Multi-Level Governance for Climate Change Adaptation in Food Supply Chains

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Abstract

The vulnerability of food supply chains to climate change is higher compared to other industries due to its dependency on climatic conditions, temperature and water supply. As a robust response to the vulnerability of food supply chains, it is essential to find ways of linking the concepts of sustainable development, climate change adaptation and risk governance into one paradigm. The risk governance of food supply chains is conducted by and across both private and public spheres. Hence, in this chapter, we introduce a dual system of governance to match the objectives of climate change adaptation, and discuss the multiplicity and potential integration of both corporate-led private governance and public governance based on the authority of governments and their institutions. The aim of this chapter is to highlight climate change adaptation in relation to the practices of risk governance of the food supply chains within a multilevel framework of private and public policies. It explores the outlook of climate change adaptation in food supply chains, probing the extent to which governance should be framed as an inter-governmental issue, a national/local issue, an upstream supply chain issue or a downstream supply chain issue. The study is carried out by delving into the international adaptation literature with focus on different levels of framing the food supply chain and its adaptation to climate. We conclude that it is important to marry the efficiency of food businesses with the attainment of wider societal objectives such as sustainable development, climate change adaptation and food security, in order to increase resilience of the overall food system.

Keywords: multi-level governance, climate change adaptation, food supply chain, vulnerability, sustainable development, resilience

INTRODUCTION

Food supply chains are characterized by increasing connectivity and complexity, which affect their vulnerability to unexpected changes. There is growing understanding that climate change will have an increasing impact on food supply chains and food security (Beermann, 2011; Paloviita et al., 2015). This means that the need for adaptation to climate change impacts becomes increasingly apparent (Dow et al., 2013) and indicates that the adaptive capacity of the food supply chain with regard to its resilience must be addressed (Smith et al., 2003). In fact, climate change is one among a set of interconnected food systems risks which are also influenced by rapid changes in biodiversity, land cover, availability of fresh water, and the nitrogen and phosphorus cycles (Vermeulen et al., 2012). This calls for the development of theoretical and practical frameworks to strengthen the capacity of food supply chains to respond to climate change impacts. This chapter aims to highlight from a network perspective climate change adaptation and the practices of risk governance of the food supply chains within a multilevel framework of private and public policies. Although climate change adaptation has been primarily a matter that is dealt with on a regional and local scale, we argue that food supply chains, governments and intergovernmental agencies have a crucial role in climate change adaptation.

Impacts of climate change, which are expected to be widespread, complex, temporally and geographically variable, and profoundly influenced by social and economic conditions (Vermeulen et al., 2012), can pose major threats to food supply chain resilience. Food supply chains have been typically designed to optimize for cost or customer service (Christopher et al., 2004), but with climate risk reduction in mind, resilience needs to be highlighted as an additional new objective. As a critical dimension of resilience, adaptive capacity refers to the degree to which the system can build and increase the capacity for learning and adaptation (Klein et al., 2003). Ability to cope with climate change impacts effectively requires that all

key activities related to the food supply chain are analyzed in terms of identifying climate risks. After analyzing the risk-related information of all food system activities, the assessment of overall vulnerability of the food supply chain is needed. We argue that effective coping with climate change risks and vulnerabilities calls for a multi-level governance framework, including both public (on a governmental level) and private (on a corporate level) policies, reflecting an essentially dual system of governance. This multi-level governance framework is essential in order to build both food system resilience and food security. In addition, we emphasize the need to address a strategic combination of climate change mitigation and adaptation requirements at the same time (Beermann, 2011), since impacts of food systems on climate change and impacts of climate change on food systems are intertwined (Vermeulen et al., 2012).

Consequently, multi-level governance of the food supply chain, including climate risk, seems to be a task of increasing complexity. Analytically, the hazards of the food system can stem either from external impulses (such as climate change) or from internal causes (such as market failure or disconnect in the food supply chain). One idea to alleviate risk in the food supply chain has been to reduce complexity, which is best manifest in the local food alternative. However, even a food supply chain that pursues the local food framework needs to adapt to external impulses. Hence, Morgan et al. (2006) conclude "…agri-food studies could also benefit from more critical engagement with theories of multilevel governance because far from being a local matter, food supply chain localization will need to draw support from every tier of the multilevel polities that govern our lives today."

Undoubtedly, the scale of the food supply chain has been one of the most pertinent issues of agri-food studies (see e.g. Thompson and Scoones, 2009). One of the main reasons for this is the perceived vulnerability of food supply chains that are increasingly extended across the globe. The counter-tendency has sometimes been identified as re-territorialisation of the food

system (Battaglini et al., 2016). Consequently, the development of food supplies is shifting towards higher diversity of food supply chains that vary according to local and regional circumstances. Thus, it seems more appropriate to envision the food supply chain as an entity of particular actions, processes and agents rather than something to be presented as a universal system. Accordingly, even the risks and vulnerabilities of the food supply chain can be more coherently identified as embedded in their territorial context rather than validated globally.

The article includes three thematic sections focusing on 1) climate risk identification in food supply chains, 2) multi-level governance represented by public and private policies and 3) building food system resilience and food security. Based on these thematic discussions we propose a framework outlining a multi-level governance of climate change adaptation of the food supply chain (Figure 1), and introduce the conclusion.

IDENTIFYING CLIMATE RISKS IN FOOD SUPPLY CHAINS

There are four essential activities in the food system and in any type of food supply chain: producing (agriculture), processing and packaging (and manufacturing), distributing and retailing and consuming (Ericksen, 2008). Although studies of climate change impacts on food systems have focused on production activities, there is an emerging understanding of how climate change will also affect storage, processing, manufacturing, transport, retail and consumption (Vermeulen et al., 2012). Identifying climate change-related risks across all these activities can be part of a vulnerability assessment of the food supply chain, which encompasses the analysis and identification of exposure, sensitivity and adaptive capacity (Smit and Wandel, 2006). By identifying risks and vulnerabilities in the food supply chain, corporations can save costs due to proactive risk management and measurements, and develop new products through innovation (Beermann, 2011). Svensson (2000), for example,

places vulnerability and related concepts, such as risk, uncertainty and reliability within the context of contingency planning, whereas in the research by Peck (2005) supply chain vulnerability is taken to be related to risk, such that something (e.g food supply chain) is at risk, vulnerable or likely to be lost or damaged.

Due to the distribution of risks on various activities in the food supply chain, multi-level governance framework for managing risk or vulnerability to climate change becomes essential. Actually, a risk can be attributed to an organization, a supply chain, a region, an economy, the environment or society at large. Simultaneously, the vulnerability of the food supply chain can refer broadly to the climatic conditions that increase the food security risk faced by households or communities as a result of a climate shock (Khrishnamurthy, 2014) or to the consequences for organizations from extreme weather events (Linnenluecke et al., 2010). Also, climate change can have more long-term effects on vulnerability of the food supply chain (e.g. food cold chain risks, James and James, 2010) in ways that increase risk and demand new investment. Furthermore, it has been argued that low-income producers and consumers of food will be more vulnerable to climate change due to their limited ability to invest in adaptive institutions and technologies (Vermeulen et al., 2012; Wheeler and von Braun, 2013).

In terms of organizations, Kamalahmadi et al. (2016) found a new trend in the literature, that focuses on resilience in the context of small and medium-sized enterprises (SMEs), many of them especially vulnerable to disruptions. If we accept the notion that food supply chains are inter-organizational networks embedded within a complex socio-ecological environment and characterized by many uncontrollable drivers, including climate change, we must also accept that there are dependencies and inter-connectedness to be addressed at the network level (Kamalahmadi et al., 2016; Peck, 2005). Thus, in adapting the food supply chain to climate

change the first priority is in facilitating risk identification and control by the (numerous) private actors in and through multilevel networks of the food supply chain.

Although climate risk may seemingly be isolated to specific regions or industry segments (e.g. typically those most directly reliant on the natural environment, such as agriculture), economic consequences or food security implications can be, in fact, magnified through flow-on effects (Linnenluecke et al., 2010). Given the interdependencies between organizations and their supply chains, risk can be a result of various supply chain disruptions (Christopher et al., 2004). Moreover, even climate change adaptation policies as implemented by governments may comprise a risk to food supply chains (e.g. strong public support policy for bioenergy, see Wheeler and von Braun, 2013; Murphy et al., 2011). Finally, adaptation lead by focal corporations in food supply chains may come as a risk to individual producers, when climate change alters the relative productivity of specific regions, affecting input costs (Porter et al., 2007). Consequently, the buyers (focal corporations) can easily replace their suppliers or even relocate the hub of a supply chain away from an area that is overly exposed to climate change (West, 2014; Paloviita, 2015).

Thus, supply chain risk can be placed into five categories relating to (1) process and (2) control risks internal to the firm, (3) demand, (4) supply risks internal to the supply chain network, and (5) environmental risk external to the network (Christopher et al., 2004). Climate change risk represents the last category, namely a risk external to networks. Nevertheless, the risk may land directly on the focal firm or on those upstream and downstream, hence requiring a broader perspective when it comes to contingency planning. As to the concerns of public interests, the broader perspective needs to be opened towards public policies and the facilitating role they can perform through measures of multilevel governance.

MULTI-LEVEL GOVERNANCE AND COPING RISKS: PUBLIC AND PRIVATE POLICIES

Governance arrangements for food supply chain management focus especially on reducing risk and uncertainty, which are usually blind to tradeoffs and resulting risks (van Bueren et al., 2014). For example, there are concerns around national and regional mismatches between responsibility for, and vulnerability to, climate change; this means that the governance of integrated adaptation and mitigation policies to achieve food security need mechanisms to avoid unequal distribution of costs and benefits (Vermeulen et al., 2012).

Existing governance activities, such as policy development, reflect objectives, attributes, norms and standards of individual and collective interests (Dow et al., 2013). Multilevel governance is the keyword that is designated to characterize the process of public development and transition in specific fields of individual and collective interests. In general terms, multi-level governance has been defined "as decision-making that is steered not only by public but by private and other interests, and as a process that takes place across multiple geographic scale levels and sectors" (Keskitalo 2010, 4; see also Boland, 1999). Some definitions highlight the non-hierarchical networking mode of multilevel governance. For example, Biermann (2009) defines multilevel governance as normally denoting "new forms of regulation that differ from traditional hierarchical state activity and implies some form of self-regulation by societal actors, private–public co-operation in the solving of societal problems, and new forms of multilevel policy." Finally, some other definitions put more emphasis on the regional dynamics of decentralization. For example, regionalization as part of multilevel governance has often been perceived as one aspect of European integration that actually limits to some extent the powers of the nation states. This perspective is interesting when applied to food supply chain risk management that leads to increasingly coordinated

action on the European Union (EU) level, yet simultaneously yields space for sub-national regional innovation in risk management (see also Hooghe, 1996). Nevertheless, nation states are still seen as key actors in the arena of international climate policy as well as in the larger scene of sustainable development.

From the perspective of governance and risk management, the food supply chain is sometimes simply conceived to be something more manageable than the entire food system. According to the FAO report *Climate change and food security: a framework document"* (2008) "the main conceptual difference between a food system and a food supply chain is that the system is holistic, comprising a set of simultaneously interacting processes, whereas the chain is linear, containing a sequence of activities that need to occur for people to obtain food." So, thinking in terms of a linear path makes it easier for policy makers to identify risk, and more specifically, the risk of disrupted processes in the food supply chain. Thinking in terms food supply chain instead of food system, however, should not imply missing the point of the locally- or regionally-embedded character of risk. In order to avoid short cuts in understanding the circumstances in which the food supply chain is vulnerable to climate change, the identification of risk still needs to differentiate between risks created by internal impulses and those created by external impulses, and set the policies to manage risk accordingly.

Recently, there has been a further attempt to define the politics of public risk management in a more ambitious manner, namely as multilevel *risk* management (e.g. Corfee-Morlot et al., 2011). The leading idea is that, as part of the general framework of climate change adaptation, nation states as well as the subnational and supranational actors should increase their capacities to make a coordinated effort to alleviate climate risk in a coordinated way and on the basis of identified risks. This applies to public food supply chain management as well

as other relevant sectors of climate policy. This obligation is, however, quite challenging due to many reasons. Firstly, there is an obvious lack of scientific information on some crucial aspects of risk in food delivery, hence impeding systematic identification of risk. For example, Wheeler and von Braun (2013) argue that globally, there is ample information on climate change and food availability but much less scientific information concerning the climate change impacts on food access, utilization and stability dimensions. However, all these dimensions should be covered in order to achieve a more holistic understanding of food security. Secondly, public government has been mostly institutionalized in a centralized top down mode and therefore it does not give much space for two-way vertical dynamics in adaptation and managing risk. Thirdly, inclusive risk governance would demand effective joint efforts of many public and private stakeholders that seldom find well-functioning channels for long-term cooperation.

In the private sphere, balancing upstream and downstream supply chain risks continues to be challenging as well. This is because purchasing and selling are taken care of by different departments within organizations (Wognum et al., 2011). Moreover, balancing overall food supply chain risks and societal risks is even more challenging because of the dual structure of governance: private and public (Barling, 2007). Consequently, coping with risks requires institutional arrangements that facilitate the processes of interaction and coordinate problem solving, focusing especially on the tradeoffs between different values and interests (van Beuren et al., 2014). Hence, climate risk can be described as a ‘wicked problem’, which refers to "an approach to understanding the dynamics of a major proposed change with multiple and conflicting inputs and multiple possible outcomes, all of which play over time against, or occasionally with, each other" (Sun et al., 2016).

Climate change adaptation is often associated with the re-territorialization of risk governance (Keskitalo, 2010). This idea fits well with some of the quality demands of the sustainable food supply chain, such as flexibility and reducing complexity. When horizontally networking actors join their efforts, the regional food supply is likely to be best secured (e.g. McAdam et al., 2014). However, this does not suffice for the sustainability of the food supply chain, especially not if we think in terms of some other food security values, such as equity of access to food, food safety and the transparency of the functioning food supply chain and the larger food system. Questions about climate risks to food security or organizational objectives lead to distributional questions and associated governance challenges, depending on whether values and objectives are common and shared, or private to certain actors (e.g. a multinational food corporation). For example, the objectives of climate change adaptation can be associated with livelihoods, profits, environmental stewardship, food security or other multiple objectives (Vermeulen et al., 2012).

At least two important remarks therefore highlight the role of public governance. Firstly, there is a need for supra-regional public risk governance, which implies that in addition to effective horizontal actor-networks, even the vertical linkages of the food supply chain need to be established and consolidated (c.f. Juhola, 2010). Secondly, it becomes evident that even if a deliberate focus on the food supply chain's eco-efficiency may advocate a turn towards increasingly regional models of food security and the adaptation to climate change, food supply chain management also implies some effective regulatory measures in the level of the nation state and even beyond. This is because in the international policy arena (IPCC, Paris Agreement, etc.) the adaptation line of discussion continues to accentuate the strong role of nation states even if the initiative and innovation are expected to happen in the local level. Furthermore, intergovernmental organizations, such as FAO, UNEP, OECD and World Bank will continue to have important influence in programming and funding sustainability

transformations in agriculture and are increasingly starting to envision for development programs concerning the entire food chain instead of agriculture only (see e.g. Bagherzadeh et al. 2014, IFAD 2017).

Much of the academic discourse on adaptation policies have so far been focused on the barriers that should be overcome in order to pursue targets of sustainable development and effective risk governance. The empirical research on barriers of implementation concerning effective climate adaptation has revealed, for example, that there is still much fragmentation in the adaptation policies, many problems in coordinating multiple issues of time and scale, as well as major disconnect of tasks, resources and interests. Moreover, local actors often perceive more strongly than actors of higher levels the barriers for their action (Biesbroek et al., 2011, Juhola, 2010). These observations in recent climate change adaptation research imply that it is important in food supply chain risk management, to identify and include the barriers of implementation and in particular, how they are embedded in the territories where food is supplied.

BUILDING FOOD SYSTEM RESILIENCE AND FOOD SECURITY

According to Vermeulen et al. (2012) there is no global food system but rather, a set of partially linked food supply chains, varying from local to global supply chains. Hence, a starting point for building food system resilience is to consider food supply chain resilience in particular circumstances. Christopher et al. (2004) call for supply chain strategies that embody a higher degree of resilience, implying flexibility and agility. Sheffi (2005) suggests that to achieve built-in flexibility, companies should adopt standardized processes, use concurrent instead of sequential processes, and plan to postpone and align procurement strategies with supplier relationships. In addition, building supply chain resilience requires an improved understanding of the network that connects businesses, upstream suppliers and

downstream customers, a reconsideration of the supply base strategy, as well as overall design principles for supply chain resilience and a high level of collaborative work across supply chains (Christopher et al., 2004).

According to Kamalahmadi et al. (2016), sourcing strategies are the main supply chain resilience strategies that are discussed in the literature. In terms of supply base strategy, the reduction of the supplier base and single sourcing can be dangerous from the resilience perspective, whereas alternative sources of supply can decrease the risk (Christopher et al., 2004). Sheffi (2005), in turn, suggests focusing on a small group of key suppliers with deep relationships (sharing the risk) or having an extensive supplier network with arm's-length relationships (distributing the risk). Finally, cultural change is an important factor in building resilience, which can be related to corporate culture (Sheffi, 2005) or supply chain risk management culture (Christopher et al., 2004), where the culture of risk management should be extended beyond the boundaries of corporate risk.

Because governments design national climate change adaptation strategies with food security in mind, there is also a need for an improved understanding of the networks that connect food supply chains, governments, households and communities. Hence, collaborative working both across and beyond food supply chains is needed in the multi-level governance of climate risk. For supply chain collaboration, Ponis et al. (2012) highlight the importance of information sharing, collaborative work and joint decision making, whereas Kamalahmadi et al. (2016) raise inter-firm trust as one of the key prerequisites for collaboration, since lack of trust increases supply chain risks. Thus, climate change adaptation in the food system requires information sharing and joint decision-making between different levels and forms of governance in order to exploit synergies.

In order to better understand the networks that should connect private and public actors, it is important to specify the patterns of food system dynamics with due consideration to their embedded character. From a global perspective, Thompson and Scoones (2009) denote agri-food systems as embedded in complex ecological, economic and social processes. Hence, instead of trusting mainstream narratives of technological change and economic growth, more attention should be paid to the complex system dynamics in order to identify vulnerable parts of the processes. Thus, the dynamics of agri-food systems contain a multifaceted risk of disruption, making it challenging even for public policy to effectively promote food supply chain resilience.

In fact, many of the public adaptation policies concerning the food supply chain are still in initial phases and should be implemented by joint effort of actors that still need to be motivated to take action (Daniell et al., 2010). Moreover, the institutional frameworks for adaptation may still be insufficient and fragmented (Juhola, 2010). Hence, topical questions remain open, such as: who (in addition to food enterprises) are setting the public agenda for increasing resilience of the food supply chain; how big a role should experts take; and what is the role of consumers in establishing food security norms under climate change adaptation (see also Adger et al., 2005; Smit et al., 2000). Many authors underline the importance of public leadership that includes not only regulation for food safety guarantees but also targets of sustainability and food supply chain resilience which is best defined in the territorial context (see e.g. Ignaciuk, 2015).

Nevertheless, we can perhaps speak of a global value community with regards to enhancing food security and the more operative food supply chains. At the least, attributes such as sustainability, eco-efficiency and transparency can be mentioned as concerted qualities associated with increased resilience of the food supply chain (see Smith et al., 2016; Smith, 2008). Furthermore, when putting stress not only on the internal dynamics of the food supply

chain but also on the larger food system, it is important to emphasize the efficiency not only of delivery but also of the access to food. Targeting improved access in a sustainable manner implies consideration of developing equity of access as part of adaptation strategy both on the global level and the territorial level.

Finally, from the perspective of the public sphere there is a necessity to consider transparency not only in the private field but also within public action. Therefore, issues of leadership and coordination become pertinent (Keskitalo, 2010). Considering the urgent character of climate change adaptation it is, however, important to balance between efficiency and democracy of decision-making. Even if participation has been cited as an important aspect of appropriate decision-making, some authors remind that increasing the number of voices in a political process also increases the complexity of decision-making – sometimes in ways that contradict efficiency (see e.g. Few et al., 2007; Lee et al., 2013). This issue is linked interestingly with the discussion on technological change and epistemic communities (e.g. Keskitalo, 2010; Vogel et al., 2007) that dominates the climate adaptation policy scene. Even if adaptation is bound to create a more inclusive concept of public governance in order to be legitimate, its structure will be molded by specific political patterns as established in a great variety of territorial settings involving, in addition to states, many subnational and even supranational actors. It is evident that these territorial settings may include conflicts of interest that intermingle with traditional discord over local issues. However, they may generate even completely new conflict situation concerning the actual adaptation measures to be implemented locally. Reconciliation is important and apparently only a part of it can be efficiently and appropriately treated though legislation and legal system. Therefore the territorially effective networks need to create more flexible measures of negotiation to solve socio-political and socio-economic conflicts that are likely to appear. In the global South the conflicts are often related to natural disaster and the consequent major crises of food supply

chain (Harris et al 2014) whereas in the North the conflict may involve less urgency on human survival and wellbeing but can still cause severe barriers to change because they may concern vital interests on values and livelihood expressed by different stakeholders (e.g. Storbjörk 2007).

Even if equity in food access has been expressed as one of the main targets of the sustainable food system, there is still a long way to secure sufficient access to food for all people (FAO, 2014; Juhola et al., 2016). In fact, there are good reasons to expect even increasing inequality of access to food due to climate change, as it affects various parts of the globe differently. Especially, extreme weather shocks, drought and flood may harm present cultivation in regions where livelihoods of big populations depend directly on food production. Moreover, poverty in general still limits access to proper nourishment. Thus, the reduced capacity of food systems to assure food security to populations vulnerable to hunger and malnutrition is one of the principal concerns related to climate risk (Vermeulen et al., 2012). Yet, climate change adaption is a major concern for all populations, rich and poor. The reason is twofold. Firstly, rich populations and western food consumption patterns tend to accelerate climate change, which leads to greater adaptation needs globally. Secondly, western consumers are increasingly dependent on cheap food produced by suppliers in poor countries, which often are very vulnerable to extreme weather events.

Cheap food is partly a result of an efficient food supply chain, which avoids surplus capacity and inventory. However, additional capacity and inventory can be extremely beneficial in building supply chain resilience, which calls for the re-examination of the efficiency vs. redundancy trade off (Christopher et al., 2004). Low-inventory food supply chains that are based on just-in-time mode of delivery are highly vulnerable to weather disruptions (Vermeulen et al., 2012) and thus less resilient. On the other hand, according to Sheffi

(2005), increasing redundancy is a very expensive measure because companies must pay for the redundant stock, capacity and workers.

Hence, from the food supply chain perspective, food security remains a complex issue to be addressed in a comprehensive way by analyzing the inner dynamics of both private and public sectors, and the complex interplay between these sectors. It is important to remember that depending on the context, the food security issue is pre-dominantly either an issue of quantity or quality. In both cases, it is useful to approach the food security in the context of multilevel and multi-sectoral dynamics involving a variety of actor-networks. Consequently, it is important to identify the key actors and their groups because avoiding disruption in the food supply chain is not only a technical matter but, very often, a social and political process. For those processes, mutual social recognition and trust consolidating the social and political process of adaptation to climate change are as important as economic growth targets and technological measures.

FRAMEWORK AND ITS APPLICATION IN THE FINNISH FOOD SYSTEM

The conceptual framework on systematizing the links between climate risk, governance, climate change adaptation, vulnerability and resilience is presented in Figure 1.

[insert Figure 1 here]

Instead of simply being an expression of a specific theoretical approach, we aim to provide a framework that can stimulate decision-making in the context of climate change adaptation. Hence, this chapter is a comprehensive representation of theoretical and conceptual ideas on how to frame climate risk and adaptation policies in a multi-level governance setting. It is commonly understood that vulnerability is mainly concerned with the inner conditions or the intrinsic characteristics of the food system that make it liable to experience climate risk (see

e.g. Birkmann, 2013). Following this understanding, we argue that even so, feedback processes and interventions by multi-level governance need to be addressed when looking for effective measures to reduce vulnerability and climate risk. In general terms, this can be translated into the question of how internally coherent a system has to be in order to become more resilient.

The framework is based on a feedback-loop system, in which climate risk is caused by the overall vulnerability of the food system. As previously explained, climate risk can be a physical, a regulatory or a financial risk, but also a litigation risk or a competitive risk. For example, a company may face a heightened risk of climate litigation and may be exposed to the risk of lawsuits, if it fails to disclose the risks to shareholders and financial regulators. Similarly, if companies do not take measures to reduce climate risks they may be competitively disadvantaged. Identifying direct and indirect climate risks, in turn, is followed by the action of climate change adaptation. In this stage, multi-level (risk) governance for climate change adaptation should be seen as an overall subject of the whole framework. Within this framework, multi-level governance deals with various actors, rules, conventions and mechanisms concerned with risk reduction and climate change adaptation while actors represent different interests of public risk governance (governments) and private risk governance (food supply chains led by food manufacturing and retail industries).

Within public governance, the challenges are associated with the integration of agricultural policies, food policies, climate change mitigation policies and climate change adaptation policies. Policies led by different ministries and governance agencies result in trade-offs, which in turn, require a more coherent policy response to promote food security. Conflicts and trade-offs are inherent within private governance as well. This requires a more collaborative approach in the food supply chain between primary producers, food industries, retailers and consumers to promote food supply chain resilience. Finally, the dual structure of

the food system governance, public and private, introduces a broad set of different interests, norms, habits, values and cognitive beliefs. Trade-offs in the multi-level governance can be dealt with by increased information sharing, collaborative work and joint decision making, and ultimately, by increasing trust.

The application of the framework is illustrated by a case study related to design of multi-level governance of climate change adaptation in the Finnish food system. Although climate change will affect most urgently the developing countries, the development of climate change adaptation is an issue also in European states, such as in Finland (Keskitalo et al., 2012). Finland has been one of the forerunners of public programming in adaptation, as the adaptation policy process in Finland started already in 2002, after the publication of the National Climate and Energy Strategy, which strongly focused on mitigation (Keskitalo et al., 2012). The first national adaptation program was launched in 2005 (Ministry of Agriculture and Forestry 2014) and has been since then further developed in parallel with the national energy and climate strategy. The Ministry of Agriculture and Forestry has the main responsibility of planning the climate change adaptation policy. The main three issues raised in Finnish national public policy with regards to managing climate risk in agriculture are firstly the support to developing species that will best adapt to climate change, secondly the preparedness to flood and other risk in water cycle management and thirdly the issue of controlling invasive species mainly from the perspective of their posing threat on biodiversity. In the following example, we address only the first issue and more specifically the question of how public policy is tackling the issue of adaptation by promoting research and development of crop cultivars in Finland.

However, the implementation of climate change adaptation in the entire food supply chain is still at early stage. Adaptation implies change in the agenda of all actors of the food chain. Looking upstream towards farms, generating change in products often implies changing

suppliers, acquiring new skills and other assets. Hence, instead of managing climate risk in one sector (agriculture) only, national public policies should shift to managing climate risk in the overall food supply chain or more broadly in the national food system. This may require that the responsibility of climate change adaptation should be shared with several ministries, not just the Ministry of Agriculture and Forestry, which typically has an agriculture-focused perspective towards the food system. In Finland there is no specific ministry for food, and there are continuous tensions between the Ministry of Agriculture and Forestry and the Ministry of the Environment. In comparison, in the UK there is the Department for Environment, Food and Rural Affairs, which may provide a more appropriate governance structure for policy making in a context of climate change adaptation in the food system.

Moreover, limited practical integration across and between national and local levels was reported when evaluating the actual implementation of the adaptation strategy (Keskitalo et al., 2012), which means that the practical implementation stills needs much coordination and joint efforts by different actors (Juhola 2010). Our framework emphasizes the fact, that climate change adaptation agendas are set not only on national levels, but through multi-level governance linkages between actors within integrated multi-participant groups.

A Finnish example of a multi-level adaptation process that draws upon several different types of actor has been coherently described by Paavola et al. (2015), who focused on the converting the concept of response diversity into a tool of reflection and decision-making in barley breeding and cultivation in Finland. As concerns the social and technological transformations towards promoted resilience in crop cultivation it is important to increase interaction between public and private actors in the specific food chain to reach an effective concept of resilience that is shared and targeted by the various actors. This can be created for example by working in plant breeding towards enhanced response diversity of specific crops to make them more persistent in cases of extreme weather conditions and in circumstances of

uncertainty of climate development. The key actors in this adaptation process are agrifood researchers and commercial breeders, but several other potential actors involved in Finnish crop production and agrifood supply were identified, such as farmers, National Emergency Supply Agency and the food industry. In this case, a multi-level adaptation process has included collaboration between researchers and the breeding company as well as discussions between the plant breeding company and farmers. However, it was noted that a commercial firm can be part of a long-term adaptation process, but cannot be solely responsible for it, as demonstrated by data in the study by Paavola et al. (2015, p.50): "what a commercial firm can do is quite restricted".

Hence, other stakeholders should be involved. As Bristow and Healy (2014, 930) note, "the institutions of purposive adaptation in regions go beyond firms and firm-related actors, and also incorporate a variety of other self-organizing institutions of collective agency, notably those of state, governance and community". First, the work of The National Emergency Supply Agency, an organization working under the Ministry of Economic Affairs and the Employment and which is tasked with planning and measures related to developing and maintaining the security of food supply, is generally associated with reduced vulnerability to crises and weather extremes (Paloviita et al., 2017 forthcoming). In the study of Paavola et al. (2015) plant breeders suggested that the National Emergency Supply Agency should take more responsibility for ensuring resilience with barley breeding in the long-term perspective. Since the National Emergency Supply Agency is maintaining safety stocks for the times of crisis, the redundant stocks in Finland have been at a high level in international comparison. In addition, a strong network around food emergency supply has emerged, including private actors, such as food companies and retailers.

Second, Finnish agriculture is almost exclusively based on family farms, who have very limited economic means for new investment, which makes them vulnerable in implementing

any changes in their product sample (Järvelä & Kortetmäki, 2015). By tradition the state in Finland has been supporting investment at farms by various means, even through direct financial support. During the last two decades, this tradition has become replaced to a great deal by mandatory and yet negotiated EU policy measures, which has made the governance for change more complex. Due to the complexities of multilevel governance of climate adaptation and risk it seems that the public private interface has still much to accomplish before reaching a state of art of promoting new climate persistent crops, especially in new range of species (Lehtonen, 2015). Sharing information is not easy since scientific experiments may still be at early stage and uncertainties are evident as concerns the sustainability of new crop choices. One policy response from public policy sources to this has been a general recommendation of cultivating a variety of crops at one farm instead of relying on monoculture.

Third, public sector can support this process in many ways e.g. by selecting measures of direct financial support or by taking a major role in research and development. In Finland, much of this public policy support has been performed through research programmes contributing to the sustainability of the food system and food security. For example, A-LA-CARTE (Assessing limits of adaptation to climate change and opportunities for resilience to be enhanced, 2015) was a four-year collaborative research project of FICCA (The Finnish Research Programme on Climate Change), which concerned agrifood systems as a case study, focusing on food supply of farms and access to food by consumers to manage climate-related risks. In addition, the Finnish Climate Change Panel, which is an independent, interdisciplinary think tank, provides scientific advice for policy making and reinforces interdisciplinary insight in the operation of different sectors. Concerning the adaptation to climate change in the food sector, the panel has examined e.g. the responsibilities associated with flood risk preventing and alleviating crop damages in agriculture (Juhola et al., 2015).

In an ideal world, climate risk provides windows of opportunity for change and innovation in food system governance (see e.g. Birkmann, 2013, 33). From this perspective, renewal and learning, as well as transformability, should be built-in characteristics of multi-level governance for climate change adaptation (Tàbara et al., 2010). Accordingly, further research on the food supply chain should critically considered and suggest what governance structures and relationships need to remain and which should change or disappear. Corporations and governments, together with civil society, have a joint opportunity to design and manage these governance structures and relationships in order to improve food system resilience and food security.

CONCLUSION

We argue that climate change adaptation is a multi-level governance obligation for a great variety of actors, given the multi-level nature of climate risk governance and its complexities. The role of governments in climate change adaptation should be framed in relation to commercial food supply chains and vice versa. As concerns the willingness of cooperation between actors at different positions of the food chain there is no easy solution for setting comprehensive public/ private policies. However, there are increasingly effective networks at sub-national and local level that can enhance joint efforts in reforming agriculture and land use. These networks are also increasingly important not only in reconciling between different interest of actors but also in building capacities for change and adaptation, which can potentially increase the effectiveness of coping strategies.

It is important to recognize that new knowledge and ideas of alternative options in crop cultivation do not inevitably lead to their acceptance and legitimate use. For example, in plant breeding one of the development strategies tested is molecular breeding. After some experiments supported by public funds in research and development and parallel opposing

civic activity there is presently a quasi-total silence in Finland about the whole issue of GMOs. Hence, even if new networks emerge enhancing capacities for sharing information, collaboration and joint decision-making on multilevel basis, it is not evident that these new constellations can handle expected and unexpected political controversies or open discussion about sensitive issues such as experiments on molecular breeding.

Anyhow, climate change adaptation at national level needs innovation towards multilevel risk-governance that implies concerted action between the many public and private actors concerned. Not only risk points in the food chain need to be located and identified but also main priorities, trade-offs, constraints and conflicts need to be acknowledged. For example, unclear divisions of responsibility for climate change adaptation governance can introduce a severe barrier for all actors in the food supply chain and therefore increase the overall vulnerability of the food system. Looking downstream in the food supply chains there is also a growing interest among consumers to adapt their diets to climate risk, even if the new climate friendly choices are still a minority life style in Finland.

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FIGURE 1 Multi-level governance framework for climate change adaptation