-led public food policy characterized by the authority of government and its institutions, and private, largely corporate led food policy characterized by the increasing influence of large retailers and food service corporations are both important in shaping food systems. Vulnerability to private sector food policies is illustrated by Worthy et al. (2012), who focuses on consumer vulnerability to weight-loss advertising among obese consumers.

From the social inequality point of view, Cahyadi and Waibel (2015) have studied contract smallholders' vulnerability to poverty. Poverty is also a major driver in the context of vulnerability to fluctuations in food prices among consumers in low-income brackets (Azzam and Rettab 2012). Changing consumption patterns can also be categorized as a socioeconomic vulnerability driver, since global supply chains ultimately connect, for example, "coffee drinking to species vulnerability" (Hertwich 2012, 36), reflecting the causal link between consumption and biodiversity loss. On the other hand, consumption activities can themselves be vulnerable. This was for example demonstrated by Lee and Soberon-Ferrer (1997), who studied consumer vulnerability to fraud and found this to occur more commonly among the elderly, women, minorities, the less educated and the poor. Vulnerable consumers have been defined as "those who are at a disadvantage in exchange relationships where that disadvantage is attributable to characteristics that are largely not controllable by them at the time of the transaction" (Andreasen and Manning 1990, 13). Baker et al. (2005), in turn, define consumer vulnerability as a state of powerlessness, a lack of control or a dependency with potential negative ramifications for the consumer. Another type of socioeconomic vulnerability driver is discussed by Bhattacharyya (2009) who presents the vulnerability of electricity supply to fossil-fuel dependence and fossil-fuel price fluctuations as an example of the impact of import disruptions and of international supply chains.

As previously mentioned, food security is the key desired outcome of a food system (Ericksen et al. 2010, 28). Food insecurity, on the other hand, can be understood as a specific manifestation of a situation of vulnerability (Roncarolo et al. 2015). There is growing pressure to achieve food security in a sustainable way as the global population rises, natural capital decreases, and our consumption patterns remain far from sustainable. In other words, there is a close relationship between food

security and sustainability. The process of identifying and seeking to address food system vulnerabilities highlights the need for greater attention to food system governance (Eakin 2010, 83). Consequently, public and private sector policies regarding food security are increasingly called on to achieve a balance between commercial, environmental and social considerations (Dyllick and Hockerts 2002). It has also been argued that nations' visions for sustainable food security as depicted in their food policies would be rendered more clear by integrating public policy across sectors (health, environment, trade, transport, regulation, welfare and education) and between different levels of governance (Lang and Heasman 2015, 286).

Lang and Barling (2012) note that there is no unifying policy framework for food security, as competing positions are maintained even by proponents from similar policy camps. The most commonly cited definition of food security was provided by the Food and Agriculture Organization (FAO) at the 1996 World Food Summit: "Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." (FAO, 2008, 1). The FAO (2008) has further elaborated upon this definition to include the physical availability of food (the supply side of food security), economic and physical access to food (household level food security), food utilization (the quality and safety of food) and the stability of food supply and access to healthy food over time without seasonal fluctuations or shortages. A more recent definition of food security is proposed by the Sustainable Development Commission (2009, 10), the UK's former government advisory board, which calls for defining food security in terms of sustainable food system

(1) where the core goal is to feed everyone sustainably, equitably and healthily

(2) which addresses needs for availability, affordability and accessibility

(3) which is diverse, ecologically-sound and resilient

(4) which builds the capabilities and skills necessary for future generations

The vulnerability of food systems is not limited to developing countries (Fresco 2009) and renewed interest in food security has emerged in European countries (Brunori and Guarino 2010, 41). However, there is a clear research gap in the existing literature concerning the future food security of European and other developed countries, which are facing multiple changes in their food systems. In this study, our empirical data focuses on the case of Finland. Although Finland can be

classified as a generally food secure country today, it will, in the future, face various food security threats that are similar to those faced by many other European countries. Another research gap is related to the definition of “food system”, which sometimes refers only to an agricultural system and at other times refers to a food supply chain, social system or coupled social-ecological system (see Ericksen et al. 2010, 69-70). In this paper, we situate our vulnerability analysis within a systems thinking approach, since food security is ultimately dependent on social systems (e.g. supplier relations), ecological systems (e.g. ecosystem services) and technical systems (e.g. electric power systems). As is the case in many other European countries, the government in Finland continues to focus on agriculture rather than on the broader food system where food policy is concerned: food policies are governed by a Ministry of Agriculture and Forestry. Consequently, the administration and management of food chain related matters is dispersed (Puupponen et al. 2016). Finally, most of the research concerning food system vulnerability focuses on exogenous vulnerability drivers, such as climate change, natural hazards and weather extremes. In this paper, we want to emphasize the double exposure of food systems to both environmental and social change, and consequently address vulnerability to multiple stressors (see Leichenko et al. 2010). We argue that greater attention should also be diverted to analyzing endogenous social drivers or internal factors (see Bohle et al. 1994) as contributors to food systems vulnerability.

The rest of this article is organized as follows. The second section describes the general inquiry approach, data collection and analysis, and vulnerability matrix methodology. This is followed by the empirical results of the vulnerability matrix and a detailed presentation of the vulnerability drivers, vulnerable systems and their inter-linkages. Finally, the implications of the operationalization of food system vulnerability to food security, food policy and food supply chain management are discussed. The last section provides concluding remarks.

2 Material and methods

The current study is abductive in nature as it is essentially a dialogue between data and theory, with the emphasis on "theory matching" or "systematic combining" (Dubois and Gadde 2002). In the abductive research process, the empirical data collection and theory building phases overlap as part of a learning loop (Spens and Kovács 2006). In our study, theories on food system vulnerability and food security, together with the empirical data, guided the selection of the vulnerability drivers and vulnerable elements. Similarly, codes were assigned to the vulnerable subclasses as a result of insights gleaned through the related literature and empirical data.

2.1 Abductive method as a learning process

Dubois and Gadde (2002) argue that successive steps in the learning process are seldom presented to the reader. Over the course of our learning process, we reformulated the vulnerability framework several times as we carried out our analysis. Our initial idea was to describe the vulnerability of the Finnish food system in the form of a matrix. We did not have any existing matrix model to guide us with regards to what the variables for the rows and the columns of the matrix should be. Starting with the conceptual definitions of vulnerability provided in the abovementioned literature, we reviewed our empirical data for potential vulnerability drivers and vulnerable food system. As a result, our initial matrix structure included food system activities (input production, agriculture, food industry, food retail and consumption) in the columns and a set of vulnerability drivers in the rows.

In the course of our research, we found an ontology-based semantic VuWiki for vulnerability assessments (Khazai et al. 2014). VuWiki proposed a division between vulnerable natural, social and technical systems and also the division between natural and social vulnerability drivers. After having reviewed the ontology-based VuWiki, we still wanted to use food system activities as the columns of the matrix but decided to redirect the presentation of the vulnerability drivers by utilizing the division by VuWiki. As a result, the new rows were hydrometeorological drivers, biological and ecological drivers, anthropogenic drivers, social inequality, food system governance and war and conflict. We used this matrix structure to review our empirical data anew, and added verbal descriptions of our empirical observations to the cells of the matrix.

Later in the research process, we explored the TRANSMANGO vulnerability matrix for the European food system by Grando et al. (2016), which proposed sixteen vulnerability factors and five vulnerability areas. It should be noted that one of the authors of this article participated in the development process of the TRANSMANGO vulnerability matrix. The TRANSMANGO matrix taught us three major lessons. First, we learned that vulnerability drivers should be more explicitly presented in the matrix instead of being combined into broad categories (e.g. "environmental pollution" instead of "anthropogenic impact"). The use of a more specific level of vulnerability driver ontology in VuWiki and the addition of food system specific drivers drawn from our empirical data gave rise to a matrix with thirteen vulnerability drivers.

Second, we learned that the columns of the matrix can and should represent a broader variety of vulnerability dimensions, i.e. more than food system activities alone. We therefore included three of the TRANSMANGO matrix's columns: food systems (which we named "food system activities"), sectors/supply chains ("food supply chains") and vulnerable social groups ("vulnerable groups"). According to our findings, these three columns represent subclasses of vulnerable social systems proposed by the VuWiki, i.e. functional systems (food system activities), organizational systems (food supply chains) and groups. The research literature also indicated that if our matrix only included social dimensions, then it would neglect to address the ways in which ecological and technical systems are vulnerable as well (Khazai et al. 2014) and the ways in which all three dimensions are interrelated in food systems. As a consequence, we broadened the matrix structure to include social-ecological-technical systems, with two additional columns named "natural systems" and "technical systems".

The third lesson from the TRANSMANGO matrix concerned the actual content of the matrix. We learned that a vulnerability matrix can only provide information about *who* or *what* is vulnerable to what. Information about *why* or *how* specific vulnerabilities exist must be presented using other approaches. For example, vulnerability matrix cannot show how specific vulnerability occurs in the interplay between the driver and the system. In practice, the abductive approach helped us to formulate more specific vulnerability drivers in a systematic manner, to include natural, social and technical systems as part of the framework, and to redirect the information provided in the cells.

2.2 Food system vulnerability matrix

As described above, the food system vulnerability matrix was built in an abductive fashion using two recently published vulnerability frameworks, the TRANSMANGO matrix and the VuWiki, and our own empirical data. Hence, our matrix is a synthesis of the abovementioned vulnerability frameworks and aims to combine the advantages of the two approaches.

The starting point in the VuWiki is the division between natural, social and technical systems. Natural systems are further divided into biological, physical and biophysical systems. Social systems, in turn, are further divided into functional systems (e.g. agriculture & forestry), organizational systems, and groups (e.g. households and communities). Finally, technical systems are divided into nine subclasses, including, for example, water and wastewater systems and transportation systems. The starting point in the ontology of vulnerability drivers is the division

between natural and social drivers (Khazai et al. 2014). Natural drivers are further divided into geological (e.g. earthquake), hydrometeorological (e.g. climate change), and biological/ecological drivers. Social drivers, in turn, are divided into anthropogenic impacts (e.g. environmental pollution), social inequality (e.g. poverty), governance (e.g. policy or policy change), and war/conflict and terrorism.

The TRANSMANGO vulnerability matrix, for its part, makes use of sixteen vulnerability factors and five vulnerability areas referring to vulnerable social groups, food needs and preferences, territories (geographical areas), sectors/supply chains (products and commodities), and food systems (food system activities) (Grando et al. 2016). The sixteen vulnerability factors represent five broader driver categories, namely environmental, technological, socio-economic, policy, and other factors. The factors are: soil fertility degradation, plant and animal diseases, extreme weather events, water shortages, increasing spread of pollutants, adoption of unsuitable technologies, impoverishment, price levels and volatility, power/market concentration, unhealthy food commercials, geopolitical tensions, weakening of political action, unfair/reduced agricultural support, social welfare cuts, accidental food contamination, and food fraud (Grando et al. 2016).

While the vulnerability drivers used in the VuWiki are very general and the factors used in the TRANSMANGO matrix very specific, our approach to vulnerability drivers represents a middle ground between these two. Instead of the sixteen vulnerability factors presented in the TRANSMANGO matrix, we selected thirteen vulnerability drivers that more closely represent the VuWiki ontology approach. We have not used the same names for our drivers as those used in the TRANSMANGO vulnerability matrix, although their meanings may overlap. Also, when the vulnerability drivers used in our matrix are compared with those used in the VuWiki, our list includes more food system specific drivers, although some of the drivers are the same. The chosen vulnerability drivers for our food system vulnerability matrix are: hydrometeorological drivers, loss of biodiversity and natural resources, plant and animal diseases, technical disruptions, land use, environmental pollution, social inequality, public food policy, private food policy, disruption of imports, consumption patterns, war and conflict, and terrorism and fraud.

Selecting and defining the classes of vulnerable food system was a more challenging task. Following the VuWiki approach, we wanted to reflect the vulnerabilities of natural, social and technical systems, all of which are crucial classes of the vulnerable food system, and also of functional systems, organizational systems, and groups within the social system. We therefore

decided to use the following columns in our matrix: natural systems, vulnerable groups, food supply chains (inter-organizational systems), food system activities (functional systems) and technical systems. The most fundamental difference between our matrix and the TRANSMANGO matrix is the inclusion, in our matrix, of natural systems and technical systems as separate columns.

2.3 Data collection and analysis

We decided to rely on publicly available documents produced by key actors of the Finnish food system for our empirical data. The first important decision in this regard was to select an appropriate geographical boundary for the data. By limiting the geographical focus to the Finnish food system (and Finnish documents) we were able to include a broader set of vulnerable subclasses in the analysis. We do not believe that our focus on a single country (Finland) poses problems in terms of relevance, since, as stated by Grando et al. (2016, 18), "an expected difference in terms of vulnerabilities between national and global food systems proved to be inexistent on the basis of the given factors." Based on this we expect, at least at the European Union level, that food systems are similarly vulnerable to the same factors, with no crucial differences in the scale and geographical extent of that vulnerability.

Our second important data collection decision was related to the selection of the relevant organizations to be included in the analysis. We sought to include the key organizations representing the state (public policy), the food supply chain (private sector) and civil society (see Lang 2005). Overall, it was acknowledged that food systems serve different functions for different actors with different outcome valuations, and that trade-offs are inherent to the relationship between the modern food system, food security, and sustainability (Ericksen et al. 2010). Public policy organizations included the ministries and administrative bodies which deal directly with food issues. The food supply chain category, in turn, included the interest organizations of primary producers, the food industry, the food retailers, and food workers in Finland. The civil society group included the Evangelical Lutheran Church of Finland and various non-governmental organizations.

Using the search engines found on the web pages selected, we searched for relevant, food-related, documents that included at least one of our keywords: (Finnish translations of) food security, food system, food supply chain, vulnerability, threat, risk, pressure, disturbance, crisis, adaptation, resilience, self-sufficiency, food safety, sustainability/sustainable development, and environment. Based on the initial search, approximately 400 documents were identified. These documents were

either included in or excluded from the analysis using a quick content check. The main criterion for the inclusion of a document was that it identified both a specific vulnerability driver and a specific class of vulnerable food system (whether a natural system, social group, food supply chain, food system activity or technical system). At the completion of this phase, a total of 163 documents from 21 different organizations had been retained. Where longer documents were concerned, it was not necessary to analyze them in their entirety when they contained sections that were irrelevant from both the vulnerability and food system points of view. The qualitative data in documentation consists of excerpts of documents captured in a way that records and preserves context (Patton 2015). The full list of the documents included in the analysis is shown in the appendix.

A total of 43 vulnerable subclass codes were created and all the document texts were analyzed according to these codes. For each class of vulnerable food system (column), we developed a set of codes representing different subclasses of natural systems (e.g. W = water system), vulnerable groups (e.g. F = farmers), food supply chains (e.g. MD = milk and dairy), food system activities (e.g. A = agriculture) and technical systems (e.g. T = transportation system). These codes were derived from the ontology for vulnerable systems (Khazai et al. 2014), the TRANSMANGO vulnerability matrix (Grando et al. 2016) and our empirical data. More specifically, there were six codes for natural systems, ten codes for vulnerable groups, eleven codes for food supply chains, eight codes for food system activities and eight codes for technical systems. These codes were placed in the appropriate rows of the matrix, depending on the context (vulnerability driver) of their occurrence in the texts. Hence, the vulnerability matrix only informs readers whether the relationship between the vulnerability driver and vulnerable subclass occurs in the documents or not. The frequency of occurrences was not reported in the matrix. However, to support the robustness of our qualitative insights, we counted the number of times that each code appeared in the texts and are also addressed these frequencies in the results section (see the "counting tactic" by Miles et al. (2013, 282).

The empirical data consisted of publicly available food-related documents from the organizations listed in the Table 1.

Organization	Web page	N of documents
Ministry of Finance (MF)	http://vm.fi	9
Statistics Finland (MF)	http://stat.fi	9
Ministry of Employment and the Economy (MEE)	https://www.tem.fi	9

MEE Business Sector Services	http://www.temtoimialapalvelu.fi	6
National Emergency Supply Agency (MEE)	http://www.huoltovarmuus.fi	5
Finnish Competition and Consumer Authority	http://www.kkv.fi	12
Finnish Food and Drink Industries' Federation	http://www.etl.fi	15
Finnish Grocery Trade Association	http://www.pty.fi	16
Finnish Food Workers' Union	http://www.selry.fi	11
Finnish Ministry of Environment (YM)	http://www.ym.fi	19
Finnish Environment Institute (SYKE)	http://www.syke.fi/	11
Ministry of the Interior (in Finland)	http://www.intermin.fi/	4
Finnish National Rescue Association (SPEK)	http://www.spek.fi/	6
Mannerheim League for Child Welfare (MLL)	www.mll.fi/	1
Ministry of Agriculture and Forestry (MMM)	www.mmm.fi	5
The Central Union of Agricultural Producers and Forest Owners (MTK)	www.mtk.fi	10
Natural Resources Institute Finland (former MTT)	https://www.luke.fi/	4
Evangelical Lutheran Church of Finland	www.evl.fi	4
Finnish Government	http://valtioneuvosto.fi/etusivu	1
Ministry of Social Affairs and Health	http://stm.fi/etusivu	4
Finnish Food Safety Authority Evira	http://www.evira.fi/portal/fi/	2
Total number of documents		163

Table 1. Selected organizations, their web pages and the number of documents analyzed.

3 Results

Subclasses of vulnerable natural systems, groups, food supply chains, food system activities, and technical systems identified in the documentation data are presented in the food system vulnerability matrix in Figure 1. Their identified vulnerability to thirteen vulnerability drivers is further discussed in the following sections. Given thirteen vulnerability drivers and 43 vulnerable system codes, there were 559 potential driver-system combinations (cells). It should be noted that more than half of these cells (306) remained empty after analysis (no vulnerability was identified in the documentation data). In order to improve the representativeness of the final matrix we decided to include only those vulnerable subclasses which were identified in at least three different documents with respect to a specific vulnerability driver. For example, vulnerability of consumption (food system activity) to public food policy was identified in the excerpts such as:

"*Excise duty hikes* from the beginning of the year had *a significant impact on food prices*."

"*Municipal food monitoring* cannot guarantee equal *food safety for all consumers.*"

"Environmental aspects are emphasized in the *city planning*, but due to the exclusion of competition aspect *large amount of consumers may be exposed to insufficient competition in retail markets*."

	Vulnerability drivers	Natural systems					Vulnerable groups									Food supply chains									Food system activities								Technic. systems	
		Water system	Air	Biophysical system	Animal welfare	Natural environment	Farmers	SME entrepreneurs	Employees	Poor	Children	Elders	Rural population	Population in general	Milk & dairy	Meat	Commodity crop	Fruit & vegetable	Fish	Local food	Organic food	Supply chain in general	Input production	Agriculture	Processing & manufact.	Distribution	Retailing	Consumption	Food system in general	Social infrastructure	Communication system
Natural drivers	Hydrometeorological drivers	*		*										*			*	*	*			*		*		*		*	*		
	Loss of biodiversity and natural resources																					*									
	Plant and animal diseases													*	*	*	*							*					*		
Anthropogenic	Technical disruptions													*		*									*			*	*		
	Land use			*																											
	Environmental pollution	*	*																					*							
Governance	Public food policy		*				*	*	*	*	*		*	*	*	*				*	*	*		*	*		*	*	*	*	*	*
	Private food policy		*		*	*	*	*	*		*	*	*	*		*		*				*	*	*	*	*		*	*		
Other socio-economic	Disruption of imports																					*		*					*	*	
	Social inequality										*			*															*			
	Consumption patterns	*	*			*			*		*			*		*						*			*				*	*		
	War and conflict						*								*	*									*	*				*		
	Terrorism and fraud																					*									

Fig 1. The food system vulnerability matrix, where vulnerability drivers are listed in the rows and vulnerable systems as well as vulnerable subclasses in the columns.

3.1 Vulnerable natural system

In recent years, increasing attention has been given to environmental vulnerability, especially the vulnerability of available natural capital stocks and ecosystem services (Birkmann 2013, 29; Ericksen et al. 2010, 29). Although natural hazards and climate variability originate from the

environment, natural systems also constitute an important resource for food system activities and food supply chains. Because farmers, food companies and ultimately all people are inherently dependent on available natural capital and ecosystem services, it is crucial to address the vulnerability of natural systems in the context of food system vulnerability. Our data indicated that natural systems are especially vulnerable to environmental pollution and consumption patterns. Emissions and effluents from agriculture and unsustainable consumption patterns were typically identified as drivers of vulnerability. Land use was identified as a driver in the context of biophysical vulnerability in particular: increasing and intensifying land use is a threat to biodiversity, including various species. It is not surprising that natural system vulnerability was mainly addressed in documents obtained from the Ministry of the Environment and the Finnish Environment Institute.

3.2 Vulnerable groups

According to Birkmann (2013, 27), the diversity and dynamics of people's changing conditions and local vulnerabilities should be addressed when identifying vulnerable groups. National and local research is also needed to assess the context in which societies or communities are embedded. In the food system, vulnerable groups can be identified based on their food security. However, the producers of food (e.g. farmers, small and medium sized entrepreneurs and employees) can also be seen as vulnerable groups, which can threaten the functionality of the food system and therefore food security. Based on our data, far more attention is paid to the vulnerability of social groups than to the vulnerability of natural systems. Public and private food policies were recognized as the key drivers of social group vulnerability. In addition, the general population’s vulnerability to consumption patterns was frequently identified due to its impact on long-term public health and well-being. Among occupational social groups, farmers, employees and small and medium sized entrepreneurs were commonly listed as vulnerable social groups. Among demographic social groups, children, rural population and poor people also emerged as vulnerable groups.

3.3 Vulnerable food supply chains

It is critical to understand also the vulnerability of commercial food supply chains to disruptions within a wider macroeconomic and natural environment characterized by many uncontrollable forces (Peck 2005). Due to political and public policy dimensions, food supply chain vulnerability

is wider in scope than integrated supply chain management, business continuity planning or corporate risk management (Peck 2005). Among the vulnerable food supply chains, meat and dairy supply chains were the most frequently identified. This is interesting, because these chains are also the most concentrated food supply chains in Finland. For an example of a discrete shock being applied to food supply chains one can look to the war in Ukraine and the resulting conflict between the European Union and Russia, which was particularly damaging to Finnish dairy and meat supply chains due to the Russian embargo on food imports in 2014. Before the embargo, Russia had been the main export market for Finnish dairy and meat products. Continuous stressors in the context of food supply chains, on the other hand, were related to legislative issues stemming from public food policy and negotiation power issues arising from private food policy. More specifically, power disparities between supply chain members and the lack of cooperation amongst public food policy makers were identified as key vulnerability drivers for food supply chains.

3.4 Vulnerable activities

Food systems include a range of activities from planting seeds to household waste disposal (Ericksen et al. 2010, 25). While agriculture is no longer the primary income generating activity in developed countries, other activities between farm and fork (processing, packaging, distribution, and retailing) have grown (Ericksen et al. 2010, 26). In our data, the vulnerability of the food system was mainly recognized as relating to the vulnerability of food system activities, which were far more commonly identified than the other classes of vulnerable food system (natural systems, social groups, food supply chains, and technical systems). Among food system activities, the vulnerability of agriculture, food processing and manufacturing, and consumption were highlighted in documentation data. The existing, compartmentalized policies that are currently being implemented by ministries, administrative bodies and interest groups are well suited to activity-based vulnerability assessments. Hence, the Ministry of Agriculture and the Central Union of Agricultural Producers and Forest Owners emphasized the vulnerability of agriculture, the Ministry of the Employment and the Economy and the Finnish Food and Drink Industries' Federation focused on the vulnerability of the food industry and so forth. Hydrometeorological drivers, including climate change, were typically associated with agricultural vulnerability. All activities were at least to some extent vulnerable to public and private food policies. For example, the Common Agricultural Policy (CAP), environmental policies and the weakening of agriculture's

competitive position under the pressure of policies implemented by food retailers and industries were all identified as vulnerability drivers for agriculture.

3.5 Vulnerable technical systems

Society's interconnected and interdependent technical infrastructures have become increasingly vulnerable to disturbances, which may have significant consequences for health, safety, security and the economy (Johansson and Hassel 2010). These consequences are passed on to the people, organizations and communities that depend on critical infrastructures (Johansson and Hassel 2010). Technical system was clearly the least identified class of the vulnerable food system. This is surprising, given that food retailers depend on retail information systems, the agriculture and food industries depend on water and wastewater systems, and the food system as a whole depends on the electric power system and transportation infrastructure. All pre-coded technical systems were occasionally identified in the documentation data, but the discussion was limited in scope. However, technical disruptions, which were included as a vulnerability driver, received much more attention in the documentation data. This might partly explain the lack of findings regarding this vulnerability column: it was perceived, in the documents, that the food system or its elements are vulnerable to technical disruptions and increasingly dependent on technical systems, but the vulnerability of those technical systems themselves was not addressed in any detail. It seems, then, that although there is some understanding of the vulnerability of food system activities and food supply chains to technical disruptions, there is less understanding of the specific vulnerability drivers threatening technical systems. For example, discussions regarding the vulnerability of information technology and cyber security were largely absent from the documentation data.

4 Discussion

In the previous sections, we presented the food system vulnerability matrix by explicitly addressing and distinguishing the vulnerability drivers, vulnerable systems and vulnerable subclasses identified by means of an abductive research process. Correspondingly, the first part of the discussion below focuses on the methodological challenges of the matrix's development and the second part on possible applications to public policy and food supply chain management.

4.1 Methodological challenges in developing the vulnerability matrix

The food system vulnerability matrix can be understood as an empirical application of the ontology for vulnerability assessments by Khazai et al. (2014). In addition, the food system vulnerability matrix in the Finnish context can be understood as a national application of the EU-level TRANSMANGO matrix by Grando et al. (2016). We argue that empirical vulnerability assessments at the national and even regional level are required in order to understand the contextual nature of vulnerability. Another noteworthy advantage of our food system vulnerability matrix is that it captures the vulnerabilities of five classes of vulnerable food system, all of which represent critical systemic dimensions of the modern food system. However, we faced a number of challenges in terms of the matrix structure and the information provided by the cells.

The development of the matrix structure included decision-making regarding its rows and columns. Presenting vulnerability drivers in the rows of the matrix provides a quick overview of the answer to the question: 'Vulnerability to what?' The ontology for vulnerability drivers (Khazai et al. 2014) introduced relatively useful driver categories, but the empirical food system context and the qualitative data suggested some specifications and additions to the list, such as "disruption of imports" and "consumption patterns". The driver categories are in some sense contingent, and given the need to keep the matrix readable some of them are very inclusive (such as the public and private food policy drivers). There are always trade-offs between readability and precision. Decisions regarding the columns of the matrix ('Vulnerability of what?') were more challenging, as they involved fundamental assumptions about the food system and its economic, social, and environmental dimensions. Our initial approach to the food system was an activity-based approach, where the food system was seen as a chain of successive activities (columns) from input production to consumption. In the EU-level TRANSMANGO matrix, in turn, the food system was presented as a broader social system including vulnerable social groups, food needs and preferences, territories, sectors/supply chains and food systems. Through the abductive process we ultimately decided to present the food system as a social-ecological-technical system, each dimension of which is vulnerable.

Information provided by the cells was determined by the coding and the qualitative analysis of the data. Codes for food supply chains and food system activities directly reflect the major themes discussed in the mainstream literature, e.g. milk and dairy supply chains or agriculture as an activity. There could have been even more subclasses associated with natural systems, vulnerable social groups and technical systems, which meant that we had to limit the number of subclasses

based on their contextual importance. The main source of uncertainty, in terms of the cells' contents, was the absence, in certain documents, of explicit mention of the vulnerability drivers and/or the vulnerable systems, such that said documents had to be interpreted. Three researchers (two doctors and one doctoral student) conducted and cross-checked the coding, which improved the reliability of the findings. Various uncertain cases were discussed by the researchers in order to generate a shared understanding of the basic interpretation principles. In our view, an occasional lack of clarity in documents does not undermine the reliability of the findings when a large enough number of documents are analysed, but populating a matrix with information taken from a very small number of documents would not serve any useful purpose.

4.2 Applications to public policy and food supply chain management

Policy engagement across the food system is necessary in order to respond to the central challenge for twenty-first century food policy: how to feed current and future populations equitably, healthily and in ways which maintain the ecosystems upon which humanity depends (Lang and Barling 2013). The food system vulnerability matrix can further promote national policy engagement with sustainable food and sustainable diets, which, in turn, are cornerstones of national food security. As the vulnerability matrix emphasizes the multi-level nature of food systems, it can contribute towards multi-level food policy. In other words, the food system vulnerability matrix can serve as the policy translation of national food security by helping to define the food system in terms of its vulnerability, using an appropriate level of detail and specificity. Moreover, the vulnerability matrix encourages us to ask "macro" policy questions (see Lang and Barling 2013), which require the multi-level consideration of natural, social and technical systems. Ultimately a set of clear and measurable social goals towards a sustainable and resilient food system are needed. However, the empirical results confirmed that the fragmented and compartmentalized public food policy in Finland constitutes a vulnerability driver across the country's food system.

Food supply chain policies can be considered as a vulnerability driver across the food system and at the same time food supply chains are vulnerable to outside-in impacts (Porter and Reinhardt 2007). Porter and Kramer (2011, 9) argue that "profits involving a social purpose represent a higher form of capitalism, one that creates a positive cycle of company and community prosperity." International and national food supply chains are powerful entities in the modern food system and they can lead social progress within the right kind of policy framework, guided by government regulation. The food system vulnerability matrix can highlight the vulnerability 'hotspots' of the food system

within which the food supply chains are embedded. Consequently, it can promote the recognition of any major social or environmental factors that should be taken into account alongside business cases (e.g. Figge and Hahn 2012) and to translate complex food security and sustainability issues into the business model. Unfortunately, our documentation data identified the private food policies implemented by large companies as one of the most common vulnerability drivers across the food system.

Supply chain vulnerability assessments (Peck 2005) contribute to supply chain resilience (Ponis and Koronis 2012) since they facilitate the proactive planning and design of food supply chain networks that anticipate unexpected and disruptive events. Diversity is generally considered important in creating resilience in the food system, allowing it to adapt to climate change, policy change and evolving resource issues (Pullman and Wu 2012, 256), and to preserve options in the event of a crisis (Ericksen 2008). This is in line with the notion that a sustainable food system is a productive system that is capable of responding to changing demands, which requires that vulnerability be minimized (Fresco 2009).

5 Conclusion

The vulnerability matrix proposed in this article was developed abductively and revised numerous times. Its objective was not to measure vulnerability, but to address and to distinguish between key components of vulnerability: vulnerability drivers, vulnerable systems and vulnerable subclasses. Through overlapping empirical data collection (excerpts of documentation) and theory building, we ended up with a matrix of thirteen vulnerability drivers and five vulnerable systems. The matrix was tailor-made for the Finnish food system, its applicability can easily be extended by making the necessary contextual, industry- and country-specific modifications. As it stands, the matrix operationalizes the concept of food system vulnerability and addresses national food security questions in the Finnish food system context.

Appropriate adaptation strategies at the public policy and food supply chain levels require explicit recognition of vulnerability drivers and vulnerable systems. Such recognition enables a higher degree of specificity when speaking about food security and sustainable food systems. Finnish food security is threatened by numerous vulnerability drivers, which can be broadly categorized as natural, anthropogenic, governance and other socio-economic drivers. Food systems, in turn, are a function of vulnerable natural systems, social groups, food supply chains, food system activities and

technical systems. Each class of vulnerable food system includes several subclasses, which were identified, attributed codes and included in the matrix. Moreover, vulnerability drivers and vulnerable systems are inherently interconnected and interdependent within and beyond the systems.

Future research should further aim to explicitly distinguish the other key factors affecting vulnerability, such as spatial scope (e.g. geographical or organizational boundaries) and temporal scope (timeframe) (Khazai et al. 2014; Birkmann 2013, 93). In addition, more attention should be given to the connections and interactions between and within societal, ecological and technical subclasses, where the focus should be on the critical linkages, feedbacks and synergies between different vulnerability drivers and classes of vulnerable food system (Leichenko et al. 2010; Khazai et al. 2014). At the public policy level, a national food security policy, which includes the criteria for sustainable food systems and diets, is needed. Currently, many developed countries, including Finland, are neglecting to develop such policies and criteria. At the food supply chain level, focal companies need to redirect their policies towards creating economic value by creating societal value through addressing society's needs (Porter and Kramer 2011), such as the need to feed everyone sustainably, equitably and healthily and to help resolve humanity's need to eat within ecological space (Lang and Barling 2013). This paradigm shift provides significant opportunities at all levels of food policy and business strategy development. If food security is the offspring of a sustainable food system, then innovation is the offspring of vulnerability.

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Appendix

Source	Name of the document (year)	Web link
Ministry of Finance (MF)	Kansallisen ruoka-strategian valmistelu (2009)	http://vm.fi/hanke?selectedProjectId=9680
	Economic survey - Autumn 2014	http://vm.fi/documents/10623/1106800/Economic-Survey-Autumn2014/0e813013-88a5-4f81-8f32-071ee6f230a6
	Sokeriverotyöryhmän loppuraportti (2013)	http://vm.fi/documents/10623/1236817/Sokeriveroty%C3%B6ryhm%C3%A4%20loppuraportti/8ebdf05f-710a-4878-aeb5-9d814f6e63c9
	The economic effects of the EU's Russia sanctions and Russia's counter sanctions (2014)	http://vm.fi/documents/10623/413004/Economic%20Effects%20Of%20The%20EUs%20Russia%20Sanctions/9d02e37f-2e48-467b-9461-8f61fea57e22
	Valtion hankintakäsikirja 2010	http://vm.fi/documents/10623/1107144/Valtion%20hankintak%C3%A4sikirja%202010/907009a1-0b4b-44e1-a408-a9b80cfdba0d
	Aluehallinnon selvitysryhmän raportti (2015)	http://vm.fi/documents/10623/1107223/Aluehallinnon%20selvitysryhman%20raportti/6671c63a-2a8b-48fd-a5c3-31c95879e01d
	Venäjän talouden näkymät ja vaikutukset Suomeen (2015)	http://vm.fi/documents/10623/1096506/Ven%C3%A4j%C3%A4n%20talouden%20n%C3%A4kym%C3%A4t%20ja%20vaikutukset%20Suomeen/82a661d4-1a31-4b4b-b71b-313bb7a25286
	VM esittää elintarvikkeiden vientiohjelman pikaista käynnistämistä (2014)	http://vm.fi/artikkeli/-/asset_publisher/vm-esittaa-elintarvikkeiden-vientiohjelman-pikaista-kaynnistamista

	Ota kantaa: Tulisiko Suomessa ottaa käyttöön sokeripitoisuuteen perustuva sokerivero (2012)	http://vm.fi/artikkeli/-/asset_publisher/ota-kantaa-ota-kantaa-tulisiko-suomessa-ottaa-kayttoon-sokeripitoisuuteen-perustuva-sokerivero-
Ministry of Employment and the Economy (MEE)	Kansallinen energia- ja ilmastostrategia (2013)	https://www.tem.fi/files/36221/TEMjul_8_2013_web_20032013.pdf
	EU:n 2030 ilmasto- ja energiapaketin vaikutukset Suomen energiajärjestelmään ja kansantalouteen (2014)	https://www.tem.fi/files/43982/T170.pdf
	Elintarvikealan yritykset panostavat kilpailukykyyn ja kansainvälistymiseen (2014)	https://www.tem.fi/ajankohtaista/tiedotteet/tiedotearkisto/vuosi_2014?117197_m=116572
	Elintarviketeollisuus tarvitsee kansainvälistymisen tueksi vahvaa kotimaista kysyntää (2015)	https://www.tem.fi/ajankohtaista/uutiskirjearkisto/uutiskirje_9.4.2015/elintarviketeollisuus_tarvitsee_kansainvalistymisen_tueksi_vahvaa_kotimaista_kysyntaa.117857.news
	Kuluttajapoliittinen katsaus 2013	https://www.tem.fi/files/37541/Kuluttajapoliittinen_katsaus_2013.pdf
	Materiaalitehokkuuden kehittäminen Suomen teollisessa rakenteessa (2013)	https://www.tem.fi/files/37387/VTT_Materiaalitehokkuus_Revisio2.pdf
	Bioteknologia 2020 -hyvinvointia suomalaisille	
	Selvitys yrityksille aiheutuvista hallinnollisista kustannuksista (2010)	https://www.tem.fi/files/29922/Selvitys_yrityksille_aiheutuvista_hallinnollisista_kustannuksista_Elintarviketurvallisuus_TEM_final_liitteineen.pdf
	Yhteiskunnan turvallisuusstrategia (2011)	https://www.tem.fi/files/41168/Yhteiskunnan_turvallisuusstrategia.pdf
MEE Business Sector Services	Toimialaraportti-Elintarviketeollisuus (2014)	http://www.temtoimialapalvelu.fi/files/2236/Elintarviketeollisuus_marraskuu_2014.pdf
	Toimialaraportti-lihateollisuus (2013)	http://www.temtoimialapalvelu.fi/files/2083/Lihanjalostusteollisuus_marraskuu_2013.pdf
	Toimialaraportti - leipomoteollisuus (2015)	http://www.temtoimialapalvelu.fi/files/2560/22_TOIMIALARAPORTTI_Leipomoteollisuus_2015.pdf
	Toimialaraportti - Kasvisten, vihannesten ja marjojen jalostus (2007)	http://www.temtoimialapalvelu.fi/files/2185/Kasvisten_vihannesten_ja_marjojen_jalostus_marraskuu_2007.pdf
	Toimialaraportti - Meijeriteollisuus	http://www.temtoimialapalvelu.fi/files/2186/Meijerite

	(2005)	ollisuus_marraskuu_2005.pdf
	Toimialaraportti - Kalakauppa ja kalatuotteiden valmistus (2004)	http://www.temtoimialapalvelu.fi/files/2189/Kalakauppa_ja_kalatuotteiden_valmistus_marraskuu_2004.pdf
National emergency supply agency (MEE)	Elintarvikemarkkinoiden tuontiriippuvuus (2015)	http://www.huoltovarmuus.fi/mediabank/876.pdf
	Naton elintarvike- ja maatalouskomitea kokoontuu Helsingissä (2001)	http://www.huoltovarmuus.fi/ajankohtaista/uutisarkisto/Naton-elintarvike--ja-maatalouskomitean-kokoontuu-Helsingissa-204.a
	Elintarvikehuoltoa tukevan varmuusvarastoinnin arviointi (2009)	http://www.huoltovarmuus.fi/static/pdf/209.pdf
	Joukkoruokailun valmiussuunnitteluohje (2008)	http://www.huoltovarmuus.fi/static/pdf/219.pdf
	Elintarvikemarkkinoiden tuonti jatkaa kasvua (2012)	http://www.huoltovarmuus.fi/ajankohtaista/uutisarkisto/Elintarvikemarkkinoiden-tuonti-jatkaa-kasvua-30435.a
Finnish Competition and Consumer Authority (MEE)	Nordic food markets -a taste for competition (2005)	http://www.kkv.fi/globalassets/kkv-suomi/julkaisut/pm-yhteisraportit/nordic_food_markets.pdf
	Children & foodstuffs marketing (2004,2015)	http://www.kkv.fi/globalassets/kkv-suomi/julkaisut/linjaukset/toimialakohtaiset-linjaukset/en/children-and-foodstuffs-marketing-2004.pdf
	Study on trade in groceries (2012)	http://www.kkv.fi/globalassets/kkv-suomi/julkaisut/selvitykset/2012/en/fca-reports-1-2012-study-on-trade-in-groceries.pdf
	Arvonlisäverotuksen aiheuttamat kilpailun vääristymät oikaistava (2000)	http://www.kkv.fi/ratkaisut-ja-julkaisut/julkaisut/arkisto/kilpailu-uutiset/2000/2/arvonlisaverotuksen-aiheuttamat-kilpailun-vaaristymat-oikaistava/
	Elämäntapa, mainonta ja ruokakulttuuri (n.a.)	http://www.kkv.fi/globalassets/kkv-suomi/opettajalle/oppimateriaalit/muu-aineisto-kalvot-sivut-esitteet-jne/elamantapa-mainonta-ja-ruokakulttuuri_-oppimateriaali.pdf
	Riittääkö vesi? (2011)	http://www.kkv.fi/globalassets/kkv-suomi/opettajalle/oppimateriaalit/artikkelit/riittaako-vesi.pdf

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	Ruokaketjun toimenpideohjelma	
Natural Resources Institute Finland (MAF)	Suomen ruokaturvan ja elintarvikehuollon nykytila ja tulevaisuuden näkymät	http://jukuri.mtt.fi/bitstream/handle/10024/438291/mttraportti80.pdf?sequence=1
	Julkiset ruokapalvelut ja ruokakasvatus: arjen käytäntöjen kautta kestävään ruokahuoltoon	http://jukuri.mtt.fi/bitstream/handle/10024/438193/mttkasvu10.pdf?sequence=1
	Monimuotoisuudesta sopeutumiskykyä. Ruokaketju uusille raiteille?	http://jukuri.luke.fi/bitstream/handle/10024/438258/mttraportti43.pdf?sequence=3
	Elintarviketuotannon ja elintarvikemarkkinoiden riippuvuus tuonnista	http://jukuri.mtt.fi/bitstream/handle/10024/438266/mttraportti61.pdf?sequence=1
Evangelical Lutheran Church of Finland	Kirkon ruoka-avustusten määrä kasvoi	http://evl.fi/EVLUutiset.nsf/0/55D1BFC453D38718C2257CBA00454A7E?opendocument&lang=FI
	Seurakunnat jakoivat ruoka-apua vähävaraisille yli 3 miljoonalla eurolla	http://evl.fi/EVLUutiset.nsf/Documents/7DE56BBFF2C41F37C2257B25004EC333?OpenDocument&lang=FI
	EU-elintarviketuki – Ruokaa tarvitseville	http://www.kirkkopalvelut.fi/eu-elintarviketuki
	Suomen evankelis-luterilaisen kirkon piispojen kannanotto maailman ruokaturvan puolesta	http://sakasti.evl.fi/sakasti.nsf/0/AC5B7C3890F48F5AC22577030038D858/$FILE/Ruokaturva_%20EVL_kannanotto_fi_061010.pdf
The Central Union of Agricultural Producers and Forest Owners	MTK:n vuosi 2014 (vuosikertomus)	https://www.mtk.fi/julkaisut/vuosikertomus/fi_FI/vuosikertomus2014/_files/93844187465006756/default/Vuosikertomus_2014_lopullinen_kevyt.pdf
	Osaava maaseutu – MTK:n tulevaisuusasiakirja	https://www.mtk.fi/mtk/strategiat_ja_ohjelmat/fi_FI/mtkn_strategiat_ja_ohjelmat/_files/90355370964419932/default/Osaava%20maaseutu.pdf
	Kohti osaavaa maaseutua 2015. MTK:n toimintastrategia	https://www.mtk.fi/mtk/strategiat_ja_ohjelmat/fi_FI/mtkn_strategiat_ja_ohjelmat/_files/90355378573739374/default/MTK_Strategia_valtuuskunnassa%20hyvaksytty%2023%2004%202009.pdf
	Vihreää kasvua ja menestystä maalle	https://www.mtk.fi/mtk/strategiat_ja_ohjelmat/fi_FI/mtkn_strategiat_ja_ohjelmat/_files/90355408563799

		477/default/MTKn%20liittokokouksen%20esitys%20valtuuskunnalle.pdf
	EU:n ilmastopolitiikka oikeille urille	https://www.mtk.fi/ajankohtaista/blogit/maanrakentaja/eun_ilmastopolitiikka_oikeille/fi_FI/
	MTK:n hyvinvointivaliokunnan tiedote	https://www.mtk.fi/liitot/pohjoissavo/ajankohtaista/utiset/fi_FI/1407484331824/
	Ruokaa koko Suomesta	http://www.mtk.fi/ajankohtaista/teemat/eurovaalit2014/fi_FI/ruokaa_koko_suomesta/
	Ruokahävikki	http://www.mtk.fi/vastuullisuus/ruokahavikki/fi_FI/ruokahavikki/
	Aidosti itsenäinen valtio perustaa kansansa ruokaturvan oman maan tuotantoon	http://www.mtk.fi/ajankohtaista/tiedotteet/tiedotteet_2012/joulukuu/fi_FI/oman_maan_ruokaturva/

Highlights

- Food system vulnerability matrix can be used in support of food security
- Vulnerable food system consists of natural, social and technical systems
- Multiple stressors include exogenous natural drivers and endogenous social drivers
- Abductive research method is described as successive steps in the learning process
- Vulnerabilities can become innovations in food supply chain management and policy