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RESILIENCE OF THE SWISS FOOD SYSTEM

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Abstract

Increase of magnitude and frequency of climate-related disturbances challenges the Swiss food system. Disturbances such as hot and dry summers in 2003, 2015 and 2018 and extended periods of cold weather in 2013 and 2017 affected Swiss agricultural production. While the regulation of food imports allows ensuring food security for Swiss residents, economic effects of climatic disturbances on the activities of actors operating within the system (e.g. agro-input suppliers, farmers, processors) remains a challenge. On the other hand, the Swiss food system is heavily reliant on state support for its functioning. The reduction of state support, which is a current global trend, would represent a significant shock for the Swiss actors. Hence, this dissertation explored the ability of the Swiss food system to function despite (a) the increasing climatic disturbances and (b) removal of border protection (free trade) with the European Union. To represent the Swiss food system, we chose four value chains: milk, beef, wheat and potato. Resilience of these value chains is essential for the Swiss food system, as they are the base for the traditional Swiss diet and account for 41% of the total agricultural value of the country. The thesis relies on a combination of quantitative surveys among producers, processors and consumers; and a transdisciplinary research approach based on engagement with stakeholders.

Paper 1 addresses resilience of four value chains to the effects of potentially introducing a free trade with the EU based on stakeholder surveys and workshops. The results suggest that the Swiss value chains do not possess resilience capacity to secure the current level of self-sufficiency by withstanding the effects of the free trade scenario. Furthermore, we identified that the studied value chains have limited adaptive capacity due to the side-effects (e.g. a strategy of one actor negatively affects other actors) and limitations (e.g. insufficient consumer loyalty) of strategies aimed at coping with the effects of free trade. Also, the results suggest that an increase of specific resilience to the effects of free trade has a potential to decrease overall resilience of the value chains.

Paper 2 presents measures to increase resilience of the value chains to drought identified at stakeholder workshops. The measures are mostly focused on the production activity and are aimed to avoid production disruptions and mitigate economic losses among farmers. While some of these measures (e.g. irrigation, drought-resistance varieties, off-farm income) can be implemented by farmers themselves, other measures (e.g. compensating prices, adjustment of quality requirements) require interventions from stakeholders including post-production actors (processors, retailers) as well as consumers. However, our results indicate that such implementation is hampered by conflicting interests, disproportional exposure of actors to

climate disturbances and the lack of motivation by the actors to act beyond securing their own operational needs.

Paper 3 summarizes results of consumer surveys and stakeholder workshops in order to investigate whether consumers could contribute to the resilience of the food value chains in case of an extreme weather disturbance. The results of the consumer surveys suggest that Swiss consumers favor the idea to pay more for food if farmers are affected. On the other hand, practitioners expressed several concerns regarding feasibility and implementation of consumer support in practice.

The results of the studies on both scenarios, drought and free trade, suggest that an increase of resilience in one activity can have negative implications on other activities. Hence, we conclude that resilience assessment and enhancement should be based on systemic approaches that allow capturing broader effects of resilience than those of just individual actors. Furthermore, the results suggest that resilience of the value chains is subject to conflicting interests of value chains' actors. This emphasizes the need for further research on motivations for actors to accommodate strategies that enhance resilience of their value chains along with the strategies that increase their individual resilience.

Résumé

L'augmentation de l'ampleur et de la fréquence des perturbations climatiques pose un défi au système agro-alimentaire suisse. Des perturbations telles que des périodes estivales chaudes et sèches en 2003, 2015 et 2018 et des périodes prolongées de temps froid en 2013 et 2017 ont affecté la production agricole suisse. La réglementation des importations alimentaires permet d'assurer la sécurité alimentaire des résidents suisses, mais les effets économiques de tels perturbations climatiques sur les acteurs opérant au sein du système (par exemple, les fournisseurs d'intrants agricoles, les agriculteurs, les transformateurs) restent toujours un défi. D'autre part, le système agro-alimentaire suisse est fortement dépendant du soutien de l'État pour son fonctionnement. La réduction du soutien de l'État, qui est actuellement une tendance mondiale, représenterait un grand choc pour les acteurs suisses. Cette thèse a examiné la capacité du système agro-alimentaire suisse à fonctionner malgré (a) les perturbations climatiques croissantes et (b) la levée de la protection des douanes (libre-échange) avec l'Union européenne. Pour représenter le système agro-alimentaire suisse, nous avons choisi les quatre chaînes de valeur suivantes: le lait, la viande bovine, le blé et la pomme de terre. La résilience de ces chaînes de valeur est essentielle pour le système agro-alimentaire suisse, car elles constituent la base du régime alimentaire traditionnel suisse et représentent 41 % de la valeur agricole totale du pays. Cette thèse se base sur une combinaison d'enquêtes quantitatives auprès des producteurs, des transformateurs et des consommateurs ; et sur une approche de recherche transdisciplinaire qui se fond sur l'interaction avec des parties prenantes du système agro-alimentaire suisses.

Le premier article examine la résilience de quatre chaînes de valeur aux effets de l'introduction potentielle d'un accord de libre-échange avec l'Union Européenne, sur la base d'enquêtes et d'atelier avec des parties prenantes. Les résultats montrent que les chaînes de valeur suisses ne possèdent pas une capacité de résilience suffisante pour assurer le niveau actuel d'autosuffisance dans le cas de l'accord de libre-échange. En outre, nous avons identifié que les acteurs et les chaînes de valeur étudiés ont une capacité d'adaptation limitée en raison des effets secondaires des stratégies visant à faire face aux effets du libre-échange (par exemple, la stratégie d'un acteur a un effet négatif sur les autres acteurs) et les limites de ses stratégies (par exemple, une faible fidélité des consommateurs). De plus, les résultats montrent qu'une augmentation de la résilience spécifique aux effets du libre-échange a le potentiel de diminuer la résilience globale des chaînes de valeur.

Le deuxième article présente les mesures visant à augmenter la résilience des chaînes de valeur contre la sécheresse. Ces mesures ont été identifiées lors des ateliers des parties

prenantes. Ces mesures sont principalement axées sur la production agricole et cherchent à minimiser les pertes de rendement et à compenser les dommages économiques auprès des agriculteurs. Si certaines de ces mesures (par exemple, l'irrigation, l'utilisation de variétés résistantes à la sécheresse, les revenus non agricoles) peuvent être mises en œuvre par les agriculteurs eux-mêmes, d'autres mesures (par exemple, la compensation des prix, l'ajustement des exigences de qualité) nécessitent l'intervention des autres acteurs, notamment des acteurs de la postproduction (transformateurs, détaillants) ainsi que des consommateurs. Toutefois, nos résultats indiquent que la mise en œuvre de ces mesures est freinée par des intérêts discordants, une exposition disproportionnée des acteurs des chaînes de valeur aux perturbations climatiques et le manque de motivation des acteurs à agir au-delà de la garantie de leurs propres besoins opérationnels.

Le troisième article résume les résultats des enquêtes auprès des consommateurs et des ateliers des parties prenantes afin d'examiner si les consommateurs pourraient contribuer à la résilience des chaînes de valeur alimentaires en cas de perturbation climatique extrême. Les résultats des enquêtes auprès des consommateurs suisses suggèrent qu'ils sont favorables à l'idée de payer plus cher les denrées alimentaires si les agriculteurs sont affectés par une perturbation climatique. D'autre part, les parties prenantes ont exprimé plusieurs doutes concernant la faisabilité et la mise en œuvre de ce soutien par consommateur.

Les résultats des études sur les deux scénarios, à savoir la sécheresse et le libre-échange, montrent qu'une augmentation de la résilience dans une activité peut avoir des implications négatives sur d'autres activités de la même chaîne de valeur. Nous concluons que l'évaluation et l'augmentation de la résilience devraient être accompagné d'une approche systémique qui permet de saisir les effets plus larges de la résilience que les effets individuels sur les acteurs. En outre, les résultats suggèrent que la résilience des chaînes de valeur est soumise aux intérêts contradictoires des acteurs de ces chaînes. Cela souligne la nécessité d'approfondir les recherches sur les motivations des acteurs à adopter des stratégies qui renforcent la résilience de leurs chaînes de valeur en même temps que des stratégies visant à augmenter leur résilience individuelle.

1 Introduction

1.1 Problem statement and literature review

1.1.1 Increasing disturbances and the need for resilient food systems

Food systems around the globe are being increasingly affected by stressors and shocks, ranging from slow shifts such as urbanization, soil degradation, dietary changes, to disruptive events such as natural disasters, economic crises, and political instabilities. Increasing risk of disruptions compromises the ability of food systems to provide food security for populations. Currently, the global food system already experiences failures in providing food security for millions of people; one billion people (one in nine) is undernourished and another two billions suffer from excessive weight or obesity[1]. When presenting food system challenges in a thesis written in 2020, it is impossible not to mention the coronavirus pandemic. While the pandemic was not part of this thesis, it is a powerful example of an unexpected challenge threatening food security around the globe, due to supply disruptions and economic crises caused by lockdowns (UN 2020). Understanding and enhancing the ability of food systems to withstand disturbances and to ensure food security for the growing population is a pressing need.

In terms of food security, Switzerland ranks high (4th out of 113 countries) in the Global Food Security Index of the Economist due to the low proportion of population under the poverty line, high food safety, and high diet diversification (Global Food Security Index 2019). However, since the Swiss food system is only 60% self-sufficient (the extent to which a country can satisfy its food needs from its own domestic production) (BLW 2019b), Switzerland depends on imports of food products and thus, is not isolated from the world food system and its challenges. In addition, various elements of the Swiss food system are also exposed to sudden changes. For example, in 2003, a heatwave accompanied with a drought affected Europe and decreased yields of different crops in Switzerland by up to 20% compared to previous years (Keller and Fuhrer 2004). More recent events include dryness in 2015, which decreased the yields of grapes and potatoes; heavy precipitation and untypically low temperatures at the end of April 2016 that affected grape yield and deteriorated potato quality hence leading to financial losses for the farmers and resulted in the lowest degree of self-sufficiency at 56% in Switzerland (BLW 2019b; RTS 2016; TDG 2015). Since the beginning of this thesis in the summer of 2016, there have been other adverse weather events that

[1] https://www.who.int/news-room/fact-sheets/detail/malnutrition

caused pressure on the Swiss agriculture. In April 2017, late frost and hail led to 26% decrease in grape yield and heavily affected production of fruits, such as apples, apricots and pears (BLW 2017, 2019b; Swiss Wine 2017). The summer of 2018 brought along a drought that affected grasslands-dependent milk production due to the loss of feed grass and sharply increased hay prices (Schweizer Bauer 2019). In 2019, Switzerland experienced the third hottest summer since the beginning of observations (MeteoSchweiz 2019). And, as was said before, 2020 is a year of the coronavirus pandemic.

An increase of magnitude and frequency of disturbances poses challenges for maintaining the current level of self-sufficiency. While management of food imports can solve the problem of temporal scarcity of food products and ensure food security of Swiss residents, ensuring ability of actors operating within the system (e.g. agro-input suppliers, farmers, processors) to withstand economic effects of disturbances remains a challenge. The objective of this thesis was to explore resilience of the Swiss food system to the most relevant shocks and prospects to increase the resilience. To introduce three papers that summarize the four-year research, I first start with a brief presentation of the theoretical background of resilience, context of the Swiss food system and plan of the thesis.

1.1.2 Resilience in socio-ecological systems

The concept of socio-ecological resilience was born from the theory of ecological stability, when ecologist C.S. Holling suggested that systems have capacities to persist within their stability domains or states of equilibria (Holling 1973). This led to another suggestion – that there is an amount of disturbance that a system can take before it transitions into another state (Holling in his email communication to colleagues cited in Folke 2006). And this is where a very attractive idea was conceived: that a deeper understanding of what makes a system to take greater amount of disturbance before collapsing would allow reducing vulnerability of socio-ecological systems. A piece of an ambitious thinking that humans can consciously influence self-organization of complex socio-ecological systems under all kinds of disturbances for a greater good. The evidence of increasing weather extremes and market turbulences that affect individuals and organizations created societal demand for research on tools to cope with disturbances, which made resilience a popular research topic in food systems, crisis management and supply chain fields (Kamalahmadi and Parast 2016; Linnenluecke et al. 2012).

Since then, definitions of resilience of socio-ecological systems have exponentially increased (Kamalahmadi and Parast 2016; Ponomarov and Holcomb 2009; Stone and Rahimifard 2018).

While there is no single definition, there is a broad agreement that resilience of a socio-ecological system relies on its capacity to withstand a disturbance and to change in face of a disturbance. As Walker (2020, p.1) concisely formulated: "*it [resilience] is all about changing in order not to be changed.*" I briefly summarize the existing views on the resilience capacities of a system. To begin with, a resilient system is thought to be able to absorb a disturbance or resist to a disturbance, i.e. maintain its structure despite a disturbance or withstand against a disturbance (Grafton et al. 2019; Meuwissen et al. 2019; Walker et al. 2004). In the literature, this capacity is referred as robustness, resistance or absorption capacity. Furthermore, a resilient system is a system that is able to change in order to better cope with the disturbance. The capacity to change that allows a system to self-organize in face of a disturbance without changing its current structure is referred as adaptive capacity or adaptability (Folke et al. 2010). Adaptive capacity enables a system to learn from a disturbance and allows influencing systems' resilience without making fundamental changes in a system (Grafton et al. 2019; Walker et al. 2004). Together, the capacities to withstand and to adapt make a system resilient, i.e. allow it to remain or fluctuate within its current state of stability by changing system parts and responses when necessary. However, the current system state might not necessarily be a desirable state. Sometime current states can be dangerous and even threaten the systems' existence in a longer term (Benabderrazik 2020; Walker 2020). Therefore, there are cases when it is necessary to reconsider the system and to transform it in order to leave the dangerous path and to avoid the system collapsing. Hence, the third important capacity of a resilient system is transformability (Folke et al. 2010).

1.1.3 Resilience in food systems

A food system is a network of activities that operate on multiple spatial scales, connect people to their food and is the largest source for employment. Food systems are highly complex and comprise various activities such as input supply, production, trade, processing and consumption; these activities connect through social, economic and ecological relationships (Schipanski et al. 2016). When applied to food systems, resilience becomes food-security oriented. Tendall et al. (2015, p. 19) defined food system resilience as "*capacity over time of a food system and its units at multiple levels, to provide sufficient, appropriate and accessible food to all, in the face of various and even unforeseen disturbances.*" Other authors suggest to understand that resilience requires broad understanding of the food security, that covers different outcomes of food systems such as employment, which supports people's livelihoods and preservation of natural capital (Meuwissen et al. 2019; Toth et al. 2016).

The attempts to investigate food system resilience yielded a large number of studies, that addressed the resilience of different parts of food systems. The research on food system resilience is largely focused on agriculture, which recognizes its critical role in food systems, as well as its vulnerability to economic, social and environmental disturbances. There is a vast body of literature on adaptation to climate change, that focuses primarily on the capacity of farmers and production systems to adopt solutions to cope with climate change (e.g. Diogo et al. 2017; Lee et al. 2014; Mase, Gramig, and Prokopy 2017; Masud et al. 2017). Other studies, e.g. by Meuwissen et al. (2019), Ashkenazy et al. (2018) extended the focus on farmers to the general, non-shock specific resilience of production systems that encompasses broader environment of farming systems: markets, technology providers, governments and consumers.

Another stream of research focuses on value chains to explore the capacity of food system networks to deal with disturbances and disruptions (Leat and Revoredo-Giha 2013; Stone and Rahimifard 2018; Vroegindewey and Hodbod 2018). This perspective unveils the need for integration of individual organizational resilience and supply chain resilience. This suggests that value chain resilience requires “egoistic” actor-centered individual resilience strategies to be implemented along “collective” value chain-centered resilience strategies that require collaboration, trust and visibility, as well as sharing risks and costs in an equitable manner.

The studies on resilience of global food systems provide strong arguments supporting the need for more “collective” resilience. Thus, it is argued that industrialized global food systems ensure predictable supplies by increasing anthropogenic inputs in production systems or abandoning the production sites that are no longer able to provide predictable and desired volumes of biomass (Crona et al. 2016; Hendrickson 2015; Nyström et al. 2019). Such an approach to resilience, steered by short-term economic considerations, makes the global food system insensitive to the resilience deficiencies in local food production systems. Accumulation of losses of resilience in local production systems jeopardizes resilience of global food system, and, if it reaches a tipping point may lead to a shock itself (Nyström et al. 2019). This suggests that a holistic approach to resilience of food systems and actors is a necessity, rather than one of possible options.

The studies on practical implementation of resilience-aimed collaborations in the value chains or food systems are few. For instance, Macfadyen et al. (2015) investigated opportunities for retailers to contribute to the value chain resilience; Kuhl (2018) suggested that agricultural resilience to climate change would benefit from improvement of market systems; and Lim-

Camacho et al. (2017) questioned whether consumers could positively affect adaptation of agri-food companies to climate change.

1.1.4 Characteristics of resilient food systems and challenges with resilience measurement

Food system resilience is problem- and solution-navigated field. The concept of food system resilience pursues a very practical purpose: to help improving the capacity of food systems to provide their outcomes and services despite increasing disturbances (Tendall et al. 2015; Toth et al. 2016). However, context-specific nature of resilience and complexity of food systems make it extremely difficult to determine how resilient is the system or, to measure systems resilience.

First of all, broader research of socio-economic systems is yet to agree on attributes to confer resilience (Walker 2020). Food systems research also actively and extensively investigates principles, attributes, factors or characteristics (the terms are largely interchangeable) that enhance resilience, but no consensus has been achieved, neither on the characteristics nor on semantics. For instance, Meuwissen et al. (2019) suggested five characteristics for resilience of farming systems, Himanen et al. (2016) identified 8 characteristics of a resilient food systems, and Stone and Rahimifard (2018) came up with 23 characteristics of resilience in food supply chains. The resilience characteristics embrace various aspects of food systems from system-engineering characteristics such as diversity, redundancy and connectedness, to business aspects, such as transportation costs, consumer loyalty and assets, and even include ecological considerations such as ecological self-regulation and responsible use of natural capital (Cabel and Oelofse 2012; Toth et al. 2016).

The key reason for the lack of consensus on resilience-enhancing characteristics lies in the complexity of food systems. Identification of resilience characteristics is an attempt to aggregate how resilience materializes. For instance, a characteristic “diversity” is rather a label that aggregates very different aspects of systems’ functioning. Diversity can be understood as diversity of response to disruptions, or a number of actors in the activity, or diversity of suppliers and sales channels, or diversity of growing methods or a diversified income; this list being far from complete (Burnard and Bhamra 2011; Choptiany et al. 2015; Himanen et al. 2016). The complexity of food systems makes it inevitable for such aggregations to differ from study to a study which leads to conflation behind the terms. Hence, diversity is often conflated with modularity, redundancy and flexibility; whereas connectedness is conflated with trust and collaboration and even ecologically appropriate production systems. Disentangling the terms seem to become a research objective on its own.

Furthermore, resilience characteristics are context-specific. Characteristics vary depending on the activity, and so does the importance of them (Himanen et al. 2016; Toth et al. 2016). Even within an activity, not all resilience characteristics are relevant at all times (Walker 2020). Maintaining all characteristics and resilience capacities enabled at all times is impossible, as (a) it is costly and (b) they can contradict each other. For instance, Ashkenazy et al. (2018) found that resilience capacities, i.e. robustness, adaptability and transformability, can undermine each other, i.e. increasing one capacity comes at the costs of reducing another. Therefore, maintaining resilience requires understanding of trade-offs and prioritization of characteristics and capacities depending on the disturbances relevant to the particular system (Reidsma et al. 2015).

To conclude, numerous attempts to pack resilience into a tool, that can be used to measure or enhance resilience, have revealed that the operationalization of resilience actually varies depending on the context and the system it is being applied to. Cabel and Oelofse (2012, p. 10) stated : "*… despite the attempts of many, measuring resilience in social-ecological systems has proven to be like aiming at a moving target.*" Meuwissen et al. (2019) suggest that a resilience assessment should largely rely on heuristics and be open to interpretations along the research process. Therefore, addressing the need for improving a food system's resilience requires a thorough research of the respective food system and what resilience means in the context of this particular system (Joerin et al. 2016; Meuwissen et al. 2019). Moreover, food systems comprise different stakeholder groups with various functions and interests who are in constant and dynamic interaction with the bio-physical, market and political environment (Ericksen 2008; Toth et al. 2016). Investigating resilience and options for improvement it in a system of such level of complexity mandates an involvement of expertise from different fields and disciplines. Tendall et al. (2015) suggested that transdisciplinarity is a suitable paradigm for the food systems resilience concept. Below I briefly describe what transdisciplinarity is and what it can offer to studies on food system resilience.

1.1.5 Transdisciplinary research

Transdisciplinarity emerged as a problem-focused and solution oriented approach for academia to address complex societal problems and to generate practically relevant knowledge (Lang et al. 2012; Pohl et al. 2017). Transdisciplinarity took up a challenge to transcend and transgress the disciplinary boundaries in order to integrate different types of knowledge and perspectives, not only scientific, but also practical; the process often referred to as co-production of knowledge (Max-Neef 2005; Nicolescu 2014). Belcher et al. (2019)

provide several examples of how research projects, which aimed at effecting change on policy and practice to resolve a societal problem, adopted transdisciplinary elements, even if they were not meant to be transdisciplinary from the beginning. Transdisciplinarity aims to meet (a) researchers' scientific aspirations guided by questions "how are things?" and "how do they function?"; and (b) practitioners pragmatic interests such as "is it the right approach?" and "does it work?" (Pohl, Krütli, and Stauffacher 2017). This makes transdisciplinarity a promising vehicle to navigate the field of food system resilience, which requires those who approach it to understand what resilience is while identifying solutions to build it.

Transdisciplinarity builds on participation of practitioners in the research process, which extends beyond consultations with actors, to collaboration that allows both parties to co-determine the process and the outcome (Krütli et al. 2010). Lang et al. (2012) suggested that ideal transdisciplinary process comprises three phases. The first phase aims at establishing the research process by identifying the problem and questions to address and building a collaborative team. Pohl and colleagues (2017) emphasize that this is a critical step that determines whether the transdisciplinary process would yield societally relevant outcomes. The second step relies on the use of various research methods to generate knowledge required to address the problems and questions identified in the first phase. Transdisciplinary process encourages the use of methods from different disciplines, which illustrates that transdisciplinarity does not oppose disciplinarity but complements it, as stated by Nicolescu (2005). In resilience studies, such methods include quantitative methods, such as statistics, econometrics and modelling, as well as qualitative methods, such as interviews, participatory approaches and stakeholder workshops (Douxchamps et al. 2017; M. P. M. Meuwissen et al. 2019). The third phase aims at effecting change, by applying and implementing the results of the second phase. This includes not only practical implementation of the results, but also adjustment and extension of the existing body of knowledge on the respective subject, thus benefitting both science and practice.

The ultimate goal of transdisciplinary process is to effect change to address a societal problem. However, such change does not necessarily have to be a result of the third phase as could be derived from the previous paragraph. A potential to effect change is integrated along the transdisciplinary process, as the process itself triggers and motivates learning among the participants (Lang et al. 2012). Tendall et al. (2015, p. 21) suggest that such a learning aspect is crucial for the resilience concept: "*the building of food system resilience will lie as much in the resilience assessment process as in the quantitative or qualitative results themselves*". Hence, Transdisciplinary process requires careful selection of participants: relevant expertise, stakes in the process and decision power being the important criteria for such selection (Lang

et al. 2012; Pohl et al. 2017). For example, participants of a transdisciplinary process can include (apart from researchers with relevant expertise): bodies that are responsible for design and implementation of policies, organizations or units that are responsible for operationalization of policies and solutions, and people affected by the issue and planned policies (Krütli et al. 2010), but a list for a particular project should be specified and tailored depending on the context.

Researchers use transdisciplinary approach to address societal problems in various domains. One example are technological projects where public is the important stakeholder: e.g. disposal of nuclear radioactive waste (Krütli et al. 2010), designing novel energy infrastructures (Cuppen et al. 2020) or integration of zoonotic surveillance systems for animals and humans (Zinsstag et al. 2020). The project of Berger-Gonzalez and colleauges (2016) applied transdisciplinarity in a project that tried to link traditional and "Western" medical provision systems to enhance cancer healing potential in Guatemala. Furthermore, transdisciplinarity is widely used in sustainability research it builds on "mixing disciplines", i.e. by definition requires expertise of various domains and stakeholders: e.g. building food, energy and water nexus for sustainable food production and ecological modernization in the US (Bergendahl, Sarkis, and Timko 2018), enhanced use of forests and landscapes to provide better livelihoods in Peru and Indonesia (Belcher et al. 2019), resolving unsustainable use of water resulting in chronic flooding and water scarcity in Mexico (Bojórquez-Tapia et al. 2020). While the projects that used TD are different, there are several characteristics of research problems and problem settings that motivate researchers to rely on transdisciplinary approach. Typically such projects have strong practical aspect and aim at finding levers to change to resolve a societal issue in which multiple stakeholders are engaged. Also, there are often large differences between the stakeholders and their interests; the differences can be further augmented by power and information asymmetries. Furthermore, transdisciplinarity is flexible: it embraces uncertainty that arise from the complexity of issues of interest and increases capacity of a research process to embrace various opinions and interpretations.

There are several reasons for my thesis to rely on a transdisciplinary approach. The thesis focused on the resilience of the Swiss food system, the capacity that allows actors to function through disturbances most relevant to this particular system. Analyzing and building such capacity is important and useful for actors of the very system under investigation, therefore there is a practical interest in such study. Furthermore, just like sustainability, resilience is an umbrella term that includes large variety of aspects, functions and considerations that require integration of several disciplines and expertise from different domains. Finally, the study's boundary extended beyond an agricultural system, where TD is often applied, and embraced

entire food value chains with their different activities. In the next subsection, I will present key actors of the Swiss food system; most of them were included in the project as collaborators and participants.

1.2 Swiss food system

Tendall et al. (2015) suggested that resilience of a food system can be assessed through its individual value chains. In this thesis, four value chains were selected to represent the Swiss food system: milk, beef, wheat and potato. These products are part of the traditional Swiss diet, dishes such as fondue, St.Galler Bratwurst, myriads of Swiss cheeses, Roesti and dozens of traditional wheat-based products date back for centuries. Furthermore, cows on alpine meadows (who belong both to milk and beef value chains), have long become one of the most recognizable symbols of Switzerland, attracting tourists from all over the world. In terms of value, these value chains account for 41% of the total value of agricultural production in Switzerland (Swiss Federal Statistical Office 2019a). The degree of self-sufficiency for milk, beef, wheat and potato value chains is 113, 86, 84 and 93%, respectively (BLW 2019b).

Agriculture is part of the Swiss constitution. Article 104 says that the state commits to support and ensure three objectives of the Swiss agriculture: (a) the reliable provision of the population with foodstuffs, (b) the conservation of natural resources and the upkeep of the countryside, and (c) decentralized population settlement of the country (Swiss Federal Government 1999/2020, Art.104). To support the accomplishment of these objectives, the state provides support for the Swiss agriculture in form of direct payments and border market protection mechanisms. Switzerland is one of the countries with the largest governmental support for agriculture; in 2019, Swiss farmers received 2’815 million CHF of subsidies, also known as direct payments (BLW 2019). The biggest part of this amount (39%) is dedicated to ensure production security for all farmers and to compensate for the difficulties in production in mountainous regions. The rest is aimed for example to promote preservation of cultural landscape (19%), biodiversity (15%) and to support bio- and extensive farming as well as grassland-based animal production (17%).

The average of the import tariffs for agricultural products in Switzerland reaches 49%, and goes as high as 128 and 188% for animal and dairy products respectively (WTO, ITS, and UNCTAD 2019). The border protection allows maintaining significantly higher producer prices than in the neighboring countries, e.g. produce price for wheat in Switzerland is 46.1 Swiss cent, whereas in Germany and Austria it is 18.1 and 16.9 Swiss cents, respectively (BLW 2019b). The protection has implications on consumer prices as well: the food expenditure per

capita in Switzerland was 62% higher compared to the EU as of 2019 (Eurostat 2019). The majority of Swiss residents (75%) agree that agriculture should be supported by the state (BLW 2018). At the same time, the difference in consumer price incentivizes Swiss residents to shop abroad, in Italy, France or Germany, a behavior known as “shopping tourism”. Estimations suggest that the food industry loses 3.4 billion francs per year due to shopping tourism, and this value is increasing (Rudolph, Neumüller, and Nagengast 2018).

Milk value chain

Milk production in Switzerland is mostly grassland-based. Grasslands take up to 70% of the agricultural lands in Switzerland, which is due to the topography, as in many mountainous areas grasslands and cattle is the only option for farming (Python, Gresset, and Réviron 2018). Almost half of the milk farmers is located in the mountainous areas. In 2018, 564’190 cows that belong to 21’884 Swiss farmers produced 4 million tons of milk, of which 3.4 million was sold for further processing (Milchstatistik der Schweiz 2018). The processing purpose determines the production mode: milk used for cheese must be produced without silage feed, whereas milk destined for other products such as milk, cream, milk powder and yogurt can be produced with silage feed. Furthermore, the type of milk determines the producer price. The producer price for non-silage milk used for cheese is higher than for silage milk (average price in 2019: 72.5 and 61.7 Swiss cents, respectively); but even more detailed distinction is made for particular types of cheeses and milk-based products (SMP 2019). One third of milk is being processed by cheese makers, whereas two thirds are being processed by 6 industrial milk processors. Industrial milk processors focus on products such as milk, cream, milk powder and yogurt but they can also make cheese. The cheese market in Switzerland has been liberalized since 2007, and 36% of Swiss cheese is exported (Milchstatistik der Schweiz 2018). Milk-based products are mostly sold at the supermarkets.

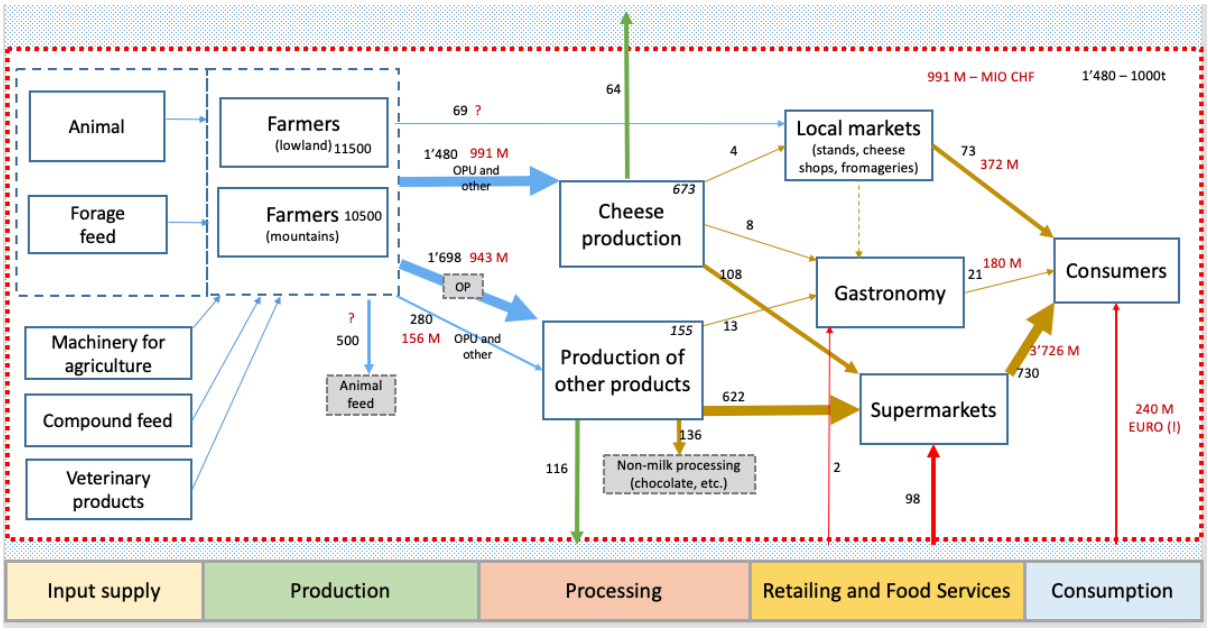

Figure 1.1: Milk value chain (created in 2017 based on various sources, mainly: (TSM et al. 2018; USP et al. 2015, interviews with stakeholders)*). Other value chain maps are presented in the Supplementary materials*

Beef value chain

Beef production counts 1.55 million animals and is strongly linked to the milk production: 39% of total cattle are milk cows (Gresset et. al 2017), and most of animals for fattening are side product of lactation, whereas only 6% are from mother cow system. Hence, the developments in milk production directly affect the beef industry. For instance, increasing productivity of Swiss milk cows leads to decrease in livestock. There are seven companies dominating 81% of the primary processing (slaughtering and carcass cutting). Overall the processing part of the value chain is divided among big retailers (60%), other butcheries (35%), and beef producers who sell directly to the consumers (5%) (Gresset et al. 2017). Beef is considered an expensive product: for instance an entrecote costs 2.5 times more in Switzerland than in France or Austria (BLW 2019b). Fifty percent of beef is being consumed at restaurants or hotels.

Wheat value chain

Wheat value chain comprises two main branches: wheat for animal feed (56%) and wheat for human consumption (37%) (BFS 2017). The rest (7%) is used for beer, starch or seeds. In this thesis, I focused on wheat for human consumption. Swiss farmers produce around 390 tons of common wheat or bread wheat (Triticum aestivum) per year (swiss granum 2020), mostly used for bread and bakery products. Fifty percent of total cereal surface is cultivated under "Extenso" requirements: no fungicides, insecticides, growth regulators and chemical synthetic

stimulators of the natural defenses are allowed[2], in an exchange for an extra subsidy. Like beef processing, wheat processing consists of two steps. In primary processing, wheat is processed into flour by 50 mills: four of them share 75% of the market (SGPV 2018). Secondary processing and retail rely on large industrial bakeries (63%) that further sell in the supermarkets and smaller bakeries (37%) that sell directly or to hospitality industry (interviews with stakeholders). Unlike in the milk, beef and potato value chains, there is no direct sale channel from wheat producers to end consumers.

Potato value chain

During the last ten years, potato farmers produced from 360 to 460 thousand tons of potato a year, depending on the seasonal conditions (Swisspatat 2019). Twenty six percent of potato yield is used for replanting, animal feed or export and the rest (74%) is used for human consumption. Half of the potatoes destined for human consumption is not processed and is sold in its fresh form, and the other half is used for processing by five potato processors into dry (1/3) and frozen (2/3) potato products such as chips and french fries (SCFA 2016). Eighty percent of the potatoes is sold through the supermarkets, 15% through gastronomy and the rest (5%) by farmers directly to consumers (interviews with stakeholders).

Bodies representing value chains and their activities

When discussing activities in Swiss value chains, it is impossible not to mention industry organizations and professional associations. Industry organizations and associations aim to represent interests of actors and to support actors in adjusting to the market demand. In addition, they collect data about activities and performance in the value chains. Industry organizations also act as a platform for exchange of opinions in value chains, and as mediators between actors. An industry organization is typically an umbrella that brings together large organizations as well as professional organizations that focus on particular steps of a value chain and represent smaller actors. As an example, swiss granum is an umbrella industry organization that brings together 14 professional associations and 3 large organizations – Coop, fenaco and UFA AG[3] (Figure 1.2).

[2] https://www.blw.admin.ch/blw/de/home/instrumente/direktzahlungen/produktionssystembeitraege/beitraege-fuer-extensive-produktion.html

[3] UFA AG is a daughter company of fenaco.

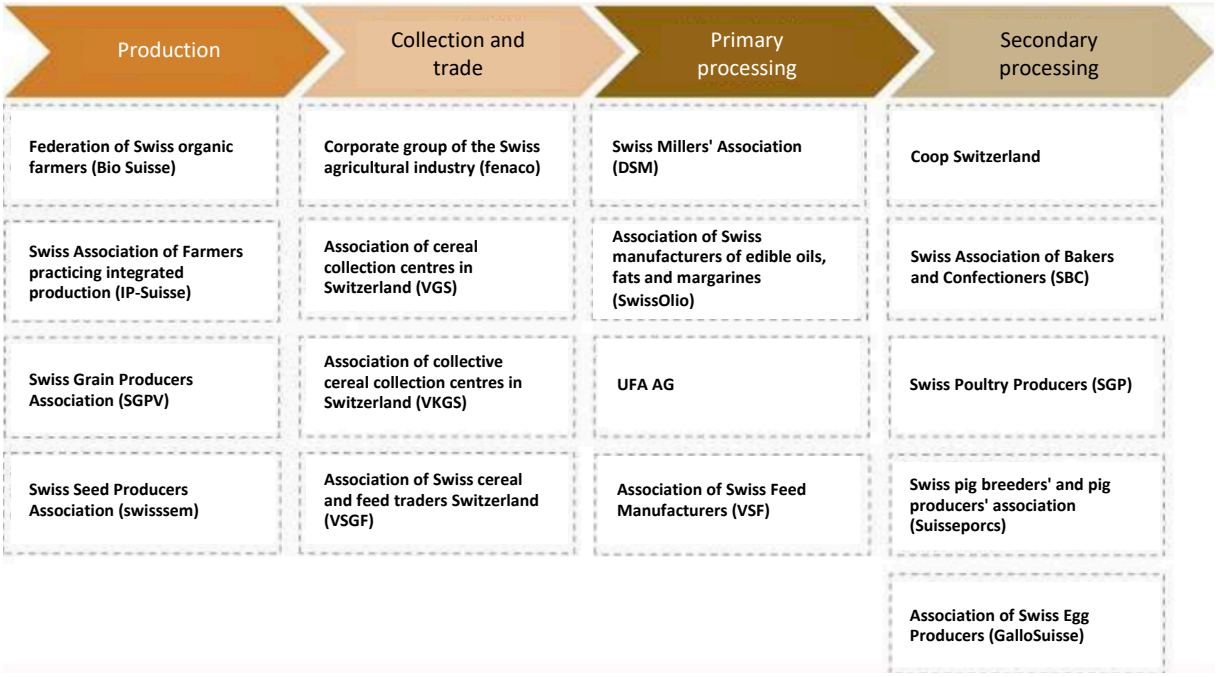

Figure 1.2: Overview of professional organizations along the wheat value chain, members of the umbrella industry organization swiss granum. Source: SGPV (2017), translated from German

1.3 Objectives, approach, plan of the thesis and specific research questions

The objective of my thesis was **to investigate the resilience of the Swiss food value chains to shocks**. In section 1.1.4, I showed that resilience is not a set-in-stone research concept, and there are knowledge gaps in what is resilience in food value chains and how it can be attained. Therefore, the second equally important objective of my thesis **was to learn about resilience of food value chains based on the Swiss case study.**

First, I would like to present the starting point, the grounding idea of my research. In this thesis, I defined the desired function of the food value chains as keeping the current level of self-sufficiency, i.e. generating the current volumes of food products. Moreover, I aimed to explore how the value chains in their current structures are able to do that despite shocks. Based on these two premises, I defined resilience of the food value chains as their capacity to maintain their functioning despite shocks without substantial changes in their structures.

My thesis is motivated by both pragmatic and scientific considerations: the problem of ensuring the current level of self-sufficiency in the Swiss food system increasing disturbances, and the need to understand how resilience materializes in food systems. Since transdisciplinarity offers a way to link pragmatic and research needs and interests (Pohl et al. 2017), it became an overarching research approach for my thesis. The transdisciplinary aspect

of the thesis was based on two pillars: “expert meetings” and “stakeholder workshops”. Expert meetings included six experts that represented different activities of the Swiss food system, namely input supply, production, processing, retail, consumption and state. These experts acted as co-leaders for the transdisciplinary process, as suggested by Scholz et al. (2006), and were continuously involved throughout the project. The experts helped steering the project, by providing feedback on results and activities, advising on further steps, and obtaining key contacts to different activities of the milk, beef, wheat and potato food value chains. The workshops were the main data source and knowledge generation for the project and included more participants (from 9 to 18). The transdisciplinary process in this thesis focused two out of three phases suggested by Lang et al. (2012): (i) problem framing and establishing transdisciplinary collaborative team, and (ii) co-creation of solution-oriented knowledge. The third phase of (iii) applying the co-created knowledge did not make part of this thesis.

The research process started in 2016 with a context analysis to identify actors and flows in the four value chains, and to draw value chain maps (Figure 1.3). In the second step, in 2017, the first stakeholder workshops were conducted in order to identify the most relevant risks that could lead to shocks in the four value chains. Based on the results of the 1st workshops (on milk, beef, wheat and potato, respectively), two shocks were selected – summer drought and a free trade agreement on agriculture and food products with the European Union (further referred as the “free trade” for the purpose of convenience).

The subsequent steps were dedicated to the investigation of resilience of the four value chains. I addressed resilience to the free trade and drought scenarios from two perspectives: (i) capacity of value chains to continue functioning and recover despite shocks, and (ii) capacity to accommodate change to improve the resilience, further referred to as withstanding and adaptive capacities, respectively. Such framing embraces the resilience capacities suggested in the literature (see 1.1.2), but is heuristic and leaves room for learning about resilience and its materialization in the food value chains. Resilience investigation was based on different research activities: farmer and processor survey, 2nd stakeholder workshops, consumer surveys and farmer surveys. While the workshops provided qualitative results, insights and nuances, several stakeholder surveys were conducted to discern how much the qualitative results are reflected in a broader quantitative overview. The results of these activities are summarized in three papers, as depicted in the Figure 1.3. The research questions of the three papers address two resilience capacities described above and are tailored to the specific shocks (Table 1.1).

Table 1.1: Papers and how they address resilience capacities of value chains in case of two shocks

Papers	Resilience to:	Research questions that address resilience as:	
		Capacity to withstand and recover* (withstanding capacity)	**Capacity to accommodate change (adaptive capacity)**
Paper 1 (free trade)	Free trade	– How actors perceive effects of free trade on their activity? – What would be actors' reactions to free trade and what implications would these reactions have?	– What are limitations and externalities of strategies to cope with the effects of free trade?
Paper 2 (measures)	Drought	– What measures improve value chain resilience to droughts? – To what extent are these measures implemented by the actors?	– What are the barriers against implementation of these measures? – Intervention of which actors is needed to implement the measures?
Paper 3 (consumers)	Drought (as example of an extreme weather event)		– Are consumers willing to contribute to the resilience of food value chains in case of a weather disturbance? – Are value chain actors ready to accommodate consumer help?

Note: "to recover" is only applicable to the drought shock, as free trade is not a one-time event, but a "new normal".

In the first paper (Chapter **Error! Reference source not found.**), I addressed the resilience of t he four value chains to free trade. More specifically, I investigated actors' anticipated reactions to the introduction of the free trade and actors' expectations regarding their production and processing volumes based on farmer and processor surveys. To further understand why the free trade was perceived to be the largest shock for the actors, I complemented the surveys' results with a more detailed overview on possible strategies to cope with the increased pressure from imports, their limitations and implications for the value chains.

In the second paper (Chapter 3), I investigated the resilience of the four value chains to droughts. I focused on measures that are or would be helpful against effects of a drought to understand (i) what coping means are currently at actors' disposal, (ii) what hampers implementation of such measures and (iii) who should act in order to implement the measures. The measures, barriers, and necessary actors' interventions were identified at the 2nd stakeholder workshops. In all four value chains, such measures predominantly focused on the production step. Therefore, following the 2nd workshops, I conducted farmer surveys to further explore these measures from the farmer perspective: their current adoption and barriers against their implementation.

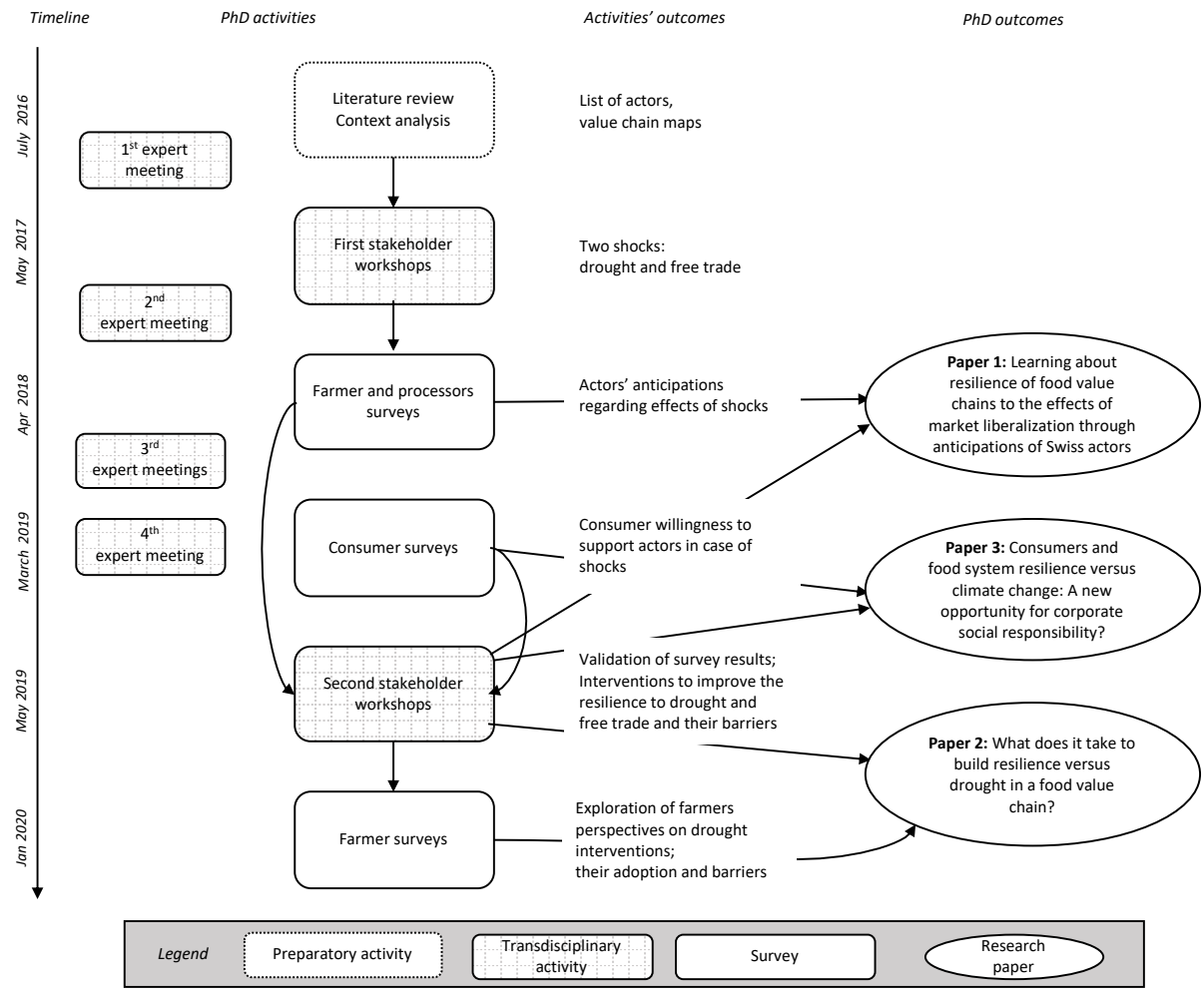

Figure 1.3: Workflow and outcomes of the thesis

In the third paper (Chapter 4), I further explored the resilience of the four value chains to droughts. I made the assumption that consumers could also contribute to the resilience of the food value chains in case of extreme weather events and tested this assumption in two complementary studies. First, I conducted consumer surveys on milk, beef, wheat and potato products[4], to find out whether consumers would be willing to support producers in case of droughts, and what are antecedents of such support. In the second workshops, I collected opinions of practitioners (farmers, processors, retailers, representatives of industry organizations) to understand whether they see consumer support as a viable measure to support value chains in case of extreme weather events, and what are the barriers against its implementation.

[4] The fifth product of interest in this study was wine, because initially the wine value chain was part of this thesis. However, in early 2019, I decided to leave the wine value chain aside due to its specific nature that is very different from the other four value chains. The wine part was later continued in a separate project by a bachelor student.

Paper 1

2 Food value chain resilience - market liberalization scenario and its anticipated effects by Swiss actors

This paper is in preparation to submit for publication to Food Policy as Monastyrnaya, E., Kruetli, P., Six, J., Joerin, J. (2020), Learning about resilience of food value chains to the effects of market liberalization through anticipations of Swiss actors.

Abstract

While food system resilience is defined as a capacity to keep functioning in face of various disturbances, most of empirical studies focus on resilience of food systems and actors to climatic disturbances. In this paper, we focus on a different example of a disturbance – market liberalization. Free trade allows for a better access to markets as well as a stable and diversified supply of foods. At the same time, a failure of domestic production and processing to operate in an open market increases country's dependency on international trade and its risks, and entails loss of agency on food production and displacement of environmental impacts. In this paper, we focus on resilience of a food system to market liberalization, i.e. its capacity to retain domestic production and processing while reaping benefits from access to international markets. Based on actors' surveys and workshops, we investigated perceptions of actors of four Swiss value chains regarding the scenario of a free trade with the European Union. We found that actors perceive such scenario as a significant shock for the Swiss food system, resulting in a decrease of domestic production and processing volumes. Further exploration of potential strategies to cope with the effects of the scenario revealed critical trade-offs: (i) cost-efficiency versus the diversity in the value chains, and (ii) resistance to the effects of market liberalization at the expense of adaptive capacity. On the other hand, the results suggest that market liberalization could result in better resilience and sustainability of the domestic food system, but under certain essential and non-substitutable conditions: consumer appreciation and trust in local production, origin recognizability and an adequate price difference between domestic and foreign food products. Our results provide suggestions for more informed decision-making and design of free trade agreements.

2.1 Introduction

Scientific literature defines food system resilience as a capacity to provide food security to all in face of various challenges posed by climate change, altering societal demands as well as market or political instabilities (Ashkenazy et al. 2018; Stone and Rahimifard 2018; Tendall et al. 2015; Toth, Rendall, and Reitsma 2016). When conceptualizing resilience, scholars broadly agree that it relies on three capacities: robustness (or resistance), adaptability and transformability. These capacities allow systems and actors not only to withstand and recover from a disturbance, but also to accommodate changes in structures and functioning to improve resilience (C. Folke et al. 2010; Grafton et al. 2019; B. Walker et al. 2006). Furthermore, it is argued that resilience of systems and actors is enhanced by characteristics such as diversity, redundancy and connectedness; the list can be extended and specified with flexibility, agility, risk and information sharing, trust, and many other often overlapping characteristics (Hohenstein et al. 2015; Ponomarov and Holcomb 2009; Stone and Rahimifard 2018).

Studies show that actors can face trade-offs when enhancing their resilience capacities and characteristics, e.g. redundancy and diversity come with costs (Grafton et al. 2019; Himanen, et al. 2016), and a strong robustness capacity can make a system resilient, but resistant to change, even when the change is desirable (Mamouni Limnios et al. 2014). Hence, increasing systems' or actors' resilience to different economic, social, and environmental impacts comes with trade-offs that require actors to prioritize the most important directions (Reidsma et al. 2015). Therefore, it is suggested that resilience assessment should be context-specific (M. P. M. Meuwissen et al. 2019) and guidelines suggest starting with identification of most important risks and shocks, in order to frame key areas for improvement (Joerin, et al. 2016; Meuwissen et al. 2019; ODI 2016; Vroegindewey and Hodbod 2018).

In 2017, we have launched a project titled "Resilience of the Swiss food system", to investigate resilience of the actors of the milk, beef, wheat and potato value chains. Following the guidelines' suggestions, in the first step of the project, we conducted a series of multi-stakeholder[5] workshops, to understand risks that could lead to disruptions in the Swiss value chains and jeopardize their functioning. The participants of all four workshops stated that liberalization of the food market in Switzerland would represent the biggest shock to the Swiss producers and processors. The current market protection is significant - the average of the import tariffs for agricultural products in Switzerland reaches 49%, and goes as high as 128

[5] The participants included different actors of the value chains; input suppliers, producers, processors, retailers and consumers.

and 188% for animal and dairy products, respectively. The border protection allows maintaining significantly higher producer prices than in the neighboring countries: e.g. producer price for a 100 kilograms of potato is 46.1 CHF in Switzerland compared to 20.1 CHF in Germany and 25 CHF in Austria (BLW 2019a). The protection has implications on consumer prices as well: the food expenditure per capita in Switzerland was 62% higher compared to the EU as of 2019 (Eurostat 2019, see more examples in Table S1). The difference in consumer price, however, incentivizes Swiss residents to shop abroad, in Italy, France or Germany, the behavior known as "shopping tourism". The value loss for food industry in Switzerland through shopping tourism was estimated at 3.4 billion francs in 2017 (Rudolph, Neumüller, and Nagengast 2018).

The Organization for Economic Co-operation and Development (OECD) criticizes the current market protection policy in Switzerland for a lack of competitiveness of the value chains, limited products' choice and reduced consumer welfare (OECD 2017). OECD recommends that "Continued reductions of import barriers and the scheduled elimination of the export subsidies to processed products are important steps to further reduce the burden to consumers and interference with markets." (OECD 2019). Also, Switzerland sees benefits of export opportunities from entering Transatlantic Trade and Investment Partnership or MERCOSUR and is engaged in discussions and analysis of effects of such agreements on Swiss economy, including the agri-food sector (Chavaz, Pidoux, and Jäger 2016; Schönenberger 2018; Ziltener 2015). Border protection is far from being unique for Switzerland, and is applied in most countries worldwide. For instance, in Norway the average import duty on agricultural products is 133.6% and in the EU the average import duty is at 12.8%, reaching 44.8% for dairy products as of 2018 (WTO, ITS, and UNCTAD 2019). Border protection worldwide has seen a decline over the last 20 years, the average ratio of producer to border price6 decreasing from 1.14 to 1.06; this being part of the global trend for lessening of agricultural support (OECD 2019).

Nevertheless, agricultural trade liberalization, and its impact on food security and resilience of food systems has been and remains a subject for debate, due to the complexity of social, economic and ecological factors to be considered. The suggested advantages of free international trade include access to better prices and diversified food, boost of agricultural productivity, increase of money flow and technology transfers (Martin and Laborde Debucquet 2018). Also, trade liberalization is suggested to affect resilience and food security

[6] Producer Nominal Protection Coefficient (NPC) is defined as the ratio between the average price received by producers (measured at the farm gate), including net payments per unit of current output, and the border price (measured at the farm gate). For instance, an NPC of 1.10 suggests that farmers, overall, received prices that were 10% above international market levels https://www.oecd.org/.

more specifically by ensuring uninterrupted resource flow in case of local crop failures (Dorosh 2001; Hosoe 2016). In addition, Hillen and von Cramon-Taubadel (2019) suggested that creation and promotion of high added value in products in a free market offers better protection against price shocks for local food systems than border restrictions. On the other hand, the global SARS-CoV-2 pandemic highlighted exposure of global food chains to export bans, border restrictions and associated food flow disruptions, which is especially harmful for countries largely dependent on imports (Koppenberg et al. 2020). Furthermore, increase of dependency on imports lead to loss of local control and agency on agri-food production (Schipanski et al. 2016). Hence, globalized trade was found to lead to displacement of environmental impacts from agriculture through an increase of expansive land use, deforestation and land degradation as well as decrease of food production diversity in major exporting countries, which jeopardizes resilience of the global food system (Kummu et al. 2020; Nyström et al. 2019). Yet, an increase of the distance between value chain actors both geographically and information-wise disguises such negative effects either because they are unknown upstream of value chains, or simply disregarded, because no direct impacts are born (Crona et al. 2016; Oliver et al. 2018). There are important pros and cons for food security and resilience at each end of the spectrum – protected market and free trade. The literature leans to the idea that resilience lies in combination of both domestic and international supply flows (Kahiluoto, Mäkinen, and Kaseva 2020), where the reasonable ratio between domestic and imported food supply depends on a country's specific context (Clapp 2017).

The participants of our workshops explicitly expressed concerns that market liberalizations would jeopardize their existence with a threat of a large loss of domestic production and processing in Switzerland. The study by Chavaz, Pidoux, and Jäger (2016) suggested that Swiss actors have a potential to keep functioning in case of a trilateral free trade agreement with the EU and the US, but strategies undertaken by the actors would largely determine outcomes of such scenario. The negative expectations of the actors at our workshops, indicated that they did not see much opportunities to adapt to a liberalized market, and perceive that dangers of a free trade are most likely to outweigh potential benefits of it.

In this study we take a closer look at Swiss actors' opinions regarding their possible strategies in the scenario of a market liberalization, more specifically a scenario of a free trade agreement with the EU (further referred as the free trade for the purpose of convenience). While empirical research on food systems' resilience to climate change is rich (e.g. Baca et al. 2014; Huai 2017; Mushtaq 2018; Zhang et al. 2020), we know relatively little about resilience of food systems to free trade; e.g. the capacity to ensure food security from access to

international trade while retaining the local capacity to feed people should the need arise, which is of importance beyond Swiss context, given the global trend for market liberalization.

In particular, in this study we aimed: (i) to explore how actors expect to react to a scenario of a market liberalization and what strategies would they undertake to deal with it; (ii) to identify advantages and disadvantages of the strategies in order to understand negative expectations of Swiss actors regarding the scenario. By learning about Swiss actors' reactions and strategies, we intend to explore how resilience, its capacities and characteristics of food systems and actors materialize in case of a trade liberalization and what caveats one can expect on the way to improve resilience.

2.2 Methods

Our study included two steps. In the first step, we conducted surveys among Swiss producers and processors, to explore their anticipations about basic effects of the free trade scenario on their activity: decision to quit or continue the activity under the free trade, as well as change in production and processing volumes. In the second step, we conducted four stakeholder workshops (one for each value chain: milk, beef, wheat and potato), to validate the results of the surveys, and to further explore actors' options to deal with the effects of the free trade.

2.2.1 Context

The milk, beef, wheat and potato are the base for traditional Swiss diet and account for 41% of total agricultural value in Switzerland: 21%, 13%, 2% and 2% for milk, beef, wheat and potato respectively (Swiss Federal Statistical Office 2019a). The degree of self-sufficiency[7] for milk, beef, wheat and potato value chains is 113, 86, 84 and 93% respectively as of 2017 (BLW 2019b). Swiss agriculture is characterized by medium-sized farms with an average size of 20.5 hectares (BLW 2019b), which is considerably smaller than in neighboring France (60.9 ha) or Germany (57.3 ha) (Eurostat 2018). Swiss processors are also relatively small compared to their European counterparts. For instance, a large potato processing company in Germany yearly processes 500'000 tons potato, which is three times more than what all the Swiss companies process together (159'000 tons) (Agrarfrost 2018; Swisspatat 2019). The processors are mainly oriented at the domestic market, except for milk processors; milk industry being a net exporter. Also, the milk value chain partially operates in a free market, as the cheese trade with the EU has been fully liberalized in 2007, but other milk products (e.g.

[7] Ratio of domestic production and consumption, considering international trade and stocks

milk, milk powder, butter) remained under protection. While the processing activity in the four value chains is dominated by large processors similarly to Europe and US, smaller processors are also important players, especially in the milk, beef and wheat industry. For instance, in milk, the four biggest milk processors process about two thirds of the total milk, whereas one third of milk is processed by 600 cheese-makers[8]. Furthermore, 50% of beef-, 37% of wheat-, and 30% of milk-based products are processed (secondary processing) and sold by smaller processors and gastronomy (interviews with stakeholders; Python, Gresset, and Réviron 2018). Potato as well as potato-based products are mostly distributed via supermarkets (~80%) (interviews with stakeholders). Overall, the retail sector is largely consolidated – the two largest companies dominating 70% of the market[9].

2.2.2 Producer and processors surveys

The objective of the surveys was to explore anticipated reactions and strategies of producers and processors to the introduction of free trade with the EU. Through learning of anticipations of managers of the four value chains, we aimed to understand how would free trade affect the Swiss food system. The following short scenario was presented to the respondents: "The state decides to introduce a free trade in agricultural and processed food products with the European Union in five years. The supporting measures (e.g. export subsidies if applicable) will remain unaffected. Producers will receive a 25% increase in direct payments. Agricultural inputs such as animal feed and seeds will also be fully liberalized." (translated from German). The respondents were asked whether they would try to adapt to the new conditions, or quit the activity. Those, who have answered to try to adapt were suggested to estimate change of their production or processing volumes with a slider that ranged from "-100%" to "+100%".

The questionnaires were designed on the platform SurveyGizmo in German and French (the predominant official languages of Switzerland). The online data collection took part between March and May 2018 through different channels. We received a list of farmers contacts from the Swiss Federal Office for Agriculture. The invitation to take part in the survey was extended through agricultural newspapers as well as farmer and industry associations. The contacts of larger processors were obtained through experts of the Swiss food system who agreed to support the project at its earlier stage. More processors' contacts (specifically of cheese-makers, butchers and millers) were obtained through an online search. To increase the response rate, we sent out two e-mail reminders, and recruited two students to make follow-up calls to processors who had received invitations but did not reply. Cheese-makers were also included in the surveys. Cheese is already traded in the free market, but cheese-makers

[8] https://www.fromarte.ch/de/ueber-uns/fromarte
[9] https://www.eda.admin.ch

also have other side products from processing milk. Furthermore, they depend on the milk producers, who are not only specialized in milk, and thus can be affected through other products, especially beef.

The obtained data underwent a quality check: we removed responses with missing, or inconsistent data. Following the quality check, 11% of responses in farmer sample and 9% of responses in processors samples were removed. The final sample size in each actors' groups used for the analysis is presented in Table 2.1.

Table 2.1: Sample sizes

Farmers		**Processors**	
Milk	179	Big milk processors Small milk processors	5 44
Beef	174	Big beef processors Small beef processors	5 49
Wheat	163	Millers Bakeries	13 52
Potato	133	Potato processors	4

The average total farm size in every sample is larger compared to the average farm size in Switzerland (33.3, 29.2, 37.2, 35.5 ha for milk, beef, wheat and potato, respectively, compared to 20.5 ha in Switzerland (BLW 2019b) (Table 2.2). Milk and beef samples are overrepresented in the plain zone (50% and 63% compared to 36% of all cattle farmers), and underrepresented in mountain zone 3 and 4 (5% and 6% compared to 14% of all cattle farmers). Wheat and potato samples are also overrepresented in the plain zone (84% and 83% compared to 75% and 72% respectively). The biofarms are slightly underrepresented in milk and beef samples: 11.7% in milk and 10.3% in beef compared to 16% nationally. However, in potato and wheat samples the percent of biofarms 8.6% and 14% was close to the national numbers: 10% and 16% (Swiss Federal Statistical Office 2019b). We ensured that the processing activity was represented by both large and smaller processors. In all samples, we were able to survey most of the big companies, hence making the results representative for a large part of the processing activities of the value chains. The obtained data were analyzed descriptively.

Table 2.2: Description of farmer samples

Characteristic		% of the sample			
		Milk	**Beef**	**Wheat**	**Potato**
Mean usable agricultural area (ha)		33.3	29.2	37.2	35.5
Production zone*	Plains	50%	63%	84%	83%
	Hills	17%	16%	13%	11%
	Mountain 1,2	27%	16%	2%	6%
	Mountain 3,4	5%	6%	0%	0%
% Bio		11.7%	10.3%	8.6%	14%

Note: *Production zones are determined by the Swiss Federal Office for Agriculture, based on the length of the growing season, access to roads and the slopes (BLW 2020); deviation from 100% due to rounding.

2.2.3 Stakeholder workshops

Four stakeholder workshops under the title "Resilience of the Swiss commodity[10] value chain" were organized in April and May 2019. The milk, beef, wheat and potato workshops had 13, 11, 10 and 14 participants, respectively (Table 2.3). Most of the participants were involved in the project kick-start workshops in 2017 where the most relevant risks of their respective value chains were discussed. All the participants were involved in the value chain activity at the time of the workshops and at least one participant representing production in each workshop was from a management board of a farmer association of a respective commodity.

Table 2.3: Number of participants per value chain activity

	Input supply	Production	Processing	Retail*	Consumption**	Industry organizations	Total participants
Milk	1	5	3	0	2	1	12
Beef	1	3	3	1	2	1	11
Wheat	1	3	1	1	1	3	10
Potato	2	6	3	0	1	2	14

Note: * - all retail representatives were from processing companies vertically integrated in large retailers; ** members of consumer organizations.

Each workshop started with presentation of results of the producer and processor surveys. Following the presentation, the participants were invited to share their feedback and opinions in an open discussion. Following the discussion of results, participants were invited to

[10] Respectively: milk, beef, wheat or potato value chains

continue the discussion in groups of 3-4 people, and to focus on possible strategies to improve the resilience of their respective value chains to the effects of the free trade with the EU, as well as the barriers for implementation of such strategies. The workshops discussions were recorded (which the participants were aware of) and transcribed. The transcription was used for a qualitative analysis: with the use of the ATLAS.ti software, we extracted information on possible reactions and strategies, their limitations and implications for the value chains.

2.3 Results

This section summarizes findings from stakeholder surveys and workshops. First, we present results from the surveys of Swiss producers and processors from the milk, beef, wheat and potato value chains, which provides quantitative information on actors' anticipated reactions in case of market liberalization with the EU. Next, we complement it with the in-depth information from the workshops' discussions on possible strategies, actions required for their implementation, and strategies' limitations.

2.3.1 Stakeholder surveys

2.3.1.1 Farmers' anticipations of effects of the free trade on their activity

According to the farmer surveys, more than a quarter of farmers in each sample reported to intend quitting production of the respective product in case of a market liberalization agreement being announced (Table 2.4). The quitting rate was the highest in the potato value chain (49%) and the lowest in the beef value chain (29%). Among the respondents who reported to be willing to continue production, more milk farmers expected to increase their production (18%[11]), compared to beef, wheat and potato farmers (8, 4 and 5%, respectively). While the proportions of farmers expecting a change in their production (quit, decrease, or increase) vary between samples, the percent of farmers expecting no change in their production is very similar: 16, 15, 18 and 15% in milk, beef, wheat and potato samples, respectively.

[11] Sum of "< than 50% increase" and "> than 50% increase" columns

Table 2.4: Anticipated changes in milk, beef, wheat and potato production

	N	Quit immediately	> than 50% decrease	< than 50% decrease	No change	< than 50% increase	> than 50% increase
Milk producers	179	39%	6%	21%	16%	15%	3%
Beef producers	174	29%	10%	39%	15%	7%	1%
Wheat producers	163	37%	14%	27%	18%	4%	0%
Potato producers	133	49%	13%	18%	15%	4%	1%

2.3.1.2 Processors' anticipations of effects of the free trade on their activity

No industrial milk processors reported to anticipate quitting their activity, and four out of five expect either no change, or increase in processing volumes (Table 2.5). The opposite is observed for potato processors who show the most negative expectations regarding the free trade: none of the processors expect to increase their processing or at least remain at the same level. This echoes the results from the farmer survey, where 49% of respondents reported to quit their activity, this being the biggest quitting rate among the value chains. Beef shows the second most negative result: 80% of processors expect negative changes. Among millers less negative actions are observed, 31 and 25% expect to quit their business or decrease the processing, but on the other hand, 19 and 25% anticipate no change or increase in their processing. Among smaller processors (small milk and beef processors, bakeries), similar proportions in each category can be observed. For instance, 16%, 10% and 12% of milk processors, beef processors and bakeries, respectively reported to intend quitting; 30, 39 and 31% expect no change and 11, 16 and 12% see market liberalization as an opportunity to grow. Although the trend is quite similar among smaller processors, smaller beef processors have slightly more optimistic expectations, which contrasts to the expectations of the bigger beef processors.

Table 2.5: Anticipated changes in milk, beef, wheat and potato processing

		N	Quit immediately	> than 50% decrease	< than 50% decrease	No change	< than 50% increase	> than 50% increase
Milk	Industrial	5	0%	0%	20%	40%	40%	0%
	Small	*44*	*16%*	*7%*	*36%*	*30%*	*9%*	*2%*
Beef	Big	5	20%	0%	60%	0%	20%	0%
	Small	*49*	*10%*	*6%*	*29%*	*39%*	*8%*	*8%*
Wheat	Millers	12	31%	0%	25%	19%	25%	0%
	Bakeries	*52*	*12%*	*2%*	*44%*	*31%*	*12%*	*0%*
Potato		4	25%	25%	50%	0%	0%	0%

Note: N – number of observations; smaller processors in italics.

The market liberalization would give processors an opportunity to process more imported primary products, which could be an option to decrease costs. Therefore, the processors who replied that they would continue their activity were asked to provide an estimation of the share of imported agricultural primary materials in their processing (Table 2.6). It is important to mention that the reported import expectations should not be regarded as a prediction for change in domestic production, but rather a strategic sentiment towards processing of imported products. For smaller processors, their plans for imports is presented as a percent of respondents answering within seven categories. We cannot, however, report answers of bigger processors in the same way due to small sample size and in the interests of data protection. Therefore, we opted to present simple means of expected share of imported primary products. While this might not be the most accurate representation, it does give an idea of the sentiment towards processing of imported agricultural primary products among bigger processors.

The results reflect that few smaller processors expect to considerably rely on imports. Only 15% of bakeries expect to have more than 30% of imports, followed by beef processors and milk processors (12% and 6% respectively). Milk processors, both big and small show very little enthusiasm for imported milk in their processing, 86% of small processors reported no plans for imports, and the mean value of imported milk for big milk processors is 6%. The average value for millers is the smallest among big processors, also indicating a strong opposition to the idea of processing imported wheat. On the other hand, small and big beef processors, bakeries and potato processors demonstrate less reluctance to accept imports compared to the milk processors and millers. Overall, the sentiments towards imports seem to be more linked to product types, rather than to processor size.

Table 2.6: Anticipated share of imports in processing. Due to the small number of observations and in the interests of data protection, we present the mean value of the anticipated import share for larger processors.

VCh	Type	N	no imports	< than 11%	11-20%	20-30%	31-40%	41-50%	> than 51%
Milk	Industrial	5	mean value of anticipated import share – 6%						
	Small	*37*	*86%*	*3%*	*5%*	*0%*	*3%*	*3%*	*0%*
Beef	Big	4	mean value of anticipated import share – 39%						
	Small	*44*	*34%*	*25%*	*20%*	*9%*	*5%*	*5%*	*2%*
Wheat	Millers	8	mean value of anticipated import share – 4%						
	Bakeries	*46*	*20%*	*37%*	*15%*	*13%*	*4%*	*4%*	*7%*
Potato		3	mean of anticipated import share – 43%						

Note: N – number of observations.

2.3.2 Workshops' results: discussion of strategies and their limitations

Four main potential strategies were extracted from the discussion of the participants of the stakeholder workshops: reducing costs, relying on consumers, reduction of dependence on agriculture and quitting the business. The participants outlined specific reactions to the free trade as well as limitations of these reactions (Table 2.7).

2.3.2.1 Reducing costs

One of the reactions, or rather strategies, that would help Swiss actors to compete with cheaper imports is to increase cost-efficiency. In production, this can be achieved through enhanced mechanization, farming intensification or increased farm size. Increased concentration through merging and replacing manpower with machines was also suggested as a way to decrease costs in processing. Another solution for processors would be to process cheaper imported primary products and to move some of the processes abroad.

Participants agreed that competing with European producers and processors on price level would be extremely difficult. Furthermore, while the cost-efficiency measures should help actors decreasing their costs, measures such as mechanization would require significant investments, i.e. would first increase pressure on actors. Also, some of the cost-efficiency measures might not be appreciated by consumers, e.g. intensification in animal production would raise more concerns about animal welfare and environmental impacts. Likewise,

outsourcing processes abroad along with the use of imported primary products could repulse consumers loyal to Swiss brands. Furthermore, some of the cost-efficiency solutions in processing, such as imported primary products and outsourcing processes abroad could be helpful for processors, but lead to disintegration of the Swiss value chains as processing becomes decoupled from production.

2.3.2.2 Relying on consumer support

Another strategy actively discussed at all four workshops was the consumer support of the domestic producers in case of market liberalization. Participants suggested that many Swiss consumers would be willing to continue purchasing Swiss products and pay more for them, which would help easing the price pressure. Therefore, the participants suggested to enhance promotion of domestic production, or "Swissness". In all four workshops, participants agreed that promotion of Swissness should not only be based on the origin but also to the extra-services such as animal wellbeing, better resource efficiency and environmental performance. Also, recognizability, traceability and declaration of origin were unanimously agreed to be key elements of the Swissness strategy.

Workshop participants discussed the results of the processors' surveys regarding the import intentions. Participants agreed that actors' anticipations regarding the imports might reflect their best intentions to stick to the Swissness strategy, but in reality import share could be higher because consumer willingness to support Swissness faces several important limitations.

First, not all consumers prioritize Swissness or sustainability over other characteristics. In case of bread, consumers tend to appreciate factors such as freshness, proximity or crunchiness rather than origin. Also, not all consumers would be willing to pay extra for Swissness, which is especially relevant for lower budget segments of Swiss society, mostly served by the bigger processors. This considerably limits opportunities for bigger processors' to rely on Swissness. Therefore, Swissness could be a more suitable strategy for smaller processors, which nevertheless could lead Swissness to reduce to niche markets, becoming rather a boutique strategy.

Second, sustainability advertisement is not an impregnable way to diversify Swiss products from imported ones. Foreign players can also offer products with enhanced sustainable performance, and hence take over the consumer segments targeted by Swissness.

Third, the participants pointed at the necessity of an adequate communication of Swissness and its values. If promotional efforts go too far in creating idyllic pictures of agriculture, it would impose unrealistic requirements on farmers. Furthermore, such requirements could create trade-offs and lead to abandonment of other practices that could be equally or more important for sustainability or animal well-being, but are less promoted among consumers. Also, participants emphasized the importance of fair redistribution of profit that would allow producers to act according to the promised standards to fulfil consumers' expectations.

Fourth, products have different recognizability. For instance, in many ready-to-eat products, potato is not the main ingredient and its origin in many cases is obscure. Same problem was mentioned at the wheat workshop. Furthermore, foods based on Swiss traditional recipes can be done without Swiss ingredients at all, yet such foods can be regarded as carriers of Swissness. In addition, by purchasing products from local sellers (e.g. butcheries and bakeries), consumers can automatically assume that the product is produced locally or made of local ingredients, which might well not be the case. To conclude, the Swissness strategy has loopholes for Swiss actors and also foreign players to benefit from Swissness, without contributing to it. This can disincentivize Swiss players from ensuring traceability and recognizability, which requires efforts along the whole value chains. In particular, participants expressed doubts, that local sellers, supermarkets and gastronomy would cooperate.

2.3.2.3 Income diversification

Reducing reliance on agriculture was suggested for farmers as a strategy to support their income and livelihoods if agricultural income decreases due to the price pressure. The options for reducing reliance on agriculture include off-farm income or para-agricultural activities (work for third parties, direct marketing or farm-based hospitality services). While this strategy would allow farmers to secure their income, it would have implications on the domestic production. Getting engaged in a new activity would reduce time and efforts spent on the farming. This, according to the participants, can lead to losses in professional skills in agriculture, compromising farmer ability to skillfully manage the farm, thus representing danger for agriculture. Furthermore, shifting a focus from agriculture, would decrease production output and have impacts on domestic self-sufficiency.

2.3.2.4 Quitting the business

Another reaction discussed by the participants that does not contribute to the resilience of the Swiss value chains, is the abandonment of the activities. The participants in all four

workshops agreed that the results of the farmer and processor surveys regarding actors' intentions to quit the businesses look plausible. What the participants noted, however, is that a massive abandonment of agricultural lands would lead to freeing extensive surfaces that can hardly be used for anything but agriculture, especially in hilly and mountainous areas. This cannot go unnoticed neither by consumers nor by the state. Therefore, one can expect that consumer support would rise, and the state would introduce additional support. This could slow down the process of abandonment or attract new farmers. This, however, would not be helpful to resurrect a large processing company that decides to shut its facilities. The process of reshaping demand would take time, and while many consumers could eventually return to support domestic products after exploring imports options, large processors might not survive this transition period; compared to the farmers, big processors getting back to functioning and re-enter markets is much more (extremely) difficult and expensive.

Table 2.7: Reactions discussed by the workshop participants

Reaction/strategy	Details	Limitations and side-effects of a strategy
Reducing costs	- Imports of primary products for processing - Outsourcing processing facilities and processes abroad - Enlargement (scaling-up) of production and processing units - Intensification of agricultural production - Giving up on "non-essential" function, such as animal welfare - Replacement of man-power with robotics, mechanization	- Cost-efficiency can require large investments (M, P) - Competing on price level is impossible (M, B, Wh) - Cost-optimization measures can be incompatible with consumer image of Swissness (M, B) - Some cost-optimization measures (e.g. imports) lead to disintegration of the Swiss value chains (B, Wh)
Relying on consumers	- Promotion of domestic origin - Promotion of superior sustainable performance - Increasing traceability of products' origin - Creation a common label of "Swissness"	- Loyalty based on nostalgic feelings is not reliable (M) - Origin is less important than other characteristics, most importantly price (M, B, Wh, P) - Not suitable for bigger processors, could lead to niche markets (M, B) - Demand for Swiss products would take time to solidify, actors (especially big processors) would not survive this period (P) - Promotion of sustainable Swiss performance could create unrealistic image of agriculture (M) - Promises of superior sustainability will increase costs; hence is incompatible with cost-optimization (M, Wh, P) - Retailers and gastronomy cannot only rely on Swissness, and abandon budget segments as it would reduce their market share (B, P) - Common label would only increase already excessive number of labels on the market and would further confuse consumers (B) - Products based on traditional recipes are considered Swiss by consumers, but can be prepared without Swiss ingredients (B, Wh) - Origin is often obscure, especially when in ready-to-eat products, or when a product is served as a side-dish (Wh, P) - Smaller sellers are considered local by consumers regardless of the products' origin, and hence are less interested to support Swissness (B, Wh) - Foreign products can be very competitive when it comes to sustainable performance (B)
Income diversification	- off-farm income - para-agricultural income	- There is a risk of losing professional skills in agriculture (B, Wh) - Decrease of production (M)
Quitting the business	*self-explanatory*	- Large surface of land become vacant, which would be noticed by the state and consumers; one can expect increase of support from both (B, Wh) - State would not let a strategic crop disappear (Wh)

2.4 Discussion

We explored prospects of four Swiss food value chains (milk, beef, wheat and potato) in case of a free trade with the EU, based on the perceptions and anticipations of practitioners currently operating in these value chains. The results of the survey among producers and processors revealed that a substantial number of actors expect quitting their businesses (e.g. 39% of milk farmers and 31% of millers), whereas the actors deciding to stay would need to rethink their activities in order to survive under price pressure in extra-competitive market conditions. Two main strategies were suggested to enhance actors' resilience to the direct effects of a market liberalization: increase of efficiency and strengthening of consumer loyalty. Below, we discuss these strategies, their implications and limitations emerged from the Swiss context, in light of current knowledge about resilience and adjacent research domains.

2.4.1 Increasing efficiency and its effects on value chains' resilience

The workshops' participants suggested that the increased competition coupled with the significant price pressure would force value chain actors to seek for greater efficiency of their activities. For instance, it was suggested that merging of businesses both on production and processing level would help scaling up capacities and optimizing costs. This is in accordance with Grafton and colleagues (2019), who suggested that resilience and in particular a resistance capacity (often referred as robustness) can be enhanced by larger economic margins. The study of Himanen et al. (2016) also envisaged enlarging unites in the Finnish food system under the scenario of a trade liberalization in a pursuit of a greater economic efficiency. Interestingly, in the workshop discussions, increase of efficiency was not mentioned only in the context of decreasing costs, but also with regards to the consumer strategy. The participants suggested that creation and adoption of a common label to communicate Swissness values would increase transparency and would be more efficient communication-wise. Indeed, there is evidence that consumers may not distinguish between different food labels and perceive their values at rather "all or nothing" without distinguishing benefits of specific labels (Tebbe and von Blanckenburg 2018). Moreover, similarity and overload of labels can lead to consumer confusion and cause negative emotions and distrust (Moon, Costello, and Koo 2017), which serves as a further argument towards creation of a unified Swiss label.

Following the efficiency considerations, the Swiss value chains should lose in diversity of units and labels to achieve greater resistance to the effects of the free trade scenario. This is consistent with the study of Himanen, Rikkonen, and Kahiluoto (2016) who found that efficiency can be a priority over diversity for a resilient food system. Vroegindewey and Hodbod (2018) also suggest that a large degree of diversity among actors can compromise collaboration due to conflicting interests. On the other hand, loss of diversity is associated with a decrease in systems' resilience. For instance, a failure of a large unit in system have large implications on the system (Himanen, Rikkonen, and Kahiluoto 2016; Hobbs 2020). In

our case this is applicable to the physical merging of production and processing units as well as to the adoption of the common Swissness label. While the latter seem to have its advantages in a sense of traceability and clarity, the common label at the expense of individual differentiation is a win-or-lose strategy for the value chains and individual actors and the stakes are very high in case of consumers not finding the common label attractive.

Furthermore, pressure to increase cost-efficiency and productivity in agriculture as well as vertical and horizontal concentration leads to a standardization of production methods (Rebecka Milestad, Darnhofer, and Taylor 2008; Schipanski et al. 2016). Imposing requirements under a common Swissness label, even a sustainability-oriented one, can be well expected to further contribute to such standardization. Standardization predefines farmers choices, limits their flexibility and capacity to adapt to change, which is the essential prerequisite for resilience (Hendrickson 2015; Rebecka Milestad, Darnhofer, and Taylor 2008). Production systems detached from the ecological processes become reliant on anthropogenic efforts (i.e. fertilizers, antibiotics, herbicides) (Rist et al. 2014). A state of a resilience that is substantially dependent on external inputs is known as a “coerced resilience”, and is particularly dangerous as it masks losses of true resilience and the system is likely to collapse as soon as the input supply discontinues (Angeler et al. 2020).

2.4.2 Consumers as an influential but missing element in a discourse about resilient food systems

The results of our surveys and workshops indicate that there is an aspiration among actors to rely on consumer loyalty, based on the expectation that consumers would support domestic production by proactively choosing Swiss products and paying more for them. This is in line with recommendations of OECD (2017) on alternative solutions for state-based market protection, as consumer support can limit market penetration for imported products under market liberalization (Norris and Cranfield 2019). The potential viability of such suggestion in the Swiss context is supported by the study of Lazzarini et al. (2016) that showed that Swiss consumers perceive that domestic food products have better environmental and social performance compared to similar foreign food products.

Workshop participants postulated that, in order to enhance consumer willingness to pay for domestic food products, consumer strategy should be based on enhanced communication of origin and sustainable performance of local production, including environmental performance, chemical use and animal well-being. Indeed, the studies show that the purchase of domestic products can be motivated by environmental concerns (Aprile, Caputo, and Nayga 2016; Tomić and Alfnes 2018; Vabø et al. 2017). Also, there is evidence that consumers have willingness to pay for domestic and sustainable production (Miller et al. 2017).

Studies show that trust is crucial for consumer loyalty and willingness to pay (Hartmann, Klink, and Simons 2015; Lerro et al. 2019). Therefore, consumer support strongly depends on the

value chain actors acting according to the values proclaimed by the Swissness marketing. Thus, participants suggested that reliance on Swissness would significantly limit the options for cost-efficiency solutions, making these two strategies incompatible. For instance, consumers who prefer buying local tend to associate it with small-scale production and processing (Jensen et al. 2019; Vabø et al. 2017), and thus consumer trust in Swissness could be compromised by consolidation of production and processing businesses. Or, consumers can perceive increase in mechanization in production as less sustainable, or simply incompatible with idyllic Alpine portrayal of Swissness created by the chains' actors. Also, intensification in animal production would raise concerns for animal welfare.

Enhancing consumer loyalty to domestic value chains and actors could be an alternative solution to improve resilience of value chains to the effects of market liberalization. While the literature states that connectedness (also often referred as connectivity, cohesion or collaboration) is an important attribute for resilience in supply (or value) chains (Kamalahmadi and Parast 2016; Ponomarov and Holcomb 2009; Smith et al. 2016; Vroegindewey and Hodbod 2018), the impacts of connectedness with consumers on resilience remains largely unexplored. In fact, resilience literature often mentions consumers as passive actors in the context of the resilience objective of food systems, which is to provide food security to all despite disturbances (Tendall et al. 2015; Toth, Rendall, and Reitsma 2016). Nevertheless, the potential of consumers to play a role in building resilience of food systems is evoked in several publications (e.g. Ariyawardana et al. 2018; Himanen, Rikkonen, and Kahiluoto 2016; Lim-Camacho et al. 2017; Oliver et al. 2018). Our results provide additional argument that consumers should be a central element of resilience in the context of a socio-economic shock, and hence we strongly suggest that consumer power in research and operationalization of food systems' resilience should be more recognized and acknowledged.

2.4.3 Can consumer support ensure resilience to market liberalization?

The results of our study indicate that market liberalization would force actors to seek for greater cost efficiency, which could result in loss of diversity and adaptive capacity in Swiss agriculture. On the other hand, our results also suggest that actors could opt for enhancing their connectedness to consumers, and would build their competitive advantage and product differentiation on localness, smaller scale production and processing, as well as on the improved environmental and animal welfare performance. This suggests that the definition of food sovereignty[12] could be operationalized as a business strategy, which aligns interests of consumers, producers and processors. These results evoke an interesting possibility that a market liberalization can trigger purely market-based mechanisms leading to better food sovereignty, sustainability and resilience of food systems instead of eroding it (contrary to the case of the cost efficiency strategy).

[12] Food sovereignty is the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems. (La Via Campesina, 2007)

The idea that market pressure would motivate actors to build their competitive advantage on services beneficial for local communities is very attractive. However, this presumption should be regarded with the utmost caution as the suggested effect of a liberalization depends on several conditions that we consider below. The results of our study in the Swiss context to some extent suggested a feasibility of consumer support, but the context is likely to differ from country to a country, and also for different types of products, as we consider below.

First, the success of a consumer strategy depends on high valuation of domestic foods by consumers. While Swiss consumers tend to value local production (Lazzarini, Visschers, and Siegrist 2017), this might not be the case in other countries. For instance, Steckley (2016) showed that the majority of Haitian consumers perceived imported wheat and oat products as more prestigious than traditional corn-based or root-based food. Also, there is evidence that Chinese consumers have higher trust in the safety of the imported pork and milk (Ortega et al. 2009; Xu et al. 2020), and that Indonesian consumers have higher willingness to pay for imported citrus compared to the domestic ones (Sinaga et al. 2017). In addition, the results of the workshops suggest even within one country, consumer loyalty can vary depending on the product type and consumer segment, which was also to a certain extent reflected in the willingness to invest in promotion of Swissness reported in the processors' surveys. Therefore, the market liberalization decision-making should rely on studying consumer attitudes for specific product types rather than overall sentiments towards local foods.

Second, our participants suggested that recognizability of products' origin plays an important role in the success of the consumer strategy. They proposed several possibilities that make it harder for consumers to understand the product's origin. For example, even for the most supportive consumer it is hardly possible to track the origin of potato served as a side dish or being a part of a multi-ingredient dish. Furthermore, some actors are recognized by consumers as local by definition, such as small butcheries or bakeries, especially those selling in the countryside. Such local image allows these actors to benefit from Swissness without using Swiss primary products, and hence represents danger for the Swiss agriculture. This provides support to the suggestion of Giampietri et al. (2016) that consumers see direct contacts as a guarantee for local origin.

Finally, while we believe that consumer support is critical for avoiding such a scenario, reaching 100% loyalty would be utopic for any product type, both because of recognizability issues and consumer preferences. For instance, the study of Rudolph, Nagengast, and Nitsch (2015) showed that 27.6% of Swiss consumers are not willing to pay more for Swiss food products. This suggests that price pressure would remain a problem for actors, which can explain a significant number of actors expecting to quit their activities in our surveys. The workshop participants expressed fears that the price difference between Swiss and imported products would lead Swissness to become a niche market accommodating only a handful of players, whereas others would still be forced to pursue cost-efficiency. Polarizations between

large players and niche markets is the scenario suggested in the study of Himanen, Rikkonen, and Kahiluoto (2016) for a liberalization in the Finnish food system. To avoid such a scenario, we postulate that viability of scalable, market-driven business orientation for food sovereignty and sustainability depends not only on the extent of consumer support (because it is not universal) but also on the degree of the price pressure.

2.4.4 Role of decision-makers' attitudes for resilience

The choice of the shock scenario for the present study was motivated by the results of the set-up stakeholder workshops, where participants unequivocally stated that market liberalization agreements would represent the biggest threat for the Swiss food system, given the high costs of domestic production and processing. The survey among producers and processors showed rather negative expectations regarding the scenario of the free trade with the EU. Our results show a significantly more pessimistic scenario than that of Chavaz, Pidoux, and Jäger (2016), who suggested that despite a price pressure, one can expect: less than 10% decrease for milk, beef and potato production, and 14% for wheat decrease, despite the significant price change for all products except for cheese and milk. In the same study, the modelling predictions were complemented by the expert interviews that, similarly to our study, shared more pessimistic expectations.

The pessimistic expectations of Swiss actors can be partially explained by the limitations that are associated with the coping strategies that we have discussed before. Furthermore, we consider it possible that the responses given by the producers and processors are subject to personal attitudes towards the state agreeing to the market liberalization. Therefore, the responses could show a political statement, rather than respondents' evaluation of potential functioning in the new conditions of an open market. This indeed suggests a presence of a subjective component in our results; we, however, argue that it does not necessarily make them less reliable. Beliefs and attitudes, along with personal norms were found to be important influencers for actions in different contexts (Grothmann and Patt 2005; Li et al. 2017; Moser 2016), and Currey et al. (2017) found that beliefs of top managers can hamper companies market orientation strategies both in large and small organizations. Although the model by Chavaz et al. (2016) predicted that the Swiss food system is able to continue operating within a liberalized market, they also emphasized that one of the prerequisites of success lies in actors' competencies and commitments to stronger market orientation and value creation. In line with this consideration, the results of our surveys suggest that personal attitudes and beliefs can influence resilience capacity of a system. For instance, a decision to quit the business as a manifestation of a protest or in anticipation of substantial challenges, indicate deficiencies in both system robustness and its capacity to adapt or to transform, and can potentially lead to greater negative effects than predicted by mathematical models, or resilience models based on indicators.

Our results, hence, support suggestions that organizational resilience includes a psychological or behavioral aspect (Kamalahmadi and Parast 2016; Mamouni Limnios, Mazzarol, and Ghadouani 2014), and suggests that human capital is an important factor to consider when assessing food system resilience. In addition, it evokes a question: to what extent does subjective judgment based on attitudes and beliefs affect actors' and systems' resilience?

2.4.5 Limitations

Our study is mainly based on opinions of farmers and processors. While input suppliers, retailers and consumers were part of stakeholder workshops, we deem it possible that their perspective is underrepresented in the results. Also, we did not manage to involve gastronomy representatives in our study. While this is a limitation of our research, it also suggests that gastronomy is not open for collaborative value chain endeavors. Furthermore, both the surveys and workshops focused on limited samples, therefore might not cover all possible aspects of actors' reactions to the free trade.

One of the most important strategies discussed in this paper relates to the promotion of Swiss products based on their localness and superior sustainability. However, "local" does not necessarily equal sustainable, as sustainability depends on the input use, production practices and marketing channels, rather than on a simple distance (Schmitt et al. 2016). In this paper, sustainable aspects of the Swiss food system are discussed from the marketing perspective as well as consumer perceptions and beliefs. Objective comparison of sustainable performance of Swiss versus European products remains out of scope of the present study.

By exploring stakeholders' perceptions we aimed to deeper understand processes and strategies that could be triggered by free trade, based on perceptions of managers. However, this approach is certainly not intended to predict effects of free trade as it lacks modelling precision and is subject to personal biases. However, we argue that personal biases are an intrinsic part of the decision-making and, therefore, investigation of managers' opinions contributes to understanding of their resilience and resilience of their respective value chains. While this study should not be regarded as predictive to the effects of a market liberalization, it provides additional insight on actors' reactions and strategies, which should be useful for modelling efforts.

2.5 Conclusions and policy implications

The results of our study suggest that a market liberalization can represent a shock for the domestic value chains, pushing actors to abandon their businesses and disrupting existing flows, whereas the prospects for adaptation are unclear. Given the global trend for reduced border protection, as well as increasing evidence for negative and difficult-to-reverse consequences of a globalized food trade, we deem it necessary to include market liberalization in the discussion of food systems resilience. Furthermore, we suggest that

resilience of domestic value chains to effects of market liberalizations could be a way to avoid the negative effects of globalized markets (such as displacement of environmental impacts and loss of local agency on food production), while retaining the opportunity to benefit from the access to food supply.

However, the results of our study suggest that not every way of increasing the resilience of domestic actors allows for avoiding the negative effects of market liberalization. For instance, an increase of cost efficiency in order to deal with the price pressure could be helpful for securing domestic production and processing but may lead to the intensification of agricultural production, an increase in the trade-offs between economic and environmental performance and to the loss of diversity in the value chain. While this issue emerged from our Swiss study, it can be even more pronounced and relevant for countries with insufficient enforcement of environmental standards. Hence, simply increasing the efficiency of local actors could lead to the localization of negative effects of a globalized food trade instead of avoiding them altogether.

Increasing connectedness to consumers, on the other hand, seems to be a less dangerous way to enhance actors' resilience, as it is based on products differentiation through local, less intensive and more sustainable production. However, an exploration of the limitations of the consumer strategy led us to a counterintuitive conclusion that actors' high connectedness to consumers does not necessarily result in the resilience of domestic value chains but can even decrease it. We believe that this finding has an important implication on how market liberalization affects domestic value chains and hence should be considered in the respective studies and projections. Furthermore, it provides evidence that resilience of an actor is not equal to the resilience of its value chains, which we strongly believe has direct implications on the resilience of food systems, and hence we call for more attention to it in the resilience research.

To conclude, our investigation of anticipated reactions of actors to the effects of the market liberalization, revealed several considerations that provide suggestions and directions for further development of the concept of food system resilience (e.g. role of consumers, role of personal attitudes and beliefs, trade-off between short and long-term resilience, resilience of an actor versus resilience of value chains). Furthermore, the results shed light on important factors, e.g. effects of strategy on consumer loyalty and processors and retailers commitment to the use of domestic agricultural products, that should be considered when modelling the effects of free trade agreements, which could improve mathematical simulations and help designing more informed policies.

Paper 2

3 What does it take to build resilience versus drought in a food value chain?

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Abstract

While impacts of climate change are increasingly challenging food production around the globe, evidence suggests that adapting and building resilience of food systems to the effects of a climate change is not a trivial task. In this study, we focused on the process of building resilience in food value chains to droughts from a multi-stakeholder perspective using qualitative and quantitative approaches. In a transdisciplinary interaction with practitioners representing different activities of four Swiss food value chains, we identified measures to build resilience, respective barriers as well as key stakeholders to facilitate the measures' implementation. Further, we complemented the results of the transdisciplinary study with a quantitative survey among 801 Swiss producers to get a deeper understanding of the barriers from the agricultural perspective. The measures proposed by the practitioners to build resilience in the value chains are mostly focused on the production activity and are aimed to avoid production disruptions and mitigate economic losses among farmers. While some of these measures (e.g. irrigation, stocks of animal feed) can be implemented by farmers themselves, other measures (e.g. compensation through price, flexibility in quality requirements) require interventions from other stakeholders including post-production actors (processors, retailers) as well as consumers. However, our results indicate that such implementation is hindered by conflicting interests, uneven exposure of actors to climate disturbances and lack of motivation by the actors to act beyond securing their own operational needs.

3.1 Introduction

Global climate change and increasing population give us little choice but to build resilient food systems that are able to withstand, to adapt and to transform in order to provide food security to all despite intensifying extreme weather events (Ben-Ari et al. 2018; C. Folke et al. 2010; Tendall et al. 2015). Climate change and its often unexpected extreme manifestations already take a toll on farmers causing production losses (Cottrell et al. 2019; Smith et al. 2016; Vermeulen et al. 2012). Researchers and policy-makers widely recognize an essential role of agriculture in the process of building resilience of food systems to climate change (Meuwissen et al. 2018; Whitfield et al. 2018). Farmers contribute to enhancing resilience of food systems by implementing measures that help decreasing variability of yield and securing economic viability of farming despite gradual or intense effects of climate change. Science and policy extensively address and emphasize the need for agricultural adaptation through context-appropriate measures and practices that include, but are not limited to, crop and income diversification, adaptation of crops, insurance, soil conservation practices and efficient water use (Cabel and Oelofse 2012; Diogo et al. 2017).

There is evidence that farmers often cannot implement climate resilience measures even if their activity is affected or is expected to be affected by the effects of climate change in the nearest future. Studies found that farmers capacity to adapt can be hampered by various barriers, such as access to extension, market and credit facilities, lack of institutional support as well as initial investment and cost of use of adaptation practices (Khatri-Chhetri et al. 2019; Long et al. 2016; Masud et al. 2017). Studies suggest that actors such as farmer associations, NGO's, state, public sector and research institutions should help farmers to bridge the adaptation gap, i.e. the distance between the adaptation need and the existing adaptation efforts (Ashkenazy et al. 2018; Chen et al. 2016; Grüneis et al. 2018). Hence, these actors also play their role in the process of building resilience in food systems by assisting farmers with expertise and innovations, raising their awareness on climate change and existing solutions, as well as facilitating farmer access to extension, market and credit facilities (Khatri-Chhetri et al. 2019; Lee et al. 2014; Long et al. 2016).

Yet much less is known about the role of post-production activities such as processing, wholesale, retail and consumption in the process of building resilience of food systems to the effects of climate change. In the context of withstanding the effects of climate change, the adaptive measures of actors involved in post-production is rather reactionary: securing material flow by diversifying source of primary products, and ensuring flexibility if logistics get disrupted (Evans 2012; Smith et al. 2016). These measures allow the actors to ensure the

continuity of their processes and contribute to food system resilience by ensuring uninterrupted flow of food to consumers.

Some authors, though, suggest that actors involved in trade and processing have more options to contribute to the process of building resilience in food systems. For instance, Macfadyen and colleagues (2015) argued that retailers, due to their influential position in value chains, can support large-scale implementation of agricultural practices by providing and promoting climate-smart technologies in order to reduce variability of supply of agricultural goods. Long et al. (2016) provided several examples of how large retailers and processors can act as providers of climate-smart agricultural technologies. Furthermore, market actors could pay more attention to variabilities in food supply, as the variabilities can indicate loss of resilience in ecosystems, and timely and transparent communication would enable actions to prevent collapses (Crona et al. 2016; Nyström et al. 2019). Kuhl (2018) suggested that agricultural resilience to climate change would benefit from improvement of market systems, e.g. improved market incentives for production and increased market efficiency. In line with this suggestion, Ariyawardana et al. (2018) proposed that consumers could as well play a role in the building of food system resilience, by paying more for food products with improved climate change adaptation performance, just as they currently do for products with environmental or social labels.

Collaboration between food system actors is often suggested to be an enhancing element for the process of building food system resilience (Himanen et al. 2016; Tendall et al. 2015). The evidence that building resilience of food system to climate change requires efforts by many actors indicates that other actors along with farmers can contribute to building food system resilience. In this study, we aim to extend this evidence by investigating the resilience building in the food value chains from a multi-stakeholder perspective. In addition, we aim to explore what are the barriers that hamper actors involved in different activities of the value chain from taking part in the resilience building process. We focused on building resilience of Swiss food value chains to droughts. According to regional climate projections, by the year 2015, summer precipitation in Switzerland is expected to decrease by 5 to 20% (Kruse and Seidl 2015). To represent the Swiss food system, we chose four Swiss value chains: milk, beef, wheat and potato. Resilience of these value chains is essential for the Swiss food system, as they are the base for traditional Swiss diet and account for 41% of total agricultural value in the country as of 2019; 21%, 13%, 2% and 2% for milk, beef, wheat and potato respectively (Swiss Federal Statistical Office 2019a). Swiss agriculture is characterized by medium-sized farms with an average size of 20.5 hectares (BLW 2019). Switzerland is one of the countries with the largest governmental support for agriculture in form of direct payments and border market

protection mechanisms. In 2019, Swiss farmers received 2'815 Mio CHF of subsidies, also known as direct payments, aimed to ensure production security for all farmers, to compensate for the difficulties in production in mountainous regions and to promote various ecological services (BLW 2019). The border market protection consists of import duties and import quotas that protect food production and processing, but allow covering domestic demand (Economiesuisse 2019). The Swiss milk, beef, wheat and potato value chains have a typical hour-glass shape structure with thousands of farmers supplying few large national and hundreds of local small processors (cheese-makers, butchers, bakeries), and a handful of retailers (the two largest dominate 70% of the market share[13]) serving 8.57 million Swiss residents.

To explore the resilience building from the multi-actor perspective, we adopted a transdisciplinary research approach, based on the interaction with actors representing different activities of the Swiss food system (input supply, production, processing, retail and consumption). Transdisciplinarity allows integration of researcher and practitioner expertise to co-produce results to address specific problems by recognizing and highlighting interests of various stakeholders (Lang et al. 2012).

3.2 Methodology

The study approach consisted of two steps (Table 3.1). In the first step, we conducted four stakeholder workshops (one for each value chain: milk, beef, wheat and potato) in order to identify possible measures to increase resilience of the four value chains to droughts. In addition, the participants were asked to specify barriers that hamper implementation of each measure and to assign responsibilities for measures' adoption. To complement the results of stakeholder workshops, in the second step, we conducted a quantitative survey among farmers to evaluate (i) the current state of adoption of the measures and (ii) importance of barriers for measures' adoption.

Table 3.1: Outline of the study

Data source	Results	Content analysis
Stakeholder workshops	• Measures to improve the resilience in value chains • Barriers that hamper implementation of measures • Responsibilities for measures' implementation	qualitative
Farmer surveys	• Current adoption of measures aimed at production • Barriers that hamper implementation of measures by farmers	quantitative (descriptive)

[13] https://www.eda.admin.ch

3.2.1 Stakeholder workshops

In April and May 2019, four stakeholder workshops were organized under the title "Resilience of the Swiss commodity[14] value chain". The workshops were aimed to explore measures to increase value chains' resilience to shocks (drought being one of two[15]) in a multi-stakeholder discussion. The milk, beef, wheat and potato workshops had 13, 11, 10 and 14 participants respectively (Table 2.3). The participants included stakeholders active in different activities of the four value chains from input supply to consumption, as well as representatives of the industry organizations that represent interests of particular value chains and are typical and important stakeholders in the Swiss food system. The main criteria for participation in the workshop was the current involvement of a person in the value chain activity and in case of members of consumer organizations – a general interest in a specific commodity. Furthermore, for the production activity, at least one participant in each workshop was from management board of a farmer association of a respective commodity. As for the processing, the participants included representatives of at least one of the biggest companies in Switzerland. Most of the participants were involved in project kick-start workshops in 2017 where the most relevant risks in the value chains were discussed.

Table 3.2: Number of participants per value chain activity

	Input supply	Production	Processing	Retail*	Consumption**	Industry organizations	Total participants
Milk	1	5	3	0	2	1	12
Beef	1	3	3	1	2	1	11
Wheat	1	3	1	1	1	3	10
Potato	2	6	3	0	1	2	14

Note: * - all retail representatives were from processing companies vertically integrated in large retailers; ** members of consumer organizations.

The participants were asked to work in groups of 3-4 people to identify up to three measures (in each group) to improve the resilience in their value chains (we did not discriminate if a group chose four measures, instead of three). Furthermore, participants were asked to list barriers for the measures, and assign responsibilities for the implementation of the measures among extended list of stakeholders (value chain actors, institutional players, service providers, consumers) of the four value chains. The groups were mixed: each group had at least one representative of farming and processing activities (or industry organizations). By

[14] Respectively: milk, beef, wheat or potato value chains
[15] Another shock of interest was a free trade agreement with the European Union

mixing the groups, we obtained lists of measures that resulted of exchange of various, often conflicting opinions, which was especially helpful for identification of responsibilities and barriers for specific measures, where inter-professional knowledge is required. Also, while sharing similar professions, individuals can have different views due to their personal experiences or psychological traits. That is why the combined lists of measures provided by three different groups at each of the workshops allowed us to get a richer and more balanced picture of measures. The results of stakeholder workshops were analysed qualitatively, by examining and sorting statements using the ATLAS.ti software to identify key themes.

3.2.2 Farmer survey

3.2.2.1 Survey design

The previous steps of the project showed that agricultural production is the most affected activity in the value chain by droughts. Therefore, to complement the stakeholder workshops, we designed a questionnaire on the basis of the workshops' findings to get further insights on the measures and, in particular, the barriers for their implementation. The objective of the survey was twofold. First, we aimed to identify adaptation gaps, i.e. to what extent are the measures suggested by the workshop participants already implemented. The second objective of the survey was to analyse the constraining environment (i.e. barriers) that hinders adaptation. The questions targeted measures that farmers have power to implement.

We conducted seven pre-tests in form of semi-structured interviews with farmers engaged in milk, beef, wheat and potato production to make sure that the questions were clearly and appropriately formulated. In addition, at the pre-test interviews we asked the farmers whether there were measures that were clearly important against effects of drought but were missing in the questionnaires. Based on the pre-tests two important additions were made. First, we included questions on off-farm employment in all four questionnaires, although they were suggested only at the milk workshop. Second, we added an extra measure that was not mentioned at the workshops: stock of animal feed for the milk and beef farmers. This measure was mentioned more than once during the pre-test interviews, and the interviewees clearly stated that it is indispensable for farmers' resilience to droughts. Finally, several adjustments to certain questions had to be made to ensure the context relevance. For example a question on price development during drought had to be formulated slightly differently for different products, albeit all the adapted questions retained their initial meaning.

3.2.2.2 Data collection and samples

The online data collection took place in December 2019 and January 2020. The questionnaires were distributed online through the platform SurveyGizmo in German and French (the predominant official languages of Switzerland) through several channels. First, we had a list of contacts of Swiss farmers provided by the Federal Office for Agriculture. The invitation to take part in the survey was extended through farmer associations: some of them send the notification to their members, and other included a note in their usual communications.

Following a quality check, we removed missing data and data with farm size of 0 ha. Furthermore, we removed responses where farm size was stated to be more than 100 ha, as there are less than 0.5% of such farms in Switzerland (Swiss Federal Statistical Office 2019b). In addition, we removed data where reported size of grassland for milk and beef and product surface for wheat and potato exceeded the total farm size. In total, 13% of responses were removed. The final samples used for the data analysis were 275 for milk, 107 for beef, 219 for wheat, and 200 for potato, totalling 801 respondents (Table 3.3). The data were analysed descriptively.

We will refer to the respondents of each sample as milk, beef, wheat, or potato farmers, respectively, for the purpose of convenience. However, it must be noted that farmers often produce more than one product, and thus, for example, a milk producer can be a potato producer as well. In milk and beef, the distinction is even more blurry as milk producers supply beef as well. Therefore, in the beginning of the milk and beef questionnaires we have suggested respondents to choose which survey to take – milk or beef. Therefore, milk or beef distinction depends on self-affiliation by the respondent. The resulted beef sample was much smaller that the milk sample (275 and 107, respectively). Self-affiliated beef farmers considered themselves to be less affected by droughts than other farmers (see Table S1), and hence could be less motivated to fill in the questionnaire. For the same reason they could rather self-affiliate as milk farmers if they happen to have milk cows.

The average total farm size in every sample is larger compared to the average farm size in Switzerland (30.4, 31.1, 35.5, 35.3 ha for milk, beef, wheat and potato, respectively, compared to 20.5 ha in Switzerland (BLW 2019b). In our milk and beef sample, farms under 20 hectares are underrepresented (16% in milk and 11% in beef) compared to the national data, where 34% of beef cattle are on farms less than 20 ha[16]. Milk and beef are also overrepresented in the plain zone (67% and 63% compared to 36% of all cattle farmers), and underrepresented

[16] https://www.agrarbericht.ch/de/betrieb/strukturen/tiere

in mountain areas, zone 3 and 4 (4% and 7% compared to 14% of all cattle farmers). Same applies for the wheat and potato samples; they are slightly overrepresented in the plain zone (82% and 91% compared to 75% and 72% nationally, respectively). Finally, the percent of bio farms in our sample is higher than nationally: 20% in milk and 25% in beef compared to 16% of all cattle farms and 14% and 21% in wheat and potato samples compared to 10% and 16% in the national production (Swiss Federal Statistical Office 2019b). In summary, all our samples are overrepresented with bigger farms, farms in plain areas and bio farms.

Table 3.3: Description of samples

Characteristic		% of the sample			
		Milk	**Beef**	**Wheat**	**Potato**
Mean usable agricultural area (ha)		30.4 ha	31.1 ha	35.5 ha	35.3 ha
Surface per product (ha)		n/a	n/a	7.1 ha	4.8 ha
GVE according to farm size	0 – 3 ha 3 – 10 ha 10 – 20 ha 20 – 30 ha 30 – 50 ha > 50 ha	0% 1% 15% 34% 33% 17%	0% 1% 10% 59% 18% 13%	n/a	n/a
Production zone**	Plains Hills Mountain 1,2 Mountain 3,4	67% 13% 17% 4%	63% 14% 17% 7%	82% 14% 4% 0%	91% 5% 4% 0%
% Bio		20%	25%	14%	21%

Note: *GVE = livestock unit (Grossvieheinheit in German) – the unit for animal farming intensity; divergence from 100% due to the calculation rounding; n/a – not applicable; **Production zones are determined by the Swiss Federal Office for Agriculture, based on the length of the growing season, access to roads and the slopes (BLW 2020)

3.3 Results

The stakeholder workshops served as a backbone for the results section: measures to improve the resilience, barriers against their implementation, actors responsible for measures implementation. The farmer surveys provide complementary in-depth information for current adoption of the measures and their respective barriers. Therefore, in the following subsections, we present results from both workshops and surveys together, and explicitly mention where the result comes from.

3.3.1 Measures to increase the resilience against droughts and their current adoption

3.3.1.1 Measures suggested at the stakeholder workshops

The participants suggested measures to increase value chain resilience against droughts and specified what activity each measure targets and who is supposed to implement the measure (Table 3.4).

In all four workshops, most of the measures to increase value chain resilience are consistently focused on the production step of the value chain, i.e. are aimed to help farmers to deal with the effects of drought. Measures such as irrigation, drought-tolerant varieties and secured purchase of animal feed are supposed to be implemented by farmers to prevent their physical losses, while measures such as insurance, off-farm income are meant to compensate for economic losses induced by droughts. However, not all measures that are aimed at the production step of the value chains can be implemented at the farm level. Measures such as securing of purchase of animal feed, adjustment of quality requirements, price policy and introduction of resilience premiums campaigns where consumers are given opportunity to pay more for product to help farmers, are supposed to be implemented by other actors of the value chains: e.g. input supply, processing or retail, but are aimed to help farmers to deal with effects of droughts.

While most of the measures are focused on the production step, some measures such as securing material flow through imports or storage of raw materials are aimed to increase resilience of other actors (processors, retailers and consumers) to production failures (disruptions) due to the drought. Also, the price policy measure was proposed as a collaborative measure aimed to aid actors whose costs have increased due to drought, which is likely to be farmers, but not necessarily. Also, at beef and potato workshops, participants suggested improvement of value chain transparency as a measure, which is supposed to indirectly help actors by improving communication, but is not targeting any of them specifically.

Table 3.4: Stakeholder workshop views on adaptation measures in four value chains (i.e. milk, beef, wheat, and potato).

Implementation by:	Target to increase the resilience of:	Measures	Measure mentioned at value chain workshop			
			Milk	Beef	Wheat	Potato
Farmers	Production	Drought-tolerant varieties	x	x	x	x
	Production	Stocks of animal feed*	x*	x*		
	Production	Irrigation				x
	Production	Insurance	x	x	x	x
	Production	off-farm income	x	x*	x*	x*
Input supply, farmers	Production	Securing purchase of animal feed (better coordination and affordable prices)	x	x		
Post-production, consumers	Production	Adjustment of requirements for product quality				x
	Production	Resilience premium campaigns	x		x	x
	Actors who bear extra costs due to drought	Price policy that mitigates losses due to drought	x	x	x	x
Post-production	Processing, retail, wholesale	Securing material flow for post-production			x	x
	All actors	Improve value chain transparency (less labels)		x		x

Note: source: stakeholder workshops, pre-test interviews; post-production = wholesale, processing, retail; * – added following the pre-test interviews.

Based on the workshops' results, we found that there are measures aimed at production and measures aimed at other value chain activities. Furthermore, measures aimed at production clearly distinguish between measures aimed at production to be implemented by farmers and measures aimed at production to be implemented by other value chain actors. Therefore, further in the paper, we will discuss three types of measures: two types aimed at production, i.e. (i) "*farmer measures*" – measures to be implemented by farmers, (ii) "*value chain measures aimed at production*" for the measures that are supposed to be implemented by other actors of the value chains. The third type (iii) "*value chain measures aimed at other activities*" refers to measures that aimed to increase resilience of other activities of value chains against droughts (Figure 3.1).

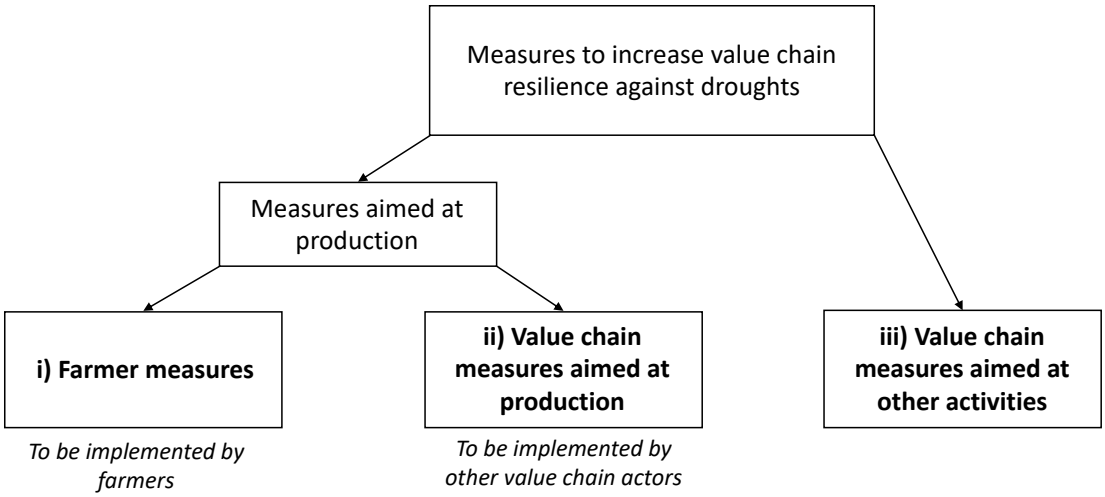

Figure 3.1: Types of measures suggested by the workshops' participants and how we refer to them in the paper

3.3.1.2 Adoption and availability of farmer measures and value chain measures aimed at production: evidence from the farmer survey

Through farmer surveys, we explored adoption of the farmer measures and of the value chain measures aimed at production. Given that the value chain measures are supposed to have direct impact on the production step detectable by farmers and that most farmers in our samples reported to have been affected by droughts (88%, 67%, 79% and 82% in milk, beef, wheat and potato samples, respectively; see Table S2 in supplementary materials), we deem it appropriate to consider farmer past experience as an evidence for adoption of the value chain measures aimed at production.

According to the survey results, none of the farmer measures suggested at the workshops has been universally adopted by farmers in any of the four samples (Table S3). The highest adoption rate is observed for stocks of animal feed (71% and 63% of milk and beef farmers, respectively), and irrigation for potato (57%). For other measures, the adoption rate did not exceed 50%; insurance having the lowest adoption rate in all four groups compared to other measures (1%, 3%, 13% and 11% for milk, beef, wheat and potato farmers, respectively).

The results of the farmer survey showed that the value chain measures aimed at production (Table S4) were not universally adopted in the value chain as well. For example, 50% of the milk and beef farmers reported to have experienced increase of price of hay and 34% and 16% of milk and beef farmers, respectively, reported to have sold their animals due to the lack of feed. Furthermore, only some farmers reported to have received higher production prices during droughts (e.g. 3% of wheat farmers, and 5% of milk farmers). As for the animal price, the situation is more complicated. At the stakeholder workshops, participants explained that

a decrease of animal price is possible because farmers start selling more animals once there is a lack of feed on the market. In our survey, 45% of milk farmers reported that the price for cows has decreased at times of drought, and 18% of beef farmers felt a price decrease for their oxen.

3.3.2 Barriers that hamper implementation of measures against droughts

The participants of the workshops identified several types of barriers and challenges that can hamper implementation of measures that are supposed to be implemented by farmers (Table 3.5, "Barriers identified at the workshops").

3.3.2.1 Barriers that hamper implementation of farmer measures: evidence from workshops and farmer surveys

Adoption challenges

Several barriers associated with the implementation of production-step measures are associated with farmers themselves and their farms. For example, there are *objective physical constraints* such as topography and soil constraints for choice of varieties or availability of water source for irrigation, which gives farmers little flexibility, given a dearth of land available for agriculture in Switzerland. High workload and absence of employment options can also be considered as a physical barrier that does not allow a farmer to have an off-farm job. Furthermore, participants pointed out at *financial constraints* associated with the costs of implementation and use of the measures, such as irrigation costs or insurance premiums. The latter in fact were explicitly said to be too high compared to the drought risks, which explains a very low adoption and planned adoption rates for the insurances reported at farmer surveys. Other barriers that hamper implementation of the measures by farmers are associated with the *decision-making* and need of considering *trade-offs*. For instance, farmers' decision on planting varieties is done in an uncertainty, given that the weather for the entire growing season cannot be predicted; and expected drought can be replaced by high precipitations. Financial constraints can in fact be considered as a decision-making trade-off as well, for farmers opt for lower costs, but with an increased risk of losses. Also, farmers might prioritize other criteria such as yield, resistance to pests and diseases or nutritional qualities (in case of feed plants), and choose other varieties, if drought-tolerant varieties show inferior performance in aspects of priority. The trade-offs and decision-making also depend on farmers perception of drought risks; hence *awareness about drought risks* was listed by the participants among barriers against implementation of the production-step measures.

Table 3.5: Barriers for preparation measures identified at value chain (M = milk; B = beef; Wh = wheat; P = potato) workshops and evaluated from a farmer perspective

Measure	Barriers identified at the workshops	Farmer opinion: Barriers listed in the survey	% of respondents selected it as a barrier			
			M	B	Wh	P
Drought-tolerant varieties (M, B, Wh, P)	**Adoption challenges:** • topography, region, soils* (M, B) • limited mobility (Wh) • lack of know-how* (B) • weather unpredictability* (B, Wh) • short-term profitability questionable* (B) • inertia in adopting new sorts (Wh) **Challenges of availability and breeding:** • availability of varieties* (M, Wh) • breeding is done for the world market (B) • CH is a small market for breeding (P) • inertia in processes: breeding, adoption (Wh), • breeding takes 10-15 years (P) • breeding requires investments (P, Wh) • lack of state support (Wh) **Constraints from demand side*:** • heterogeneous demands for varieties (P) • consumers have strong preferences (P) • critical attitude to GMO (M, B, P)	Low efficiency against drought	3%	6%	19%	8%
		Lack of knowledge*	5%	16%	31%	20%
		Topography constraints*	16%	16%		
		Soil constraints*	14%	14%	10%	10%
		Crop rotation constraints*			2%	2%
		Low yield	9%	13%	19%	6%
		Not financially attractive*	6%	6%	7%	6%
		Other criteria are more important	9%	7%	37%	32%
		Unpredictable weather*	17%	25%	28%	16%
		Prefer buy feed	10%	13%		
		Enough feed storage	19%	41%		
		Drought risk too low	15%	40%	45%	10%
		Lacking demand			19%	69%
Irrigation (P)	**Adoption challenges:** • availability of water*, • availability of water in case of drought, • costs of use, investment costs* **Challenges with existing solutions:** • lack of efficient technological solutions **Regulatory challenges:** • uncertainties/poor compliances in water-use laws	No water source for irrigation* **				71%
		Costs of use*				22%
		Investment costs*				17%
		Extra effort				14%
		Drought risk too low*				7%
		Unclear laws*				6%
Feed storage	*Has not been suggested at the workshops; added following the pre-test interviews*	Not enough land	54%	35%		
		Prefer sell animals	30%	50%		
		Prefer buy feed	29%	28%		
		Too many animals	11%	10%		
Insurance	**Adoption challenges:** • high premiums vs risks, extra costs* (M, B, Wh, P) • low risk perception among farmers* (B) **Lack of solutions:** • unclear what to insure: prices or feed (B) • risks for insurance providers (M) • a short-term relief (P)	No knowledge of a solution**	82%	82%	59%	57%
		Premiums are too high*	15%	13%	23%	24%
		Drought risk too low*	8%	13%	25%	17%
		Lack of trust	2%	3%	3%	2%
		Complicated conditions	3%	3%	5%	6%
Off -arm emplyment	**Adoption challenges:** • high workload, extra workload (M) • lack of job opportunities in the rural areas (M)	Current workload is high*	82%	64%	69%	81%
		Animals – time-consuming	59%	43%		
		Farming provides enough money for living	58%	59%	53%	66%
		No opportunities in the area*	2%	5%	6%	3%

0-10%	10-20%	21-30%	31-50%	51-70%	71% and more

Note: Source: stakeholder workshops and farmer surveys; *barriers mentioned at the workshops that were used in farmer surveys; **exclusive option

Barriers associated with lack of solutions

Another type of barriers identified by the participants is associated with insufficiency or inefficiency of existing solutions. For example, challenges and barriers associated with breeding directly affect availability and quality of drought-tolerant varieties. Participants mentioned that high investments, small agricultural market in Switzerland and sluggish processes (research, trials, approval, and large-scale seed production) that can take up to 15 years in case of potato, are the main barriers that along with farm-gate barriers affect adoption of drought-tolerant varieties. Furthermore, participants noted that the agricultural insurance yet to become solution for many Swiss farmers as existing premiums are quite high for insurances to be universally adopted. Also, participants suggested that lack of technologically innovative solutions, affordable and water efficient at the same time (which is especially important by possible water scarcities at droughts), is a barrier that can hamper implementation of irrigation as a measure against droughts.

Barriers associated with demand

Finally, participants suggested that the demand side of the value chains can create barriers against implementation of measures against drought. In case of potato, participants reported consumers to have strong preferences for certain varieties, and not necessarily drought-tolerant varieties. In addition, retailers, processors and wholesales also have their requirements regarding potato size, biophysical properties such as starch content and storage durability. Therefore, clients' preferences can decrease flexibility of potato farmers regarding choice of potato varieties. Also, the participants mentioned that strong societal position against genetically modified products reduces breeding potential.

Prevailing barriers

According to the farmers survey, some barriers appeared to be more prevalent than others (Table 3.5, "Barriers listed in the survey" and "% of respondents selected it as a barrier"). Several major bottlenecks were observed in each of the four value chains. For example, more than half of farmers sampled in each value chain, reported to not be aware of insurance solutions against droughts (82%, 82%, 59% and 57% in milk, beef, wheat and potato, respectively), which is consistent with the observation of the workshops participants regarding the lack of insurance solutions. A similar consonance is observed in barriers for off-farm employment, where high workload was reported to be a barrier, the percent being strikingly higher than that for the lacking opportunities for employment. For drought-tolerant varieties, no universal barrier in all four value chains was observed. For potato farmers the demand for varieties clearly plays an important role, with 69% of farmers having reported not to plant drought-tolerant varieties because their clients have very specific demand for

varieties, not necessarily drought-tolerant ones. For wheat farmers, on the other hand, client preferences do not to seem to play such a decisive role (19% chose it as a barrier). Important barriers against drought-tolerant varieties for wheat farmers include personal assessment of drought risk (45%), importance of other criteria (37%) and lack of knowledge on drought-tolerant varieties (31%). Also, 40% of beef farmers had similar perception that drought risks are low and 41% reported to prefer feed storage rather than plant drought-tolerant varieties. In the milk farmer responses no major bottlenecks were observed, i.e. milk farmers seem to have different reasons for not opting for drought-tolerant varieties, which suggests that the barriers are rather context-specific than activity-wide.

3.3.2.2 Barriers that hamper implementation of the value chain measures aimed at production and other activities

At the workshops, the discussion on barriers for measures to be implemented by other value chain actors focused on two main aspects: conflicting interests of actors and lacking instruments of resolution of such conflicting interests (Table 3.6).

Since the suggested measures strongly rely on collaboration between actors, conflicting interests were named as a barrier for six out of seven measures. For instance, the price-policy measure suggested at all four workshops requires consideration and acknowledgment of drought-effects on costs by the value chain actors; who would need to agree to redistribute the value and possibly even to sacrifice part of their profits in order to share the risks. Furthermore, participants suggested that consumers would not be willing to accept increased prices on food products, which is another example of interest-conflict barrier for price-based interventions. For the potato value chain, heterogeneous demands among processors, traders and consumers, as well as their conflicting interests were also mentioned to hamper relaxation of requirements for potato quality, should it be affected by a drought. The conflicting interests barrier becomes even more difficult to deal with when actors have different market power, as suggested by the participants of the milk workshop.

The participants suggested that a lack of tools and solutions to help resolving conflicting interests is another barrier that hamper collaboration-based measures against droughts. For instance, there is no swift collaborative mechanisms of recognition and distribution of costs induced by droughts and conflict resolutions that would allow immediate redistribution of such costs. Reducing number of labels was suggested to increase the transparency and improve the information flow in the chains, however it would deprive actors from opportunity to differentiate themselves on the market, and hence would compromise their competitive advantage.

Table 3.6: Barriers for measures supposed to be implemented by traders, processors, retailers

Measure	Barriers identified at the workshops
Securing purchase of animal feed better coordination between import regulation, trade, farmers	• lacking instruments (M, B) • conflicting interests of actors (M, B)
Relaxation of requirements for product quality	• demands of traders and consumers are very heterogeneous (P) • consumers might not be ready to accept imperfections (P) • risks of shelf-life increase (P) • development of new products takes time, efforts and money (P)
Securing material flow for processing, retail and consumption	• how to distribute costs for stocks in VC (Wh) • little barriers (P)
Price policy that mitigates losses due to drought	• effects on production are too small to affect the prices (M, P, Wh) • lacking flexibility in trade and processing (P) • conflicting interests (M, B, Wh, P) • market power imbalances (M) • slow communication between actors (B) • difficult to acknowledge and assign costs (Wh) • current system aims at market stability beneficial for the farmers (P) • no interest to increase price when other countries are not affected – industry rather imports (P)
Resilience-Premium campaigns	• unclear if consumers are ready (Wh) • no interest to increase price when other countries are not affected (P) • lacking flexibility in trade and processing (MC)
Improve value chain transparency	• conflicting interests (B, P), • actors want to distinguish and promote their own products (B)

Note: Source: Stakeholder workshops; M, B, Wh, P = milk, beef, wheat and potato, respectively.

3.3.3 Overcoming the barriers: actors responsible for building resilience and their roles

The overview on the barriers shows that several measures require collaboration between actors and even the implementation of production-step measures is not dependent on farmers only. The lists of key actors responsible for building resilience (Table 3.7) to a large extent addresses barriers that hamper the measures' implementation, and suggests that the implementation of almost all measures requires efforts from several actors and stakeholders of the value chains.

3.3.3.1 Actors responsive for implementation of farmer measures

Farmers, not surprisingly, were identified as key players responsible for implementation of drought-tolerant varieties, irrigation, insurance and off-farm employment measures.

Implementation of these measures requires farmers to be aware and practical about their risks and capacities to make informed trade-offs. However, the participants made it clear that farmers are not the only players responsible for implementation of these measures. Intervention of research institutions is needed for measures that require new technical solutions: drought-tolerant varieties and efficient irrigation. Farmer consulting companies and farmer schools support farmers in making informed decisions by raising their awareness on possible risks, disseminate information on existing solutions and innovations and to educate farmers on their use. The role of the state in the resilience building, according to the participants, consists in improving availability of several production-step measures, through investing in technologies and research for irrigation and drought-tolerant varieties, and provision of subsidies for agricultural insurance. Interestingly, at the beef workshop, some participants expressed an opposite view on the state support of insurances and argued that to be relevant and economically sustainable, the insurance market should develop and to mature naturally due to the demand from farmers. Although such conflict of opinions emerged once during the four workshops, it nevertheless indicates that the direct state interventions can be a controversial topic.

In addition to facilitation efforts by the state, research and consulting, participants suggested that implementation of drought-resistant varieties requires the demand to adapt. In case of potato, that means that actors engaged in post-production activities such as wholesale, processing and retail should accept drought-tolerant varieties, which would possibly require them to adjust storage and processing facilities and processes. Consumers were also identified as influential players because of their preference for potato varieties, which affects what farmers plant. Participants of the beef and milk workshops stated that if consumers or society in a broader sense would have tolerated genetically modified plants, it would significantly facilitate the breeding process.

3.3.3.2 Actors responsible for implementation of value chain measures aimed at production and other activities

The measures that are supposed to be implemented by other actors of the value chains (wholesalers, processors and retailers) require them to recognize the effects of droughts on actors in their value chains and to be open for collaboration. The workshops participants suggested that these measures require support and facilitation from industry organizations that should motivate actors for discussion, negotiation and collaboration, and provide a platform for it. Furthermore, participants identified farmers associations as responsible for promoting farmers interest in such discussions and negotiations in order to overcome power imbalances, which is important, given that farmers are the primary beneficiaries for most of

these measures (see Table 3.4). Furthermore, the price-based measures and relaxation of quality requirement measures require consumer support and solidarity. Participants suggested that media and consumer organizations should reach consumers in an attempt to motivate them to collaborate by paying more during a drought or accepting potato with visual imperfections.

Table 3.7: Key players responsible for measures' implementation and their roles

Measure	Aims to increase resilience of:	Implementation by:	Facilitation/Intervention needed by:	
Drought-tolerant varieties	**Production**	**Farmers** • plant more dt varieties, • consider risks in decision-making • consider soil conditions when choosing varieties	**IS**	**Seed producers** • make varieties available at large scale
			PP	**Trade, Retail** • accept new varieties
			Cons	**Society, consumers** • accept new varieties • accept breeding methods
			OS	**State** • finance research & trials on dt varieties • facilitate research and trials • develop strategies • ensure policy compliances **Research and breeders** • develop and test new varieties **Farmer consulting** • increase farmer awareness • introduce dt varieties • educate farmers on use and trade-offs
Irrigation	**Production**	**Farmers** • install irrigation, • think of more efficient ways of water use	**OS**	**State (local government)** • promote efficient use of irrigation, • make laws clear **Research** • develop new solutions for efficient irrigation (e.g. drip irrigation)
Insurance	**Production**	**Farmers** • think about having an insurance, • calculate benefits	**OS**	**State** • subsidize insurance* • make insurance compulsory **Insurance providers** • develop insurance options introduce more options
Off-farm job	**Production**	**Farmers** • individual action, farmer or their family members	**n/i**	**n/i**
Securing purchase of animal feed	**Production**	**Farmer associations** • coordinate feed supply **Farmers** • participate in coordination	**OS**	**Branch associations/state** • decrease import taxes when needed
Relaxation of requirements for product quality	**Production**	**Clients (traders, processors)** • allow for flexibility in quality requirements • educate consumers **Consumers** • accept quality imperfections	**OS**	**Media** • inform consumers on current producer challenges **Research** • develop new ways for using the lower-quality products

Resilience premium campaigns	**Production**	**Consumers** • agree to pay a premium during hard times **Actors operating between farmers and consumers: traders, processors, retailers** • organize infrastructure for premium distribution • organize ways for consumers to pay premiums • agree on distribution terms	**OS**	**Branch associations** • ensure transparency of the process of collection and distribution of premiums **Consumer organisations** • inform consumers on campaigns and farmer challenges **Media** • inform consumers on current producer challenges
Price policy that mitigates losses due to drought	**Actors who bear extra costs due to drought**	**Individual actors (all actors)** • look for collaborative options **Consumers** • agree to pay a premium during hard times	**OS**	**Branch association** • provide platform for discussions, motivate actors for it **Farmers associations** • promote farmers interests at discussions
Securing material flow for post-production	**Post-production**	**Actors operating between farmers and consumers** • have stocks • decide who should pay for stocks • import materials, and plan for it	**OS**	**Associations/state** • ensure imports
Improve value chain transparency	**All actors**	**Processors and retailers** • reduce number of labels	**n/i**	**n/i**

Note: Source: stakeholder workshops; dt – drought tolerant; *there was a disagreement between participants; n/i = not identified during workshops; IS = input supply, PP = post-production, OS = other stakeholders.

3.4 Discussion and implications

In this study, we explored resilience in the food value chains from a multi-stakeholder perspective. We found that improving resilience in a value chain against droughts requires a variety of measures and actions from different actors within value chains: from input suppliers to consumers. However, our results show that the implementation of these measures is hampered by multiple barriers, which results in significant adaptation gaps for all actors.

3.4.1 How food system resilience can be built by the food system actors and why value chain collaboration is needed

It is hard to miss the fact that the measures proposed to increase the resilience in value chains have a strong focus on the production activity. This pattern can be observed in all four value chains, and suggests that the resilience in the food value chains heavily relies on the resilience of their production step. This reflects that the production activity is especially exposed to the extreme weather events compared to other activities of the food system (Himanen, Rikkonen, and Kahiluoto 2016) and rationalizes the fact that most of the studies focus on building resilience of agriculture. The stakeholders suggested several measures aimed to prevent disruptions in production due to droughts. The proposed measures appear to be quite generic for drought-exposed agricultural systems, and can be found in scientific literature as well as in practical guides for agricultural adaptation to droughts (see for instance Khatri-Chhetri et

al. (2019); Knutson et al. (2011)). In addition, the material flow is suggested to be secured by stocks or imports of primary agricultural materials. These measures should serve as a backup for the post-production activities (traders, processors, retailers), in case of failures in the production step, to ensure an uninterrupted flow of food products to the consumers. This is consistent with Wong and Schuchard (2012) and aligns with one of the aims of resilient food systems – to provide food for people despite shocks (Tendall et al. 2015). In our results, such substitution through imports or stocks was relevant for wheat and potato value chains, as their output is much more sensitive to weather events, than that of milk and beef production.

Extreme weather events are also known for causing economic losses due to the production failures as well as an increase of management costs associated with some measures aimed to prevent such failures, e.g. irrigation (P. J. Ericksen 2008; Grafton et al. 2019). Accordingly, workshop participants recognized financial stability as an important aspect of resilience of the food value chains, and suggested several measures to compensate for financial losses induced by droughts. While insurance and off-farm source of income are often suggested as measures (Khatri-Chhetri et al. 2019; Mase et al. 2017), our results suggest that market-based measures could as well be used as a remedy to compensate economic losses due to production failures. For instance, much of the production losses even at “normal” times happen because clients (processors and retailers) are not interested in buying produce that does not fit the standards, often due to visual imperfections (Devin and Richards 2018; Johnson et al. 2019). This becomes even more of a problem when product quality is affected by an adverse weather. The participants suggested that relaxations in quality standards would lessen economic losses among farmers and hence increase production resilience to droughts. Furthermore, the participants suggested that drought-induced economic losses and costs could as well be compensated by price premiums, coming either from profit redistribution along the value chain, or from the increased consumer price.

The market-based interventions proposed at our workshops align with the suggestions that sharing the costs of climate change adaptation among different actors (including consumers) could increase the resilience of a food sector (Ariyawardana et al. 2018; Vroegindewey and Hodbod 2018). Kahiluoto (2020) succinctly justified the need for collaborative actions: «food systems are only as resilient as their weakest actor». Indeed, our results indicate that farmers, who are primarily exposed to effects of droughts, have limited resources to accommodate measures to help themselves, and often have to prioritize other considerations over drought resilience. This is consistent with previous findings that resilience strategies compete for scarce resources such as money and time, and the improved resilience to specific disturbances can come at the expense of other farms operations (Ashkenazy et al. 2018; Darnhofer 2010).

It is suggested that diversity and redundancy of responses increases farmers resilience, but at the same time results in price increases and can result in decreased efficiency of other functions (Choptiany et al. 2015; Grafton et al. 2019). If fully born by farmers, the costs induced by climate change can have long-term detrimental consequences. First, increased resilience costs coupled with limited capital are major factors impeding sustainable practices among farmers (Knutson et al. 2011). Higher productivity through input-fuelled intensification and specialization is one of the obvious options to compensate the increasing costs (R. Milestad et al. 2010). Therefore, a seemingly enhanced agricultural resilience could in fact turn into "coerced" resilience, where a production system is decoupled from its ecological system and can collapse as soon as the human effort discontinues (Angeler et al. 2020; Ashkenazy et al. 2018; Rist et al. 2014). In that sense, we argue that creating market mechanisms such as price compensation or relaxation of quality requirements would provide a safety net for the farmers and, hence would not only facilitate their short-term recovery, but would contribute to an improved resilience and sustainability of agriculture and hence food systems.

Another role that actors engaged in post-production activities can play in building agricultural resilience to extreme weather events is related to their market power. In our study, preferences of clients were named as a barrier that hinders potato and wheat farmers from cultivating drought-tolerant varieties. In case of the potato, clients' preferences created one of the largest bottlenecks that we have observed in our study. This illustrates how market standards and consumer preferences can outweigh ecological conditions and risks in farmers' decision-making, which can make them more vulnerable to weather disturbances. Furthermore, this finding supports the argument of Hendrickson (2015) that demand from market systems are often incompatible with goals for agricultural resilience, and deprive farmers from their capacity to adapt and thus substantially undermining their resilience. Therefore, we join authors (i.e. Macfadyen et al. (2015); Nyström et al. (2019); Oliver et al. (2018)) who state that post-production activities possess exceptional power in making large-scale changes, and hence their engagement in building resilience of agriculture, and food systems in general, is vital.

3.4.2 Why status quo persists despite the need to build resilience in food systems

Our results show that the implementation of measures against effects of droughts is hampered by a variety of barriers, which results in significant adaptation gaps for most of the measures. The major adoption barriers for farmer measures were primarily associated with a need for trade-offs, for many farmers (despite being affected by droughts in the past)

considered that drought risks are not yet high enough to prioritize them over other considerations, especially in the beef and wheat production. This is consistent with previous findings that highlight the problems of allocating scarce resources to accommodate various production needs and effects of personal evaluation of risks on the adaptation behaviour (Darnhofer 2010; Grothmann and Patt 2005; Li et al. 2017). The results of the workshops suggest that the barriers also result from challenges present to actors that could facilitate farmers' adaptation. For example, researchers cannot quickly develop varieties for small regions (which Switzerland is) because breeding is a complicated, expensive and long process. Another example, insurance providers offer expensive premiums due to the high weather risks. This is in accordance with the study of Long et al. (2016) who highlight that barriers of technology providers play an important role in agricultural adaptation to climate change.

Participants in the stakeholder workshops suggested that value chain actors other than farmers can contribute to building agricultural resilience by creating back-up mechanisms for the farmers in case of extreme weather events, or facilitate or incentivise farmers' adaptation to climate change. However, the participants also outlined several reasons that hamper practical realization of such contributions. Conflicting interests in various combinations were most often suggested as a barrier. For instance, relaxation of quality requirements for potatoes could help farmers, but increases risks of shelf-life and hence, can compromise food security. Furthermore, relaxation of quality requirements is extremely difficult for processors, as a large-scale processing requires uniformity of inputs. Similar logic applies to the demand for varieties that was reported to impede farmers' adaptation. Processing and storage require certain biophysical qualities, which determines the choice of varieties. While the processors and retailer can adapt their requirements, it is a difficult, slow and potentially expensive process, due to the scale of their activities. The participants pointed out that post-production actors have the opportunity to secure their material flow with imports or stocks in case of production failures, hence minimizing drought impacts on their activity. Thus, there is little incentive for them to help producers by partially accepting physical or financial implications of droughts, and producers do not possess the equal market power to promote such measures.

Workshop participants pointed out the lack of formal instruments that could resolve conflicting interests, but they suggested that discussions, where different actors would try to find an agreement, could potentially resolve conflicting interests. The discussions could be motivated and organized by industry organizations that are active in Switzerland and whose role is to promote interests of the value chains. Furthermore, participants suggested that the conflict of interests can at least partially be resolved if consumers cooperate. Therefore, they

suggested that actors having power to reach consumers (retailers, media, consumer associations) should make efforts to educate them on the challenges of climate change and the importance of their support in building resilience.

Although we show that multiple barriers can significantly hamper farmers adaptation, climate change itself provides motivations for the farmers to change. Experience with extreme weather events along with the increased awareness of climate change risks has been shown to motivate adaptation behaviour (Grüneis et al. 2018; Li et al. 2017; Mase, Gramig et al. 2017). Therefore, it is possible that the increasing incidence of droughts and associated losses would force farmers to prioritize drought-dealing measures in decision-making. Post-production and consumption, on the other hand, are currently protected against impact of climate change even if the domestic production gets temporarily disrupted, which fulfils the aim of a resilient Swiss food system "to provide sufficient, appropriate and accessible food to all [Swiss residents], in the face of various and even unforeseen disturbances" as defined by Tendall and colleauges (2015). However, our results suggest that the security through substitutions disincentivizes value chain actors from contributing to truly building agricultural resilience against effects of climate change in the long-term. Similar conclusions but on a global scale, were reached by other studies that show how efforts of ensuring at-all-time predictable flow of food through substitutions successfully mask challenges and collapses in production, instead of creating stimuli to prevent it (Crona et al. 2016; Nyström et al. 2019).

Our results suggest that the proposed measures require efforts, trade-offs and costs also from the processors and retailers involved in the respective value chains, and hence there should be motives other than benevolence for these actors to overcome these barriers. Although the contributions of other actors to agricultural resilience would potentially be beneficial to them in the long-term, it does, however, not resolve the lack of short-term benefits. In the workshop discussions, participants suggested that price premiums in case of a drought (be it a result of profit redistribution in the chain, or consumer contribution) should help compensating for the increased costs of other actors, should they be negatively affected by effects of extreme weather events. Ariyawardana et al. (2018) suggest that food companies can make use of the noticeably increasing climate pressure, by communicating their climate change strategies to consumers as a corporate social responsibility (CSR). Hence, climate change adaptation could help companies to enhance their competitive advantage, as CSR can positively affect consumer perception of companies production and help gaining consumer loyalty (Chernev and Blair 2015). We suggest that it is a promising avenue in stimulating food companies to contribute to the resilience to climate change, and would like to call attention to the need for

further research on motivations that would stimulate multi-stakeholder approaches in building true food system resilience for the long-term.

3.4.3 Limitations

The present study on building resilience to droughts is based on four Swiss food value chains and therefore generalizing the findings to other countries and contexts should be done with care.

Nevertheless, by comparing the results of our study with other studies, we observe that the challenges of the Swiss food system regarding building resilience to climate change are, in certain respects, similar to those reported in other regions. For instance, the results indicate that Swiss farmers despite receiving extensive state support are still facing trade-offs in their decision-making, and resilience measures compete over financial and time resources with other practices. This can explain why the need for value chain measures emerged regardless of Swiss agriculture already being heavily supported by the state. Therefore, it may be assumed that a value chain support for production can be even more critical in agricultural systems that have less of support from the state; this nevertheless requires further research.

The set of resilience-enhancing measures included measures aimed at helping production by processors, retailers and consumers. We argue that this is unlikely only relevant within the Swiss context (especially given a plethora of strong barriers to such measures), but it emerged from our transdisciplinary research design where the post-production actors were engaged in joint discussions with producers. However, while the research-induced discussions among practitioners certainly allowed opening non-conventional collaborative perspectives into resilience building, one could see it as a limitation and question the probability of a similar discussion in a business setting that could lead to binding agreements. On the other hand, our results indicate that research, and transdisciplinary research processes in particular, has a potential to unveil contradictions and evoke solutions that are unlikely to emerge otherwise.

Lastly, the set of resilience measures is biased towards droughts, as it was a specific focus of the study. Nevertheless, we strongly believe that our major conclusions regarding the need for the value chain approach can be generalized to the resilience building to climate change in general. We acknowledge that the study is based on a limited sample of practitioners, and retailers were underrepresented compared to other activities. Therefore, the set of measures, as well as lists of barriers and key players might not be exhaustive. Hence, our study should be considered as a road map that can provide indications for possible directions for resilience building and further research on the topic, but not as a precise action plan.

3.5 Conclusion

Our study showed that practitioners see resilience of the food value chains mainly as agricultural resilience, which resonates with the fact that scientific and practical literature discussion on building resilience and adaptation in food systems to climate change focuses mainly on farmers. However, we argue that synonymizing food system resilience with agricultural resilience should be done very carefully. On the one hand, the focus on resilience of agriculture indeed highlights its vulnerable position to the effects of climate change and results in substantial efforts to design and evaluate measures and strategies to build agricultural resilience. On the other hand, such focus can be treacherous as it narrows down the understanding of food system resilience and can create a belief that farmers are the only ones responsible for resilience of food systems; hence limiting the opportunities to build long-term food system resilience. We must mention that we do not imply that farmers should outsource all the resilience building to other value chains actors. Nor do we want our results to be interpreted as other actors being solely responsible for the current lack of action in building food system resilience. However, we believe that the findings of our study emphasize the importance of stronger inclusion of value chain actors other than farmers in the process of building food system resilience to climate change.

In summary, our study provides suggestions for the food value chains to benefit from engagement of various actors of the value chains including consumers. The results of the stakeholder workshops and farmer surveys showed that building resilience to droughts is a challenging task which requires actors of the value chains to act beyond their immediate needs. For post-production actors and consumers that means sharing the risks of farmers, in order to provide extra redundancy for the production step in face of climatic shocks. Furthermore, our results indicate that post-production actors and consumers can create barriers for agricultural adaptation to droughts, which provides additional evidence that the engagement of processors, retailers and consumers is essential for building resilience. Nevertheless, low exposure to climatic disturbances coupled with the presence of replacing mechanisms to ensure the material flow disincentivizes post-production actors from investing in building resilience. Drawing on barriers outlined by the practitioners, we strongly suggest that more research should be done to explore possible motivations and incentives for value chain actors other than farmers to build resilience of food systems to climate change.

Paper 3

4 Consumers and food system resilience versus climate change: A new opportunity for corporate social responsibility?

This paper is in preparation to submit for publication to Nature Sustainability as Monastyrnaya, E., Kruetli, P., Joerin, J., Six, J. (2020), Consumers and food system resilience versus climate change: A new opportunity for corporate social responsibility?

Abstract

Companies improve their images and fight for consumer loyalty by integrating corporate social responsibility (CSR) in their business models. Support for environmental and social causes such as animal welfare, fair compensation for farmers and reducing environmental impact, have been extensively used to attract and retain customers in food businesses. In this paper, we propose another CSR opportunity – resilience of the food systems against extreme weather events. We tested if resilience can be integrated in CSR at times of extreme weather events in form of short-term resilience premium campaigns, where consumers are given opportunity to pay voluntary premiums on food products to support farmers affected by the event. In two complementary studies we investigated the opportunity to implement resilience premium campaigns from consumer and business (practitioners) perspectives. The results of five online surveys among 1'107 Swiss consumers show that consumers, in general, favour the idea of supporting farmers in the case of extreme weather events by paying more for food products. On the other hand, practitioners made it clear that several concerns, e.g. lack of studies on consumer support, benefits for other actors than farmers, should be addressed to implement resilience campaigns in practice. Since conflicting interests were found to be one of the barriers against introduction of resilience premium campaigns, it can indicate lack of adaptive capacities in the value chains.

4.1 Introduction

Global climate change increasingly challenges food production and raises concerns about the resilience of food systems to unexpected weather extremes, such as heat waves and droughts (Ben-Ari et al. 2018; European Environment Agency 2019). A resilient food system is characterized by the capacity to withstand, to adapt, to recover and to transform in order to ensure food security at all times, also in the face of unexpected and extreme weather events (M. P. M. Meuwissen et al. 2019; Tendall et al. 2015). While literature recognises consumers and their food security as a primary reason for why we need resilient food systems (e.g. Tendall et al. 2015; Vroegindewey and Hodbod 2018), only few studies suggest that consumers could play an important role in the process of building resilience in food systems (Himanen, Rikkonen, and Kahiluoto 2016; Lim-Camacho et al. 2017). There is evidence that consumers (and public in general) are aware of challenges that climate change imposes on farmers (Lim-Camacho et al. 2017) and express willingness to invest in prevention of major shifts in ecosystems (Scheufele et al. 2012) and in adaptation of farmers to climate change (O'Garra and Mourato 2016). However, in order to act, an individual needs not only knowledge on the issue and motivation, but also an infrastructure that makes an action possible (Lorenzoni, Nicholson-Cole, and Whitmarsh 2007).

Corporate social responsibility (CSR) in companies is an example of such infrastructure for consumers concerns regarding sustainability. CSR strategies recognize consumer demand for sustainability and willingness to pay for it, and offer consumers an opportunity to act according to their concerns by purchasing products with improved ecological and social performance (Bocken et al. 2014; Seuring and Mueller 2008). CSR allows companies to enhance their reputation, build trust with consumers, and can even improve consumer evaluation of companies' products (Chernev and Blair 2015; Lavorata 2014; Luhmann and Theuvsen 2016). In food businesses, CSR strategies embrace various perspectives, such as product safety, environment, occupational welfare, animal welfare, economic responsibility (e.g. price development) and local well-being (Forsman-Hugg et al. 2013; Luhmann and Theuvsen 2016), however resilience or climate change adaptation has remained out of scope. So far, research offers a scarce evidence that consumers are willing to support climate change adaptation strategies by purchasing from companies that implement such strategies (Lim-Camacho et al. 2017) or paying a premium to support the companies that were forced to adapt to new weather conditions (Ariyawardana et al. 2018). Nevertheless, this all does suggest that building resilience to climate change effects can become a new CSR dimension for food businesses.

The literature shows that direct experience of extreme weather events increases individual awareness of climate change and motivates climate change adaptation and mitigation actions (Broomell, Budescu, and Por 2015; Demski et al. 2017). Based on this evidence, we postulate that an occurrence of an extreme event, such as a drought, can give rise to consumer willingness to support domestic farmers to recover from the effects of the event, and hence to contribute to their resilience. By ensuring farmers' recovery, consumer support would increase the food systems' resilience in the longer term. Therefore, we propose that resilience can be integrated in CSR, in a form of short-term resilience campaigns, where consumers have an opportunity to pay a resilience premium on specific products to support farmers when an extreme weather event occurs. In the CSR domain, campaigns where a products' purchase leads to a monetary donation to a specific cause are known as cause related marketing (CRM) (Chang 2011; Hartmann, Klink, and Simons 2015), and we suggest that they can become a tool to build resilience in food systems.

We aimed to evaluate perspectives of implementation of resilience premium campaigns in two related but experimentally separate studies. In the first study, using an online survey, we investigated whether and to what extent consumers support the idea of financially helping farmers in case of an extreme weather event. This would help us to understand whether such an idea is viable at all, as consumer support is a primary prerequisite for implementation of resilience campaigns. In addition, we aimed to identify consumer motivations for farmers support, which would provide practical insights for promotion of resilience campaigns. In the second study, we explored what practitioners (farmers, processors, retailers) think about resilience premium campaigns, and what are the barriers that would prevent the introduction of such a measure. The second study adopts a transdisciplinary research approach that relies on involvement of practitioners in the research process (e.g. Lang et al. 2012). The transdisciplinary approach allows us to co-produce research findings on a new CSR tool with relevant stakeholders, and to understand their considerations and concerns regarding introduction of resilience premium campaigns (Aeberhard and Rist 2009).

Our study is part of a broader project that investigates resilience of the food system in Switzerland against extreme weather events. The parent project focuses on milk, beef, wheat, wine and potato value chains, as they account for 42% of total agricultural value in the country (Swiss Federal Statistical Office 2019a) and their continuous functioning is essential. Therefore, we also focused on food products from these five value chains. Consumer attitude to support local farmers is investigated in two scenarios: i) an extreme hot and dry summer for milk, beef, wheat and potato products, and ii) a spring hail and frost for wine. Both of

these scenarios are well relatable to the Swiss consumers, because Switzerland has recently experienced effects of similar events (heatwaves and drought in 2018 and a sudden snowfall, hail and frost at the end of April 2017), which were extreme enough to gain considerable public attention (MeteoSchweiz 2017, 2018).

Following the introduction, we first present the theoretical background and methods of the consumer study (further referred to as "consumer perspective"), and then transdisciplinary design the study among practitioners of the value chains (further referred to as "business perspective"). Further, we present and discuss the findings from both studies to shed light on prospects for implementation of resilience premium campaigns, and derive recommendations for further research.

4.2 Methods

We investigated perspectives for implementation of resilience premiums as a CSR tool in two studies. The first study (further referred as "Consumer perspective") aims to estimate consumers' attitude to support farmers using an online survey. The study further investigated personal attitudes and traits that affect attitude to support, by re-applying some of the findings from adjacent literature on ethnocentrism, sustainability and domestic food consumption.

We investigate perspectives for implementation of resilience premiums as a CSR tool in two parts. The first part aims to estimate consumers' attitude to support farmers using an online survey. The study further investigates personal attitudes and traits that affect attitude to support, by re-applying some of the findings from adjacent literature on ethnocentrism, sustainability and domestic food consumption. The second part is based on the transdisciplinary approach and explores the attitude of practitioners to implement resilience premiums to increase the resilience of the value chains they operate in. Specifically, in the second part, we aim to identify practitioners' concerns as well as barriers that could hamper the implementation of resilience premium campaigns.

4.2.1 Consumer perspective: methods

4.2.1.1 Hypotheses development

In the absence of studies on consumer attitudes to support domestic farmers in case of an extreme weather event, to formulate our hypotheses, we relied on the assumption that

people tend to be consistent in their beliefs, attitudes and actions and strive to avoid cognitive dissonance (Thøgersen 2004). Since our suggestion concerns support of domestic farmers, we assumed that consumer attitude to support them in case of an extreme weather event shares the same motivational roots with preference for domestic products in general. Specific attachment of consumers to products from their own countries is described by the concept of consumer ethnocentrism developed by Shimp (1984). Extant literature widely recognizes consumer ethnocentrism as a strong predictor for preference of domestic food products (Aprile, Caputo, and Nayga 2016; Tomić and Alfnes 2018; Vida and Reardon 2008). Ethnocentric people tend to believe that local food is superior in freshness, quality and taste compared to imported food, and choose local food to support the economy, and especially the domestic farmers (Carpio and Isengildina-Massa 2009; Vabø et al. 2017). Since ethnocentric people prefer buying domestic food products in ordinary conditions, we also expect that:

> H1: Ethnocentrism positively affects consumer **attitude to support** farmers in case of an extreme weather event.

We also hypothesised that sustainably-minded consumers have more positive attitudes to support farmers. First, concerns for sustainability were found to be another factor motivating consumers to prefer local food products (Aprile, Caputo, and Nayga 2016; Vabø et al. 2017). For instance, consumers can believe that local food production has smaller environmental impact because of shorter transportation distances (Kumar and Smith 2018; Lazzarini, Visschers, and Siegrist 2017; Vabø et al. 2017). Second, people with stronger environmental concerns show more positive attitude to measures aimed at adaptation and mitigation to climate change (O'Garra and Mourato 2016; Schwirplies 2018). Since individual extreme weather events are likely another manifestation of the ongoing climate change (Ben-Ari et al. 2018; Diffenbaugh et al. 2017), we postulate that environmental concerns also positively affect consumers' attitude to support farmers against extreme weather events. Finally, we postulate that social considerations is another reason for sustainably-minded consumers to support farmers to recover from negative socio-economic consequences of extreme weather events. Based on these considerations, we suggest the second hypothesis:

> H2: **Attitude to support** in case of an extreme weather event is positively affected by attitude to sustainability.

In 2019, the Swiss state spent 2'815 million Swiss francs to support the domestic agriculture (BLW 2019b). The state support of agriculture in Switzerland, also known as direct payments, is part of the Federal Constitution and aims to support farmers socially by securing their income and to ensure sustainable use of natural resources (Swiss Federal Government 1999/2020, Art.104). The majority of Swiss residents (75%) agree that the agriculture should be supported by the state (BLW 2018). There is evidence that people who express costly prosocial behaviour are more likely to engage in another costly prosocial behaviour (Gneezy et al. 2012). Since Swiss residents are already supporting the domestic agriculture through their taxes, and given their positive attitude to this support, we hypothesized that they will as well express positive attitude towards the support of domestic farmers in case of extreme weather events. Also, because Swiss agricultural policy encompasses economic and social perspectives, and is aimed to support domestic food production, it would be reasonable to assume that the attitude to direct payments would partially mediate the effects of ethnocentrism and attitude to sustainability on the attitude to support farmers in case of extreme weather events.

H3: Attitude to direct payments positively affects **attitude to support.**
H4: Attitude to direct payments partially mediates the effects of ethnocentrism (4a) and importance of sustainability (4b) on **attitude to support**.

Finally, trust was shown to play a key role in affecting consumers support of cause-related marketing initiatives of food companies (Hartmann, Klink, and Simons 2015; Lerro et al. 2019). To be convinced to donate within a cause-related marketing campaign, consumers should not only understand the cause, but also feel that an information provider is transparent about the purpose of the campaign, and is driven by benevolence rather than self-interest (Chernev and Blair 2015). In this study, we will measure trust as a propensity to trust, i.e. an individual predisposition to trust others, stable across different situations (Mayer et al. 1995, cited by Alarcon et al. (2018)). We suggest that people who tend to trust others would be predisposed to believe the resilience premium campaigns and its cause, and therefore our fifth hypothesis is:

H5: Propensity to trust positively affects **attitude to support (ATS)**.

4.2.1.2 Measures and survey design

To measure ethnocentrism, attitude to sustainability, propensity to trust and attitude to direct payments, we have used existing scales. Ethnocentrism was measured with the reduced version of the consumer ethnocentrism tendencies scale (CETSCALE) of 10 items

(Shimp and Sharma 1987). The scale was adapted to capture ethnocentrism regarding food products (Jiménez-Guerrero, Gázquez-Abad, and Linares-Agüera 2014). To measure attitude to support farmers through direct payments, a question from the previous survey in Switzerland was adopted (BLW 2018). The questions to measure propensity to trust were adopted from the European Social Survey (ESS 2016). ATS was measured directly, by a straightforward question, as a single-item variable. All the aforementioned variables were measured with the 7-point Likert scale (where 1 = strongly disagree and 7 = strongly agree). The items (questions and statements) are presented in Table 4.3.

In addition to the general attitude to support farmers in case of an extreme weather event, we estimated how much would consumers be willing to pay more for 15 different products from the milk, beef, wheat, wine and potato value chains. Although in this study we focus on general attitude to support farmers and factors that motivate it, we nevertheless find it important to report the results of the monetary willingness to pay (further referred to as WTP) to support farmers. Hence, the detailed information on WTP as well as on methods we used to assess it can be found in the supplementary materials (Tables S5 and S6).

4.2.2 Data collection and sample

The questionnaires were pre-tested by five members of the research group and one of the questionnaires (milk) has undergone an online pilot test (200 responses) to prevent errors related to phrasing, design and technical aspects. Based on the pre-tests and the pilot test, the questionnaires underwent minor modifications: some questions were removed and others were reformulated. Online data collection took place in March, April and May 2019 through a marketing research company “Respondi”. To take part in the survey, respondents had to be over 18 years of age and consume at least one product of interest. Each respondent obtained a unique link to a survey and could only participate once. The questionnaires were in German and French (the predominant official languages of Switzerland).

The obtained datasets underwent a quality check. We removed bad quality responses: those with missing observations, straightlining (responses in option grids with the same answers) and patterned responses (where every answer is within one step from the previous row's answer). In addition, we have conducted a simple consistency check, where the responses for two very similar questions were compared and if opposite scores were given (e.g. “strongly disagree” and “moderately agree”) the response was removed. Based on the quality check

13% of responses were removed. The number of responses available for the analysis is presented in Table 4.1.

Table 4.1: Number of responses: total and per sample

Total	Milk	Beef	Wheat	Potato	Wine
1107	224	212	223	218	230

The demographics of the total sample of 1'107 was pooled together from the five samples (see Table 4.2). To enhance generalizability of the study, we used stratified sampling by age, gender and six greater regions of Switzerland. Compared with the general Swiss population, individuals with the lowest educational level were slightly underrepresented (5%; census: 11.6%), and the percentage of individuals with medium education was higher (50%; census 44.7%) (Swiss Federal Statistical Office 2018). Chi-square and t-tests showed no statistical difference in demographics in the final subsamples.

Table 4.2: Demographics of the sample (N = 1'107)

Characteristic	% of the sample	Characteristic	% of the sample
Gender		Age	
Male	47%	18 - 29	18%
Female	53%	30 - 39	19%
		40 - 49	20%
		50 - 59	21%
		60 and more	22%
Grossregion (NUTS-2)		Education	
Espace Mittelland	23%	Lower (compulsory school)	5%
Lake Geneva region	16%	Medium (vocational or middle school)	50%
Northwestern Switzerland	15%	Higher (higher vocational education or university)	45%
Eastern Switzerland	16%		
Central Switzerland	10%		
Zurich	20%		

Note: Grossregion (NUTS-2) – Greater regions of Switzerland according to Nomenclature of Territorial Units for Statistics.

4.2.2.1 Statistical analyses

The four constructs (ethnocentrism, attitude to sustainability, propensity to trust, attitude to the state support of farmers) were tested using Structural Equation Modelling (SEM) for their explanatory power in relation to the attitude of consumers to support farmers in case of extreme weather events. SEM is particularly suitable for our purposes because it allows us (1) to test reliability and validity of scales used to measure constructs (latent variables), (2) to test for relationships between independent and dependent latent variables and (3) to check specific mediation effects between the variables. The structural equation modelling was conducted in R using the package "lavaan".

4.2.3 Business perspective: methods

We used a participatory collaborative approach to explore whether practitioners see resilience premiums as a potential measure to increase resilience of food value chains against droughts and what barriers can hamper implementation of such measure. In April and May 2019, we have organized four half-day stakeholder workshops for the milk, beef, wheat and potato value chains, where stakeholders representing different activities jointly discussed measures to improve the resilience of their respective value chains. The wine workshop, unfortunately, did not take place for reasons we did not have control over. The participants included input suppliers, producers, processors, retailers, consumers and relevant professional associations, and the number of participants ranged from 10-14 people per workshop. Most of the participants were part of the transdisciplinary platform of the parent resilience project, have attended stakeholder workshops before, and were continuously providing feedback on project findings.

The workshops were organized under the title "Resilience of the Swiss commodity[17] value chain" and embraced several topics, consumer support of farmers in case of a drought being one of them. The workshops were aimed to validate farmers', processors' and consumers' perceptions on effects of shocks and to identify various ways to increase the resilience of the value chains. With regard to the resilience premium, the workshops allowed identifying concerns/barriers of stakeholders regarding its implementation, as well as to assess how stakeholders value this measure among other alternatives aimed at increasing the value chain resilience against droughts.

[17] Respectively: milk, beef, wheat or potato value chains

In each workshop, the leading researcher first presented the results of the farmers', processors' and consumers' surveys, and participants shared their feedback and opinions in an open discussion. Second, participants were divided in groups of 3-4 people and were asked to identify and write down the most useful measures (up to three) to increase resilience of their value chain against droughts. The potato workshop was the first one in a series of four, and showed that the design of the group activity, how we designed it at first, was not optimal. Based on the feedback from the workshop participants, we had to substantially reworked the task. At the milk, beef and wheat workshops group activities that followed new design were conducted. As for the potato participants, we asked them to complete the tasks individually, as the new potato workshop was not possible. Therefore, one should pay attention that the measures for the potato value chain were suggested individually, whereas for milk, beef and wheat value chains measures are result of the group discussions.

The written notes were collected at the end of the workshops (with the exception of potato, which was collected after the workshop), and the discussion was recorded and transcribed. The transcription was later used to extract opinions on barriers/concerns/ that can hamper implementation of a resilience premium. The workshops were conducted in German, and the findings were translated in English.

4.3 Results

4.3.1 Consumer perspective: Results

4.3.1.1 Descriptives

A Kruskal-Wallis test was conducted to examine the differences in attitude to support between the milk, beef, wheat, wine and potato samples. No significant differences in ATS were identified (Chi-square =8.86, $p > 0.05$, df = 4), and thus the samples were pooled together for further analysis.

The answers to the attitude to support question are skewed to the right (Figure 1), which suggests that respondents tend to agree that consumers should support domestic farmers in case of another hot and dry summer (M=4.7; SD=1.36). The majority of respondents (60%) agreed to the statement, whereas 22% remained neutral and 18% disagreed that consumer support should take place.

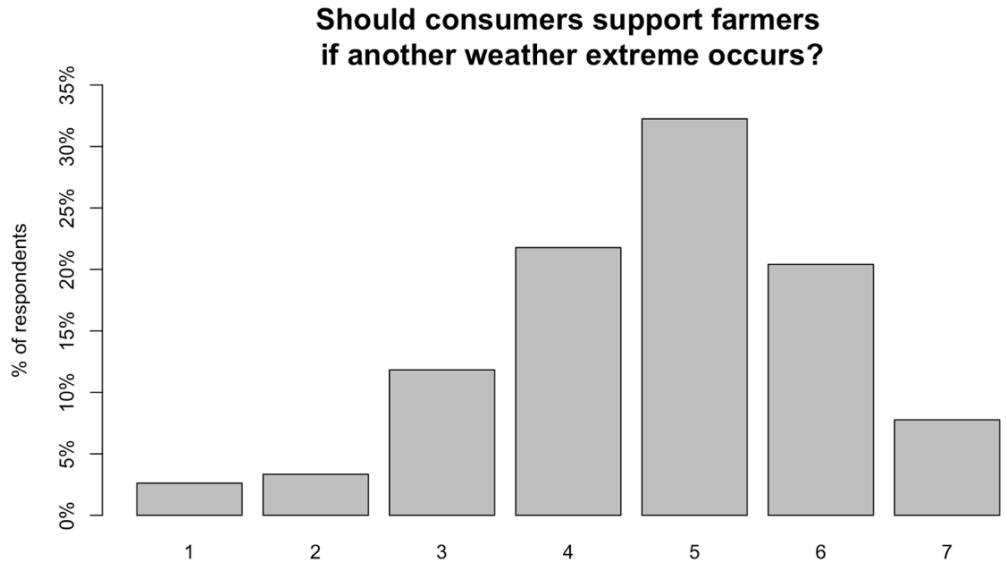

Figure 4.1: Responses on attitude to support (1 - fully disagree, 7 - fully agree)

4.3.1.2 Measurement model results

To assess the measurement model, we conducted a confirmatory factor analysis (CFA). To evaluate reliability and validity of the measurement components of the model, standardized factor loadings, Cronbach's alpha, average variance extracted (AVE), composite reliabilities (CR) and inter-construct correlations were calculated (Table 4.3, Table 4.4 and Table 4.5). The factor loadings for all items ranged from 0.5 to 0.9 (Table 4.3) and the Cronbach's alpha values for all constructs ranged from 0.8 to 0.92 (Table 4.4), which confirms internal consistency of scales (Bagozzi and Yi 1988; Hair et al. 2014).

Table 4.3: Results of measurement model analysis

Construct	Items	Standardized factor loadings
Propensity to trust	Do you usually assume that most people can be trusted, or do you rather think that you cannot be careful enough?	0.807
	Do you think that most people would try to take advantage of you if they had the chance, or do you rather assume that they would act fairly?	0.801
	Would you say that, in general, most people try to be helpful, or are they mostly just concerned about their own benefit?	0.676
Attitude to sustainability	How important is environmental friendliness of the product for you when you buy food?	0.876
	How important for you is that the food product that you buy is produced in a socially-fair way?	0.892
Ethno-centrism	Only those food products that are unavailable in Switzerland should be imported	0.706
	Swiss food products, first, last, and foremost	0.823
	Purchasing foreign food products is un-Swiss	0.579

	It is not right to purchase foreign food products	0.723
	A real Swiss should buy Swiss food products	0.773
	We should purchase Swiss food products instead of letting other countries get rich off us	0.806
	Swiss should not buy foreign food products, because it hurts Swiss food industries and causes unemployment	0.747
	It may cost me in the long run but I prefer to support Swiss food products	0.678
	We should buy from foreign countries only the products that we cannot obtain in Switzerland	0.722
	Swiss consumers who buy imported food products are responsible for putting their fellow Swiss out of work	0.696
Attitude to direct payments	Swiss agriculture should be supported by the state	1
Attitude to support	Should consumers support farmers in case of a next extreme weather event?	1

Furthermore, average variance extracted (AVE) and composite reliability (CR) of the constructs exceeded the recommended value of 0.5 and 0.7, respectively (Table 4.3), thus suggesting adequate convergent validity (Fornell and Larcker 1981; Hair et al. 2014). Finally, the AVE estimates for each factor exceed square of the correlation between factors, suggesting that scales are sufficiently different from each other, and hence providing evidence of discriminant validity (Hair et al. 2014). Based on results of CFA, all items initially included in the measurement model were retained.

Table 4.4: Reliability and validity tests

Construct	AVE	Cronbach's alpha	CR
Propensity to trust	0.58	0.80	0.88
Attitude to sustainability	0.78	0.88	0.94
Ethnocentrism	0.54	0.92	0.94
Total	0.57	0.84	0.96

Note. CR = Composite reliability, AVE – Average variance extracted.

Table 4.5: Correlations between the constructs

Construct	1	2	3	4
1. Propensity to trust	1			
2. Attitude to sustainability	0.122	1		
3. Ethno-centrism	0.019	0.338	1	
4. Attitude to direct payments	0.065	0.265	0.287	1
5. Attitude to support	0.083	0.323	0.342	0.468

To evaluate fit of the measurement model, the following criteria were used: GFI > 0.9, RMSEA < 0.07, CFI > 0.92 and SRMR < 0.08 (Hair et al. 2014). The question 9 repeated question 1, but in a different wording (see Table 4.3); the closeness in meaning suggests that they form a variable on their own, and their residuals are correlated. Therefore, we modified the model by allowing non-zero covariance between questions 1 and 9. By adding this non-estimated relationship within the construct, we did not alter the hypothesized structure of our model, which is the major concern for adding such relationship (Bagozzi and Yi 1988; Hermida 2015; Whittaker 2012).

Table 4.6: Model fit indices for measurements and structural models

	Chi-square	df	GFI	RMSEA	CFI	SRMR
Measurement model fit	749.862	110	0.913	0.07	0.937	0.050
Structural model fit	751.393	111	0.913	0.072	0.937	0.050

Note. df = degrees of freedom, GFI – goodness-of-fit index, RMSEA – root mean square error of approximation, CFI – comparative fit index, SRMR – standardized root mean residual

4.3.1.3 Structural model results

In a second step, we tested our hypotheses based on the structural model depicted in Figure 4.2. The fit indices indicated that the structural model provided an acceptable fit to the data (Table 4.6).

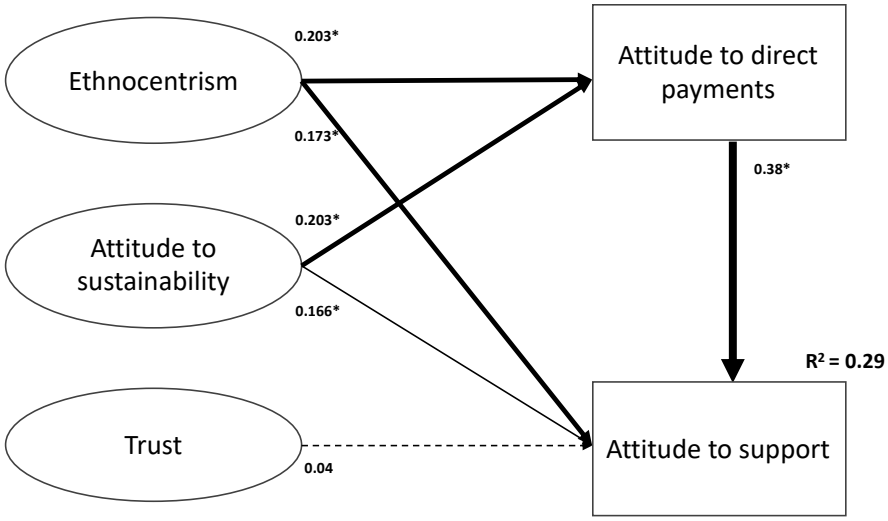

Figure 4.2: Structural diagram of the model. Path coefficients represent hypothesized structural relationships between the variables. Statistically significant paths are marked with solid lines, whereas insignificants paths are marked with dotted lines. Note: p<0.001. Latent variables depicted in ovals are latent variables with multiple survey items; those in rectangular boxes are observed variables. Exogeneous variables are allowed to be correlated.*

Ethnocentrism (β = 0.173, p < .001) and attitude to sustainability (β = 0.166, p < .001) are significant predictors of attitude to support, but the path from propensity to trust was not statistically significant (β = 0.04, p > .05) (Figure 4.2). Hence, H1 and H2 were supported but H5 was rejected. Attitude to direct payments is a significant predictor for attitude to support (β = 0.38, p < .001), which supports H3 and indicates that people who support the idea of state support to farmers, also agree to support farmers individually when it comes to a an extreme weather event. Furthermore, the attitude to direct payments was found to partially mediate the effects of both sustainability and ethnocentrism. Hence H4a and H4b were confirmed. Finally, we have assessed R^2 values to examine the predictive power of the structural model. The predictor variables explained 29% of the variance in attitude to support farmers in case of an extreme weather event.

4.3.2 Business perspective: results

Resilience premium campaigns were selected in three out of four workshops during the group activities aimed at identification of measure to increase the value chain resilience in case of a drought (Table 4.7). In the beef workshop, none of the groups selected it as a compensation measure, and opted for insurance and improved coordination in the value chain, which would buffer possible price fluctuations caused by an extreme weather event. In fact, insurance was the only compensation measure suggested at all four workshops, and was suggested by at least 2 out of 3 groups in milk, beef and wheat workshop. Potato participants focused much more on prevention measures, rather than compensation measures, but nevertheless 2 out of 11 chose resilience premium as a useful measure.

In milk, wheat and potato workshops, a balance between measures aimed at prevention and compensation of losses induced by a drought on farming was observed. Although the resilience premium campaigns were not chosen unanimously in any of the workshops, the results suggest that it could become part of an integrative solution to increase the resilience of the value chains.

Table 4.7: Measures selected to increase value chain resilience against droughts and number of groups in the workshop that selected them (2/3 = two out of three groups; for potato: 3/11 = three out of 11 participants)

Mechanisms aimed at compensation of financial losses induced by a drought	
Insurance	Milk (2/3)
	Beef (2/3)
	Wheat (2/3)
	Potato (3/11)

Resilience premium	**Milk (2/3)**
	Wheat (1/3)
	Potato (3/11)
Price policy that mitigates losses due to drought	Milk (2/3)
	Potato (3/11)
	Beef (2/3)
Off-farm employment farmer	Milk (1/3)
Relaxation of quality requirements	Potato (2/11)
Mechanisms aimed at prevention of physical losses induced by a drought	
Use of more drought and heat-tolerant varieties	Milk (2/3)
	Beef (3/3)
	Wheat (2/3)
	Potato (11/11)
Securing purchase of animal feed	Milk (1/3)
	Beef (1/3)
Irrigation	Potato (9/11)

Note: participants of the potato workshop have completed the task individually; the number indicates a number of people who selected a measure (3/11 = two out of eleven participants)

In all four workshops, the participants pointed out, that several actors (retailers, processors, wholesalers - depending on how financial flows in the value chain are organized) would need to be engaged in collecting the premiums from benevolent consumers and in sharing the money among affected farmers (Table 4.8). Hence, concerns were raised regarding motivation of actors in the value chain to invest efforts in organizing the process and to carry the costs of it. The lack of immediate obvious benefit for actors other than farmers was thus named as an important barrier for implementing resilience premiums. Also, actors questioned why farmers' entrepreneurial risks should entail actions from the whole value chain, and why not to opt for solutions that does not require a collaborative effort, such as insurance or increased governmental support. In addition, the participants suggested that introduction of resilience premiums can be a source of risk for actors. Beef products, for example, are very expensive in Switzerland, and consumers have shown high price sensitivity to them. Therefore, introduction of a premium (even a voluntary one) on a product considered already expensive can undermine consumer attitude to the retailer. In case of milk, some consumers who agreed to support farmers might be disappointed to learn that their money is used for extra imports of animal feed, for it being a controversial subject among sustainably-minded consumers.

The participants emphasized that transparency would be crucial in maintaining consumers' support to the resilience cause. For instance, if consumers suspect unjustified monetary interests from actors in the campaign, it could deteriorate public attitude and reduce WTP.

Therefore, the participants suggested that neutral actors, e.g. representing research or state institutions, should be engaged in order to ensure that resilience premiums are collected at the time they are needed, and directed to those who are in need.

Other concerns were raised on operational aspects of a resilience premium campaign. To reach the maximal efficiency, a campaign would have to be launched at the moment when consumers personally experience weather effects and the media coverage is at its' active phase. For example, if a premium is introduced in summer, consumers would technically be paying a premium for products harvested earlier, when farmers were not yet affected. In addition, at this moment the extent and magnitude of the effects are not yet clear until later, when the drought and heat is well over. In case of wheat and potato it could be in late summer and autumn, when the harvest is collected and quality evaluated, and in case of milk and beef, it can take several months for effects to manifest fully, e.g. when animal feed reserves are exhausted. Also, distribution of collected premiums among farmers would not be a trivial task, as a drought could affect farmers very differently, depending, for example on the altitude and soil properties. Therefore, one would need to measure to what extent a farmer was affected in order to share the money fairly.

Finally, one of the key concerns that was expressed in all four workshops, was related to the novelty of the suggestion. Little theoretical, not to mention practical evidence exists that consumers might be willing to pay a short-term premium to support farmers. The participants agreed that emotional effects of a weather event enhanced by the media can induce WTP among consumers. However, participants suggested that more experiments should be conducted to explore attitudes stated by consumers and their real behaviour. Furthermore, to implement resilience campaigns, actors would need deeper understanding of consumer behaviour: i.e. how consumers would react to using part of the premium to cover the campaign costs; how would resilience premium affect their loyalty; if consumers start paying more, would they purchase less?

Table 4.8: Thematic analysis of the barriers for "Resilience Premium" and concerns raised by participants of the workshop

1. What is real WTP	
There is a gap between stated intention and real behaviour. More research should be done to test consumers ATS and WTP.	M, B, Wh, P
Consumers who start paying more, can start purchasing less of a product they support, which would annihilate their contribution.	B
2. Value chain actors have different interests and little incentive to introduce resilience premiums	
The value chain is complex and comprises several actors between farmers and consumers). One cannot expect a full amount to reach farmers.	M, Wh, P
Implementation of a resilience premium would require a great amount of solidarity, willingness to collaborate and trust between actors who have different interests.	M, Wh, P
Organization and coordination of a fair and transparent process would require additional costs.	M, Wh, P
Switzerland has diverse topography and soil conditions; same weather event could affect Swiss farmers very differently. Hence, the difficulty would be to distribute the money from "resilience premium", in a fair and transparent manner.	Wh
There are easier solutions to compensate for farmers' losses that do not require a whole chain to collaborate, such as insurance or targeted governmental support.	M, Wh, B
Farmers should be able to deal with the single drought; it is their entrepreneurial risk.	M, B, Wh, P
Retailers are not willing to cooperate.	P
Beef price development affects competitive position of retailers and they would be very careful when considering any price-related actions.	B
Consumers might be empathetic and determined to pay more to not let cows starving, they also are likely to react negatively to the increase of animal feed imports	M
3. Lack of transparency would decrease consumers' WTP	
The need for resilience premium should be communicated by independent actors who do not have direct monetary interest in collecting money, like e.g. retailers.	M
Consumers who are determined to pay money to support farmers would expect that the amount would be directed to farmers, otherwise, their attitude to support would be significantly undermined.	M, Wh, P
Moreover, the communication of RZ could be confounded with other numerous labels, whose number already make it difficult for consumers to clearly understand their values and differentiate between them.	B
4. Drought effects covered by media do not necessarily coincide in time with effects of droughts on agriculture	
Effects of a drought on cattle production are delayed. Farmer exhaust their feed reserves and feed prices increase later in the year, when the drought is long over.	M, B
If a resilience premium would be collected in the very moment of a drought, benevolent consumers would technically be paying more for the wheat harvested earlier, and not for wheat from the affected season. Introducing a resilience premium later in the year would be inefficient, as the drought would be long-forgotten among consumers.	Wh

4.4 Discussion

This paper investigated prospects of introducing resilience premium campaigns as a measure to compensate for farmers' losses induced by extreme weather events, and hence, to increase their resilience. Two complementary empirical studies were conducted independently to embrace opinions of consumers' and practitioners on resilience premiums. We found that consumers, in general, favour the idea of supporting farmers by paying more for food products, and can have various motivations for it. On the other hand, practitioners point at a number of issues to address in order to implement resilience premiums in practice, but do not reject the idea.

4.4.1 Consumers attitude to support farmers in case of weather extremes

Based on theoretical and practical examples of consumer WTP for sustainable and local food products, as well as on evidence of their support of cause-related marketing campaigns, we postulated that consumers would be willing to pay a premium on food products to support farmers in case of an extreme weather event.

The survey shows that the majority of the respondents either support the idea of paying more for food products in case of extreme weather events, or remain neutral to this suggestion (60% and 23%, respectively). There can be several reasons for this high support of the resilience cause by consumers. While we cannot rule out bias typically present in surveys on consumer willingness to pay (Schmidt and Bijmolt 2019), the degree of support of resilience premiums shown in our survey is rather consistent with previous research on consumer attitude to monetary support of agricultural adaptation to climate change. For example, a survey conducted in Australia, by Ariyawardana et al. (2018) shows that at least 50% of consumers express to be willing to pay a premium for fresh mangoes and potato chips to support domestic agri-food companies in adapting to climate change, whereas for wine this percent is somewhat lower, at around 40%. In our study, 46% of the respondents reported to be willing to pay a premium for chips (60% of total supporters minus 14% with 0-WTP, see Table S6 in supplementary materials), and 55% for wines (60% total, minus 5% of 0-WTP). Also, in a survey among UK residents, 54.3% of respondents reported to be willing to contribute to support global climate adaptation projects in developing countries, by increasing their annual income taxes (O'Garra and Mourato 2016).

Furthermore, the literature suggests that awareness and personal experience of weather extremes affects climate change concerns and respective behaviours among consumers

(Broomell, Budescu, and Por 2015; Demski et al. 2017). When asking for an attitude to support farmers, we made respondents recall the recent extreme weather events: an abnormally hot and dry summer of 2018 (milk, beef, wheat, potato) and a spring hail and frost at the end of April 2017 (wine). Both events affected several European countries, were extreme enough to be well-noticed by the Swiss public and were extensively covered by media. Hence, the high support for the resilience premium can be explained by the personal experiences and awareness of possibility of such extreme events. Also, the resilience premium is characterized by a good fit between the cause and the product (paying more for food to support farmers), which was found to be an influential factor for CRM campaigns (Melero and Montaner 2016). Interestingly, there was no difference between milk, beef, wheat, wine and potato samples with regards to the attitude to support. This suggests that personal experience and awareness, along with sustainable considerations, play a more important role than a product or a specific scenario (drought or hail).

The previous research shows that ethnocentrism and attitude to sustainability influence consumer choice for domestic food products (Aprile, Caputo, and Nayga 2016; Fernández-ferrín et al. 2018; Tomić and Alfnes 2018; Vabø et al. 2017; Vida and Reardon 2008). In our study we found that both of these factors also positively affect consumer attitude to support domestic farmers in case of extreme weather events. Furthermore, our study revealed that attitude to state support of agriculture is positively correlated with attitude to individual support through resilience premiums, which provides additional evidence that people tend to behave consistently when costs are involved (Gneezy et al. 2012). Attitude to state support of agriculture only partially mediated effects of ethnocentrism and attitude to sustainability, which suggests that people who do not approve state support of agriculture, can still be willing to support farmers individually, because of their ethnocentric or sustainability concerns. On the other hand, contrary to our expectations, propensity to trust was not found to be a predictor for attitude to support. One of the possible reasons can be that we have measured trust as a general personal characteristic, whereas studies that showed influence of trust on CRM campaigns investigated it more specifically, e.g. as a trust in cause-related marketing or trust in particular CRM campaign at a certain supermarket (Hartmann, Klink, and Simons 2015; Lerro et al. 2019).

4.4.2 Practitioners perspective and barriers for implementation of resilience premiums

The practitioners workshops allowed us to further evaluate perspectives of implementing resilience premiums as a measure to help farmers to recover from extreme weather events. Most concerns and barriers mentioned by the practitioners were replicated in all workshops,

and no significant discrepancies, apart from some context specific comments, were observed. This suggests that the opinions of the workshops' participants can be shared by other value chain actors, and therefore can be representative for the actors within the Swiss food system.

The participants suggested that a resilience premium campaign can be used among other tools to enhance farmers' resilience to extreme weather events. However, the participants made it clear that to implement this measure several concerns have to be addressed. First, the participants in all four workshops stated that in order to be implemented, the resilience premium needs to be strongly justified. One of the concerns raised at all four workshops was related to the results and design of the consumer survey. It is well known that consumer surveys contain biases; e.g. Schmidt and Bijmolt (2019) estimated that a WTP for consumer goods measured in real contexts is on average 21% smaller than a WTP estimated in hypothetical scenarios. Although we were able, to a certain extent, justify the results of our survey by comparing them with other studies, we accept the possibility that the real attitude to support by paying more for food products can be lower (i.e. 25-35 % instead of 45-55%) than reported by the participants of our survey.

The participants pointed out that the design of the survey did not cover various scenarios of consumer behaviour. For example, Ariyawardana et al. (2018) found that consumer WTP largely decreases in case of visual quality defects in food products (which could be the case for drought or spring frost), and that consumers can start buying less of a product if the price increases. Whereas the data suggest that consumers would be paying a resilience premium voluntarily, we cannot rule out a possibility that benevolent consumers would start purchasing products they support less frequently, hence cancelling out their contribution. Also, the survey did not further investigate behaviour of consumers who did not agree to support farmers. Since consumer disagreement can, in extreme cases, manifest in boycotts (Braunsberger and Buckler 2011), deeper understanding of the non-supporters would provide important insights on possible risks associated with resilience premium campaigns.

Finally, the participants suggested that a resilience premium campaign would require extra costs, and hence a part of this premium should be used to finance operationalization of the campaign. However, our survey did not reflect these considerations, and suggested a scenario, where all the money collected in a campaign would be used to compensate for farmer losses induced by the weather event. The literature suggests that consumers are more willing to support domestic farmers, than processors (Vabø et al. 2017), and can negatively react if they feel deceived by the purpose of CRM (Hartmann et al. 2015). Therefore, it is possible that consumer support would be reduced if part of the money is used to cover other actors costs

and not to help farmers. In addition, the participants raised concerns regarding motivation of value chain actors to introduce resilience premium campaigns. Based on previous research (Chernev and Blair 2015; Loussaïef et al. 2014), we assume that a resilience premium campaign would have positive effects on company's image and performance, however, more research should be done to test this assumption.

While the concerns outlined above, can be addressed with further consumer studies, we sense that a greater barrier to resilience campaigns stems from considerations such as "Farmers should be able to deal with single drought; it is their entrepreneurial risk" and "There are easier solutions to compensate for farmers' losses that do not require a whole chain to collaborate, such as insurance or targeted governmental support". These considerations show doubts in the need for collaboration as such within the value chain. Since collaboration is seen as an important component for resilience in value chains (Kamalahmadi and Parast 2016; Stone and Rahimifard 2018), we have to question to what extent these signals reflect inability, or unwillingness to collaborate, and how this truly affects the resilience of the Swiss milk, beef, wheat, wine and potato value chains in the long-term.

4.4.3 Study limitations

The limitations regarding the consumer survey were extensively discussed at the stakeholder workshops. Participants drew attention to the intrinsic bias of the consumer surveys, and suggested that more surveys and experiments should be conducted to understand true consumer attitudes for farmer' support. However, we also strongly suggest to further investigate the barriers that the practitioners themselves might put up, i.e. the critical conflicting interests and power interactions between food system actors. Nevertheless, we acknowledge that our consumer survey aimed to broadly explore consumer attitude to support farmers and thus more research should be done to explore side-effects of consumer support, such as whether people who agree to pay more would keep buying the same quantities, and whether non-supporters would abstain from buying from supermarkets that launch resilience campaigns. Furthermore, we acknowledge that while the participants of our workshops were practitioners actively engaged in current business activities of the four value chains, the study was based on a limited sample. Hence, further barriers can exist, which were not identified with this research. Lastly, we recognize that the results of this Swiss-based study may not be representative of other countries, especially since Switzerland has a high GDP and relatively low expenses on food among the population. Thus, we suggest that more studies on larger samples and other countries would shed light on whether consumer support can become a global measure for resilience in food systems.

In summary, our study, exploratory in nature, should be considered an initial step in investigating prospects of implementing resilience premium campaigns to support food systems' resilience. One of the advantages of the transdisciplinary approach based on interaction of researchers and practitioners, is that it provides clear indication for further research directions. The fact that the concerns on the resilience premium idea are coming directly from stakeholders who are supposed to implement the measure in practice, suggests that research which would address these concerns would have not only theoretical, but also practical implications.

4.5 Conclusion

This paper offers an alternative view on the role of consumers in the resilience of food systems and suggests creating an instrument that would allow consumers to contribute to the resilience of value chains against extreme weather events. Our study showed positive attitude among consumers to support farmers and identified several factors affecting the attitude to support.

The resilience premium, in the way we explored it in our study, aims at improving the recovery component of resilience, as it can complement, or even substitute insurance or state support in compensating farmers for their financial losses induced by extreme weather events[18]. Although a resilience premium targets the recovery component of resilience, its implementation requires adaptive capacities in food systems. First, actors would need to accept the new measure: this would require them to change their view on consumers, and to review their CSR toolkit. Second, resilience premium campaigns would require introduction of new mechanisms based on engagement and collaboration of multiple actors in the value chain, who are hardly inspired by purely altruistic motives. As our study shows, conflicting interests and unclarity of benefits is seen as an important barrier against introduction of resilience premiums and hence indicates a possible deficiency in adaptive capacity of the value chains. A lack of adaptive capacity compromises value chain resilience in the long-term, due to high inertia which makes it difficult to implement changes.

Drawing on concerns expressed by the practitioners regarding resilience premiums, we suggest that further research should focus not only on providing additional evidence of consumer support for resilience-related causes, but also on the ability of value chains to

[18] We can also imagine that resilience premiums collected at times of extreme weather events would be used to invest in more innovative, collective solutions to increase farmers' preparedness for the next adverse event.

collaborate and to change, which is an essential prerequisite to accepting consumers in the resilience building process. We conclude that more effort should be done to incorporate consumers as active stakeholders of the resilience of food systems and believe that transdisciplinarity offers a useful approach that allows identifying possible bottlenecks to collaboration and designing a resilience-aimed measure that will consider consumers' concerns and accommodate interests of relevant stakeholders.

5 Conclusions and outlook

In this last section of my thesis, I provide a short summary of the results of my study. First, I present a short summary on the research findings (5.1). Further, in the section 5.2, I provide a critical review on the project, to show challenges that I encountered throughout the project. Finally, I propose several directions for future research (5.3).

5.1 Research findings

This thesis pursued two objectives: (i) to investigate the resilience of the Swiss food value chains to shocks and (ii) to learn about resilience based on the Swiss case study. In the next subsections, I summarize what the results of the three papers suggest about the resilience of the four value chains, and what implications the results have for the general concept of food system resilience.

5.1.1 Summary of resilience of the four value chains against free trade and droughts

In this thesis, I investigated the withstanding and adaptive capacities of the milk, beef, wheat and potato value chains against two very different shocks. A free trade leads to an influx of foreign food products, hence affecting the demand for domestic products: both primary and processed. Droughts primarily affect the supply part of a value chain, most importantly, agricultural production. A free trade is a result of a political will, whereas a drought is a non-controllable weather event. The effects of a free trade are lasting and become a new normal, while a drought (in this project) is understood as a sudden disturbance that goes away with time. The three papers show how the withstanding and adaptive capacities affect the resilience of the four value chains against these two very different scenarios.

The results of the three papers suggest deficiencies in the withstanding capacity in the value chains against both shocks. At the first round of the stakeholder workshops, market liberalization was named to be the biggest potential shock for the Swiss actors. The results of the first paper confirmed negative expectations among producers and processors regarding the scenario of a free trade with the EU. First, a significant percent of actors, both farmers and processors, reported that they would not try to adapt to the new conditions and would quit their activity even before the free trade agreement comes into force. Furthermore, many actors among those who reported planning to continue their activity expected a decrease of

their production or processing volumes. Hence, the findings suggest that producers and processors lack a withstanding capacity to face the effects of the free trade scenario.

In the case of the drought scenario, participants perceptions on the withstanding capacity of the value chains somewhat contradicted my conclusions on it. Throughout the transdisciplinary process, stakeholders repeatedly stated that past droughts had not caused severe shocks for the value chains and that the actors, including farmers, have so far been able to deal with them. However, the high non-adoption and non-availability rates of drought resilience measures (e.g. insurance, drought resistance varieties, compensation through price) indicate that the value chains might be lacking a withstanding capacity to droughts, should they occur repeatedly or become more frequent and intense. The drought study, hence, suggests that the withstanding capacity, or rather a stakeholder perception of thereof, is partially subjective and depends on the exposure and previous experiences of the stakeholders.

The results of the studies showed that Swiss food system have resilience deficiencies, that question its ability to ensure food security for Swiss residents especially in a medium to long term. This is a concerning finding given that Switzerland is generally perceived as a very food secure country, Global Food Security Index of the Economist giving it the 4th place in the world (Global Food Security Index 2019). Interestingly, this index can be adjusted by "natural resources & resilience", which moves Switzerland even higher in the ranking – it becomes 3rd out of 113 countries. Of course, the ranking suggests a relative position of Switzerland compared to other countries, which could mean that even more resilience deficiencies can be found in other 110 countries. However the rating creates an impression that Switzerland is highly food secure in absolute, not relative terms. Given that the rating is aimed at a general public it can form a public opinion, which would disincentive changes, even when they are needed.

The results of all three papers on both scenarios revealed deficiencies in the adaptative capacities of milk, beef, wheat and potato value chains, thus substantiating their lack of resilience. Moreover, the results allowed me to identify factors that affect adaptive capacities in the value chains that emerged in both studies. I will elaborate on two of these factors, in the following subsections. These factors continuously emerged throughout the project and were often the central themes in resilience discussions.

5.1.2 Withstanding capacity and its effects on adaptive capacity

One of the factors that can limit the capacity of actors and value chains to adapt is rooted in the interplay between withstanding and adaptive capacities. Resilience theory suggests that adaptive capacity positively influences withstanding capacity, allowing systems to increase their resilience (Grafton et al. 2019; Brian Walker et al. 2004). However, in both scenarios, I have found indications that an opposite effect might be taking place: withstanding capacity can negatively affect adaptive capacity. This suggestion emerges from the way the stakeholders justified the need to adapt based on their capacity to withstand shocks' impacts. Throughout the transdisciplinary process, on several occasions, stakeholders stated that the value chains, including production, had so far shown enough withstanding capacity against droughts and, since the effects of a drought on the value chains are not critical yet, there is no need to change. Stakeholders used this as an argument to justify why an intervention is not possible or needed. In the case of the free trade scenario, stakeholders, on the contrary, perceived the withstanding capacity of the milk, beef, wheat and potato value chains as low. While the perception of the withstanding capacity was the exact opposite of the drought scenario, it nevertheless led the stakeholders to the same conclusion against the need to adapt: the effects of free trade would be too strong, hence no need to even attempt to adapt to the new conditions of the liberalized market. This reasoning was used, at numerous communications with stakeholders, as an argument for quitting the activity in case if a free trade agreement were to take place.

The insights from the drought scenario indicate that a high withstanding capacity (or a perception of thereof) can disincentivize actors from a change, i.e. it negatively affects their adaptive capacity as well as adaptive capacity of their value chains. This supports Mamouni et al. (2014) who suggest that a high resistance to disturbances in systems causes inertia that negatively affects the adaptive capacity of such systems, ultimately making them vulnerable. However, I found indications that both extremes – high and low withstanding capacity, can negatively affect adaptive capacity: too little of withstanding capacity to free trade can as well demotivate actors from adapting. Hence, the results suggest that there should be a "golden middle" for the withstanding capacity to activate the adaptive capacity, which requires further investigations. Furthermore, I suggest that stakeholders' perceptions on the current withstanding capacity can affect the transdisciplinary research process; I elaborate on this in 5.2.1.

5.1.3 Capacity to adapt can be limited by trade-offs

Another factor that can limit adaptation capacities of actors and their value chains is the trade-offs that actors face when needing to increase their resilience. Such trade-offs, in different forms, emerged in both scenarios.

In the free trade study, a trade-off emerged as an incompatibility of the two main coping strategies. Actors opting for decreasing costs would need to intensify their activities, enlarge their units, and possibly give up on "non-essential" things, such as animal welfare or improved environmental performance. While cost optimization might allow them to compete on the price level, such actors risk losing the support of consumers who believe that Swiss production and processing should be on the smaller-scale and have better sustainability performance, thus compromising the actors' competitive advantage. On the other hand, trying to win consumers with "Swissness", by promoting its localness and superior sustainable performance, limits actors' options for cost optimization. Also, this strategy heavily relies on the strength of consumer loyalty and products' recognizability, which are not a given. Therefore, actors would find themselves between a rock and a hard place, facing a choice to rely on consumers but risk shrinking to a niche market; or, risk losing consumer loyalty but compete with foreign products on the price level.

The results of the drought study revealed that resilience enhancing measures -- such as irrigation, off-farm jobs and drought-tolerant varieties -- compete with other farm activities and considerations. This supports other studies that found that resilience strategies compete for scarce resources such as money and time, and the improved resilience can come at the expense of other farms operations (e.g. Ashkenazy et al. 2018; Darnhofer 2010). Moreover, some of the measures suggested to increase production resilience against droughts required actions, or change in behavior, from other actors: e.g. processors, retailers, consumers. For instance, for farmers to grow drought-tolerant potato varieties, consumers should be ready to change their potato preferences, and processors would need to adjust their equipment. And to compensate production and economic losses among farmers caused by droughts, processors and retailers would need to agree to share the risks with producers. However, such actions would contradict the interests of post-production actors and thus require certain trade-offs. Other actors (processors, retailers, consumers) were found to have little motivation to share the risks of producers as they have an option to import food products in order to compensate for failures in production. This type of trade-off is no longer a actor individual trade-off, when the consequences of the decision are born by the actor themselves. This trade-off becomes apparent on a value chain level.

Free trade study also showed such “value chain” trade-offs: i.e. strategies that could allow actors to continue their activity in a liberalized market do not necessarily secure functioning (i.e. maintain the current level of production or processing) of their respective value chains. An example of such strategy is reliance on imports by processors, or outsourcing processing facilities abroad in order to decrease costs. This strategy would decrease the demand on Swiss primary agricultural products and push producers out of the business, hence decreasing the resilience of the Swiss value chains. Another example is the strategy of reduction of reliance on agricultural income for farmers. While shifting towards off-farm income would allow maintaining farmers’ personal livelihoods, it would decrease the domestic production, thus failing the quest for commodity value chain resilience.

The “value chain” trade-offs that emerged in the results of all three papers, led me to the conclusion that an increase of individual resilience can have negative effects (externalities) of other actors. Such “value chain” trade-offs have an implication on the understanding of food system resilience and its operationalization.

5.1.4 Resilience of an actor is not the same as resilience of its value chain

In this subsection, I further elaborate on how high resilience of one actor can compromise resilience of other actors in the same value chains.

In the first paper, we suggested that high connectedness to consumers positively affects resilience of actors to the effects of free trade. However, the results indicate that high connectedness of an actor to consumers can have negative implications on the resilience of the value chains. Small actors such as bakeries and butcheries are considered local by definition, making consumers less vigilant to the origin of their primary agricultural products. Bigger players can also enhance their image of localness through processed products with a traditional sentiment, especially those combining multiple ingredients. Such options of “being local without being local” decreases actor dependency on the domestic agricultural production, and essentially deprives domestic producers from other ways of competing on the markets, than decreasing their production prices or ignoring the value chains or creating new sales channels. Hence, the increase of individual connectedness of particular actors to consumers may “isolate” them from their value chains and decrease their motivation to contribute to the value chains’ integrity. Therefore, the individual connectedness should be enhanced by the measures that take into account a broader value chain outlook.

The second paper showed that the post-production actors of the value chains compensate failures of local production by imports, hence ensuring an uninterrupted flow of food assortment to consumers. This indeed fulfills one aspect of resilience of the food system, namely providing food for all (Swiss population in this case) despite shocks. Also, diversity of supply channels, as suggested by the literature (Ponomarov and Holcomb 2009; Stone and Rahimifard 2018) is a resilience increasing factor, and in case of the Swiss food system it increases resilience of post-production actors to weather-induced shocks. Our study suggests, however, that resilience of post-production actors against weather disturbances ensured by the opportunity to compensate failures in domestic production, has negative impacts on the resilience in the production activity. The relative safety of post-production actors loosens feedback mechanisms in the value chains and disincentivizes the actors from collaboration and risk sharing in the value chains (although they are factors for value chain resilience (Stone and Rahimifard 2018)), which is further exacerbated by power asymmetries in the value chains that typically have hourglass structures, with processing and retail being the most concentrated activities. This was further supported by the results of the third paper, which suggests that a lack of individual benefits for post-production actors is one of barriers against introduction of consumer campaigns to support farmers in case of shocks.

The results of my study, hence, support scholars like Crona et al. (2016), Hendrickson (2015), Nyström et al. (2019), Oliver et al. (2018), who argue that the race for predictable all-time supply of foods led to decoupling of food systems to the extent that the impacts of demand on food production is ignored, denied or unknown. Lamine's (2015, p. 42) comment highlights the sad absurdity of the situation: "*Of course, the connection between agriculture and food seems so obvious – agriculture produces mainly food, most food comes from agriculture – that one largely fails to see their contemporary disconnection.*" This concerns not only post-production actors such as processors and retailers, but also consumers. Scholars suggest that distance plays a critical role in such decoupling. However, the Swiss case study indicates that decoupling is not only a matter of distance, nor of a lack of contact. Switzerland is a small country, and people working in the food system often literally know each other. Also, the activities and the value chains are represented by multiple industry organizations, and the actors have opportunity to communicate with each other, and they actually do it. Still, as the results show, the conflict of interests persists, which suggests that simply creating means of communication is not enough to build resilient food value chains and food systems.

To conclude, increasing resilience of its individual actors does not automatically increase resilience of their value chains. On the contrary, increasing resilience in one activity can have negative implications on other activities. Therefore, the results of my thesis strongly suggest

that resilience enhancement should be based on systemic approaches that allow capturing broader effects of resilience of individual actors. Preventing negative externalities, however, is a difficult task, because such externalities result from conflicting interests of actors, who naturally strive for better performance, and short-term considerations most often outweigh long-term implications.

5.2 Critical reflections

5.2.1 Methodological boundaries and associated limitations

The starting point of my research was that the resilience of the Swiss food system is the ability to retain the current levels of production and processing volumes despite shocks. While this allowed me to draw conclusions on whether the value chains can keep their status quo despite shocks, and what are the factors hindering them from doing so, I did not question whether the current status quo is a desirable state of the system. This means, that I did not question whether decreasing animal production would increase resilience of milk and beef value chains. I questioned whether a system is resilient in its current state, and whether the current system could be improved. This probably did not let me explore a potential of radical transformations in the system: ones that would change the structures, and production volumes of the value chains.

At first, I made an attempt to approach the value chains' resilience with a framework of resilience based on indicators suggested by the literature. I gave up fairly early on, as I grew conscious that the framework could not accommodate the complexity coming from interactions with various stakeholders of the four value chains. Therefore, I modified and significantly simplified the framework, leaving some boundaries that allowed me to remain on the track for resilience research in value chains (i.e. two resilience capacities), but I made the framework largely heuristic. Thus, I could learn about resilience from the stakeholders without worrying that it does not fit the preconceived ideas. This, however, shifted my research towards exploratory path. I identified important deficiencies in withstanding and adaptive capacities in case of both shocks, but I did not attempt to quantify the resilience.

Overall, I find that the transdisciplinary approach was very useful in exploring resilience in the value chains. The workshops were a source for different insights on different stages of workshops' organization. It was not only what happened at the workshops, that provided indications for resilience aspects. I did draw some suggestions also from how actors reacted to invitations to attend the workshops and whether they attended the workshops. Overall, I

find that the project was well received and stakeholders were interested to take part in the resilience project (with some exceptions that I discuss in 5.2.2). Therefore, when I say that actors lack motivation to build resilience, I primarily mean that they lack motivation in regards to the solutions that were suggested as resilience building measures, but I do not imply that they are not interested in building resilience per se. This indicates opportunities for further dialogues and transdisciplinary research that would be aimed specifically at resolving conflict interests.

In section 5.1.2 I described how perceptions of actors on their high withstanding capacity to a shock, can affect their adaptive capacity. Interestingly, I found indications that such perceptions can affect a transdisciplinary process as well. Several times arguments of "so far value chains were able to deal with droughts" were used as an argument against the project's focus on droughts, although further interrogation of people expressing such opinions always revealed that they did perceive droughts as a problem, just the one that so far could be dealt with. Or, it was stated that this was a problem of farmers, hence it was not relevant for the rest of the value chain. Such opinions were expressed even by farmers themselves. This happened also at the stakeholder workshops. This clearly reflects uneven exposure of actors in value chains to shocks, in this case, droughts. In the case of this project, such opinions did not affect the transdisciplinary process, which withheld until the end of the project. I can assume that in case of my project, this problem was partially resolved because the workshops always focused on droughts and free trade, the latter being extremely relevant for processors and retailers. Would these actors support the project that exclusively targeted only climatic problems? I think some of them would. However, it raises a question on the issue that can affect any transdisciplinary project on resilience: to what extent can transdisciplinary research be efficient to solve issues that involve multiple actors, but burdens of such issues are unevenly shared by those actors? It could lead to discontinuous participation, as well as insufficient legitimacy of team of actors, which are important challenges for transdisciplinary research, and can undermine trust in the transdisciplinary project (Lang et al. 2012).

I prioritized a broad overview on the value chain functioning over the in-depth analysis of resilience in a particular activity. This allowed me to investigate value chains' mechanisms that have implications for resilience and draw conclusions on a need for shifts in the value chains' functioning. This, however, came at the cost of deeper understanding of variations in resilience within the activities. That said, I am not sure whether the results of my thesis fulfilled the expectations of the participants of the transdisciplinary process, who could have

expected more concrete suggestions for individual actions with clearer individual benefits[19]. In fact, I think that the level of aggregation taken in this PhD project – four value chains, different activities – limits opportunities to develop ready-to-implement solutions for the actors.

The transdisciplinary process of this project ended at the stage, where possible solutions were identified, and stakeholders listed the barriers against implementation of such solutions. However, finding a common denominator for the proposed solutions remains to be done. I worked in that direction in the third paper on consumers, which revealed that consumer support might be possible, but this obviously could not trigger an implementation of such measure.

5.2.2 Value chains' representation in the project

The idea of the approach was to engage all core activities of the value chains in the transdisciplinary process. However, I faced multiple challenges in this regard.

For instance, I certainly had difficulties in engaging retailers in the project. I cannot say that the major national retailers were not cooperative: I had several opportunities to discuss my study with their representatives and collect the data, and had good contacts with their vertically integrated processing companies. Furthermore, representatives of the national retailers (or of their vertically processing companies) took part in most of the workshops. However, there were several issues regarding retail participation in the workshops:

- An employee who is not directly engaged or responsible for the product of interest takes part in the workshop;
- An employee attends one of the workshops, and then considers that the company is sufficiently represented in the project, hence no one else attends other workshops;
- A contact person changes their job, and the successor (a) cooperates but is not aware of the previous steps of the project or (b) does not cooperate.

I suggest that the challenges that I faced in engaging retail in the transdisciplinary project have more fundamental reasons behind than seemingly a lack of interest in full collaboration. First, retailers are large systems on their own, with complex managerial and decision-making structures. Hence, it is hardly possible from the outside to identify the decision-maker or a

[19] This is to be addressed in the final report that summarizes the findings for the stakeholders of the Swiss food system.

person with an appropriate expertise for “resilience of a particular product”. Hence, the complexity of retail structures is a factor limiting their full participatory potential in transdisciplinary processes. Second, the dynamics between products, the segments they target, the changes in prices and discounts makes it hardly possible to get a simple and consistent overview on the main strategy, which was the focus of my research. Hence, I did not manage to collect meaningful data from the retailers during the surveys. Also, several times in the interviews, I heard a statement such as “retailers do what consumers want”. On the one hand, retailers indeed do adjust to the consumer demand. On the other hand, a demand is influenced by the commercial interests (Schipanski et al. 2016), such as what retailers do, how they promote and what they sell. This conflation is difficult to disentangle, and, it somehow masks the major power of retailers in the value chains.

Furthermore, I did not manage to engage gastronomy in the project. I contacted several restaurants in the beginning, but none agreed to participate in the workshops. I tried to get access to restaurants through their industry organization, but it did not work out either. Therefore, the gastronomy part was dropped out. The uncooperativeness of gastronomy relates to the issue of disproportional exposure of stakeholders of an issue to the effects of this very issue.

I also opted to exclude wholesalers from the process, because on multiple occasions during the interviews with stakeholders (including two with the industry organization of wholesale), I was told that wholesalers are driven by logistical considerations and interests of other actors, and hence unlikely have a stance in discussions about resilience of value chains. Nevertheless, I think that deeper investigation of interests of gastronomy and wholesale would have added strength to the discussion of value chains’ resilience.

I also did not extensively cover the input supply part. The industry organizations and the largest input supply companies took part in the workshops and responded to the survey. However, the input supply world is very diverse, and is very different for the value chains that I investigated. While I discuss some aspects of input supply in the papers, I admit that this is a mere preamble to the role of input supply to the resilience of the value chains.

To conclude, the value chains in my thesis were primarily represented by farmers, processors, industry organizations, to some extent retailers and consumers; and the conclusions on the role of other activities were mainly extracted from the opinions of these stakeholders.

5.3 Recommendations for future research

5.3.1 Tackling resilience externalities as a way to increase food systems resilience

As climate change increasingly affects the production systems worldwide, the need for building resilience of food systems to the effect of climate change becomes more obvious. The scholars warn, that the attempts to maintain predictable production often comes at the expense of other systems and locations (Angeler et al. 2020; Nyström et al. 2019; Rist et al. 2014). The results of my thesis support this concern and show that actors' individual resilience can yield negative effects on other actors in the value chain. Furthermore, I found indications that an increase of withstanding capacity in the value chain to effects of free trade can come at the expense of its adaptive capacity, which supports other authors who say that resilience is associated with trade-offs (Ashkenazy et al. 2018; Reidsma et al. 2015). Thus, the attempts to build resilience to a shock won't necessarily bring the desired outcome, if externalities are not considered. Walker (2020) suggests that resilience: "*is about learning where not to go rather than perfectly controlling where to go*." I suggest that research is needed to understand and learn to identify undesired outcomes of resilience. This is especially important for designing interventions to increase the resilience: to avoid creation of systems that are accidentally more fragile after an intervention than they were before.

I suggest that resilience assessment guidelines and approaches should encourage investigating broader effects of resilience on actors in the food system, also in the long-term. This is, for instance, already part of the framework for resilience of farming systems designed by Meuwissen and colleagues (2019). Nevertheless, I suggest that investigation of actors' resilience externalities should go beyond production systems and embrace greater food systems and their multiple activities, to avoid. In that sense, I suggest that the resilience building potential could lie in "redistribution of resilience" between different activities of the value chains, rather than in increasing of resilience of particular actors. One way to "redistribute resilience" could consist of identification of causes for resilience deficiencies in some actors caused by other actors of the food system.

I think that identifying and working with causes for resilience deficiencies is a more prominent way to go than researching ways to increase resilience. The latter, in my opinion, is often a mere treatment of symptoms. I suggest that resilience projects would benefit from a more formalized way to identify criteria for resilience externalities and evaluation of their effects. This is not a simple task, given that resilience materialization is highly context specific. In my opinion, a meta-analysis of cases of resilience externalities should be the first step. Such meta-

analysis should identify types of resilience-related externalities and causes of such externalities, hence assigning responsibilities for them. This would allow specifying knowledge gaps for further, more targeted research. These efforts should pursue an ultimate objective of helping actors, scholars and policy-makers to design interventions aimed at treating causes for resilience deficiencies. For instance, creating incentives and motivations for building collective resilience.

5.3.2 Motivations for value chain actors for building collective resilience

Walker (2020) said that efficiency considerations lead to lack of a response diversity to shocks, as actors strive to get rid of redundant elements as much as possible. I suggest that building engagement of post-production actors in building resilience of value chains (and agricultural resilience as its part) could be a way to ensure response diversity to effects of climate change. However, the results of my studies highlight factors that disincentive actors from building resilience of their value chains; conflicts of interests and trade-offs being important limitations for value chains' adaptive capacity. Himanen et al. (2016) state: "*Although the ability to recognize the main determinants of adaptive capacity is important, the knowledge itself does not yet yield system change, nor does this recognition drive actor adaptations*". Hence, I hardly expect that this finding on its own would motivate actors to change their functioning and behavior. After all, each actor, be it a farmer, a processor, or a retailer, organize themselves to ensure functioning and prosperity if only for a short- to medium-term. This is a clear and, in my opinion, valid motivation. Thus, I am firmly convinced that it is a motivation that should be worked on and suggest that finding (or creating) motivations and incentives for post-production actors (most preferably economic) to share resilience is a prominent and powerful way to go.

Ironically, the study on the free trade suggest that a trade liberalization has a potential to activate collaborative processes in the value chain, and enhance actors' motivations for "belonging together". I should make it clear though, that I do not suggest free trade with the EU as a solution, as the results showed that the Swiss value chains lack resilience to this scenario. However, the free trade study suggests that events that activate people's attachment to domestic value chains can incentivize better collaborations in those value chains. Therefore, I suggest that future research could explore how (and what amount of) market pressure could be used as a motivational factor for better defined and integrated domestic (or localized) value chains.

Also, future research could address whether a state could play a role to create incentives for common rather than individual resilience through regulations or taxation. Creating demand for resilience can be another way of motivating post-production actors to contribute to the resilience (especially in the domestic value chains), which I present below in more details.

5.3.3 Including consumers in the resilience concept

I am convinced that consumers should be recognized as influential stakeholders in the food system resilience concept. Their engagement could be helpful: for example, I found evidence that consumers could share the economic risks of climate change born by farmers. Also, their engagement is not only helpful but essential: consumer can increase value chains' adaptation capacity by adapting their purchasing behavior and adjusting their expectations regarding the food they purchase. Multiple times throughout the project I heard skeptical comments about consumers being not interested in resilience and impossible to rely on. While the results of my study merely suggest possible consumer support, on a global scale we observe a growing trend for increased public awareness for sustainable matters. Such public awareness already went beyond charity and retranslated into consumer demand, which on the one hand creates business opportunities, and on the other hand exerts pressure on businesses to change (or pretend changing) their "business as usual". Given that the general resilience concept is technically even closer related to climate change than the sustainability concept, I believe that resilience can become a new corporate social responsibility tool for agri-food businesses, resulting in a symbiosis of social and economic considerations. I am convinced that consumers role in the resilience of the food systems is a prominent research perspective that has direct practical implications, and hence could be attractive not only for scholars but also for businessmen.

I suggest that future research in this direction should focus on exploring the possibility of extent of consumer support in different contexts (countries). Furthermore, the question is whether consumer support only applies to domestic food products, or could regions that supply the world be supported by consumers when affected by shocks covered by the media (e.g. the hurricane Irma in 2017 that affected banana production in the Caribbean[20])?

Also, it is very important to investigate whether, and to what extend would such campaigns affect consumer loyalty, and whether other benefits (or risks) could be there for actors, other than farmers. For instance, "domino effects", i.e. if one value chain or actor launches such campaign, then consumers would be disappointed in other actors who did not act similarly,

[20] https://www.iica.int/en/node/17467

creating consumer pressure, like in sustainability domain. Another research opportunity concerns a possibility to cover campaigns' costs without compromising consumers trust. I also suggest that additional evidence is needed on practical mechanisms to implement resilience campaigns: e.g. collection and distribution mechanisms, accounting details and taxations.

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8 Appendix

8.1 Supplementary materials for chapters

8.1.1 Value chain maps

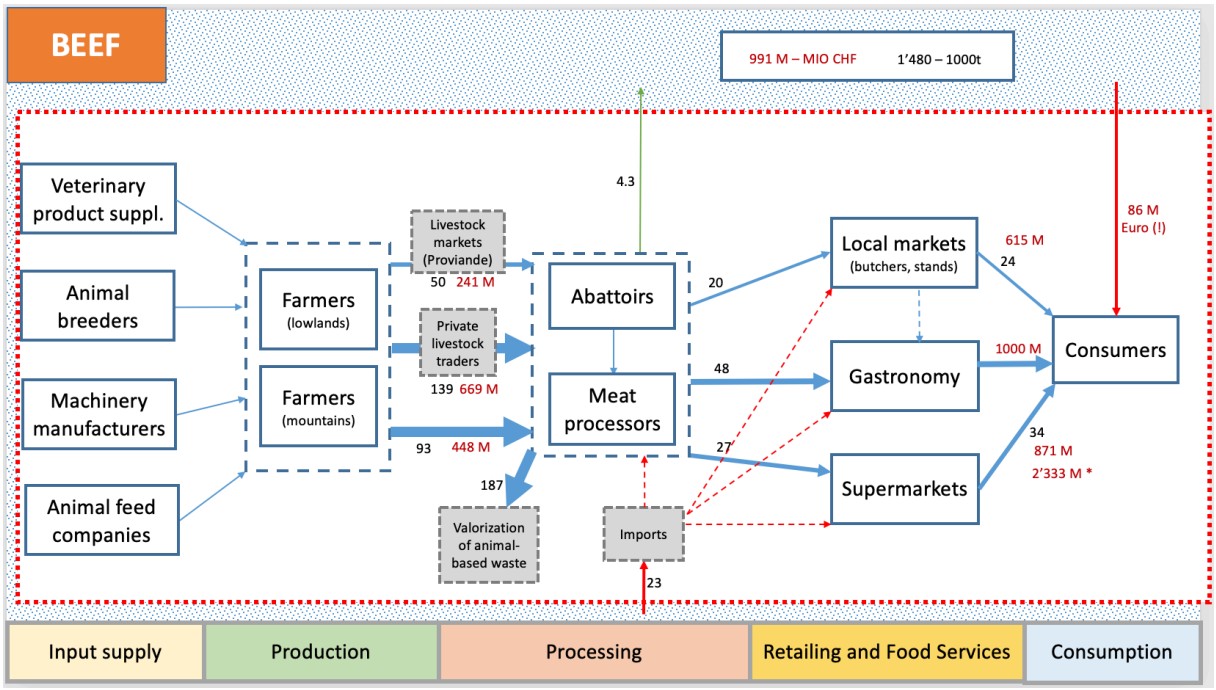

Figure S1: Beef value chain

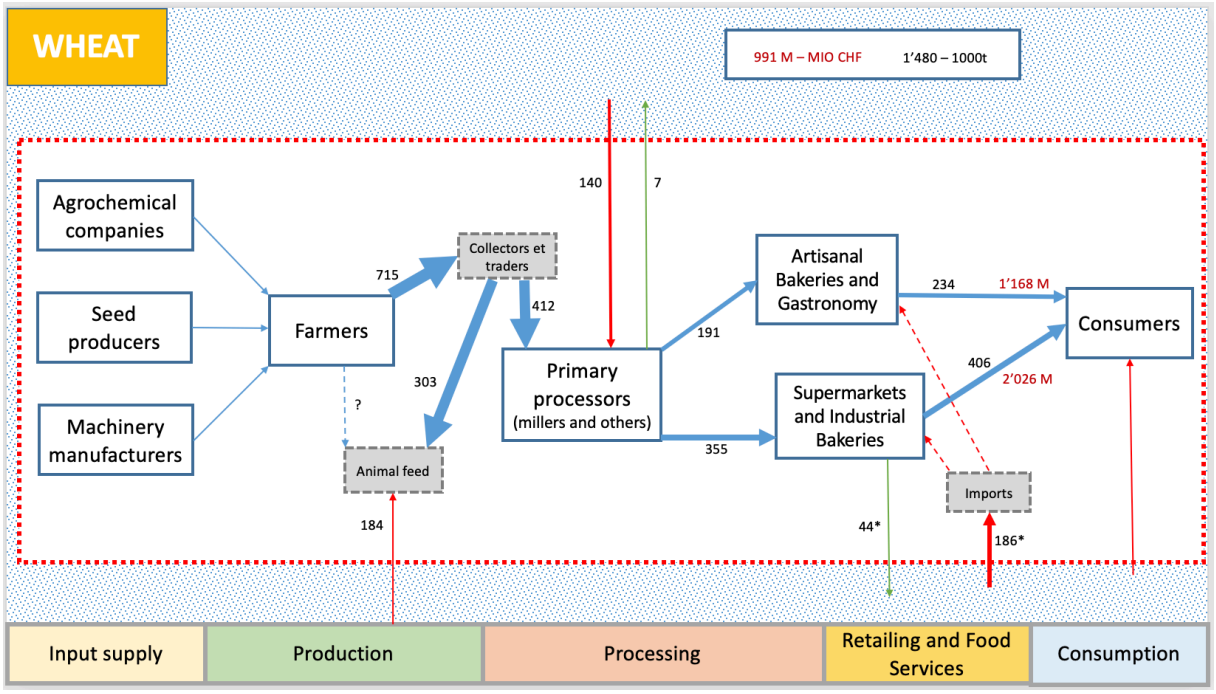

Figure S2: Wheat value chain

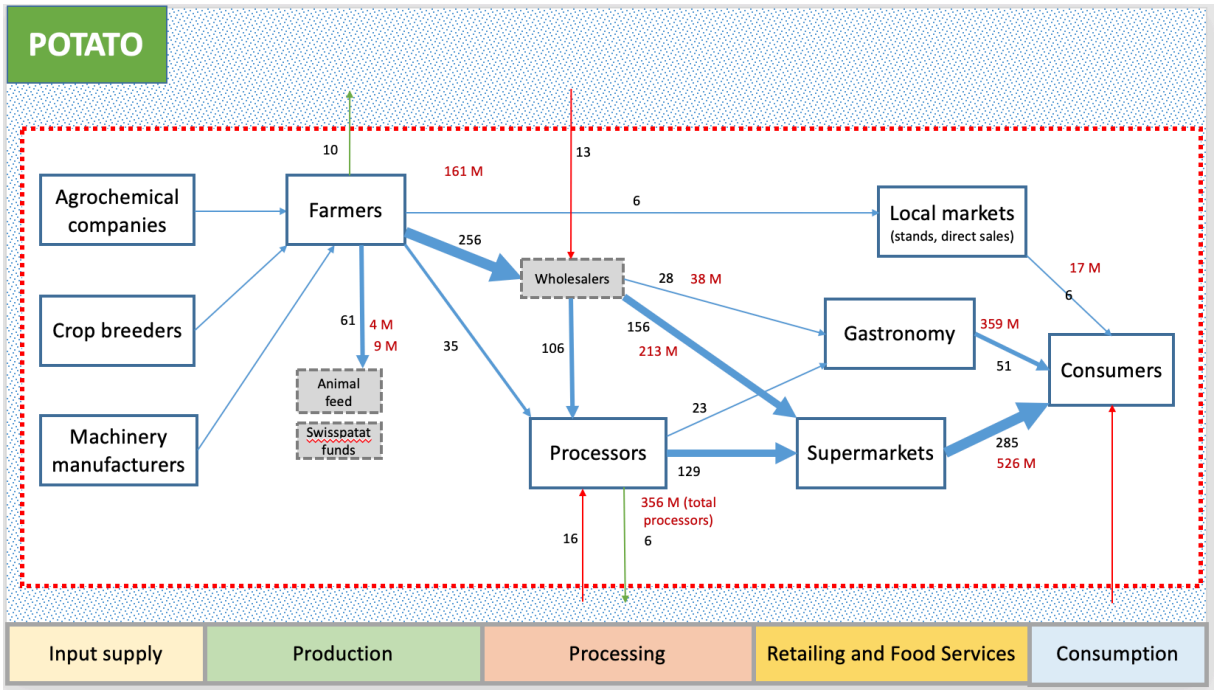

Figure S3: Potato value chain

8.1.2 Supplementary materials for Free trade paper

Table S1: Consumer price comparison (2018)

	Unit	Germany	France	Austria	***Switzerland***
Whole milk	CHF/l	0.92	0.99	1.12	*1.5*
Natural yoghurt	CHF/kg	1.27	1.64	2.12	*2.31*
Ground beef	CHF/kg	8.17	-	7.95	*18.91*
Beef entrecôte	CHF/kg	-	28.4	25.45	*73.44*
Potato	CHF/kg	0.94	-	1.17	*1.92*

Note: 1 CHF = 1.08 USD; source (BLW 2019a)

8.1.3 Supplementary materials for Interventions paper

Table S2: Past experience with droughts among milk, beef, wheat and potato farmers

		Milk	Beef	Wheat	Potato
Percent of farmers who have ever experienced droughts:		88% *(241)*	67% *(72)*	79% *(175)*	82% *(167)*
Of which: number of droughts experienced since 2010	1	54%	47%	43%	32%
	2	33%	31%	31%	39%
	3 or more	13%	19%	24%	26%
	0	<1%	3%	2%	3%
Of which: the year of latest drought experienced:	2019	30%	27%	38%	57%
	2018	70%	68%	54%	32%
	earlier	<1%	6%	3%	11%

Note: "*Of which"* refers to the number of farmers who have experienced droughts, specified in brackets.

Table S3: Current adoption and plans to adopt measures against drought among farmers

Measures	Value chain	Current adoption	Current adoption	Planned adoption (3 years)	Non-adoption
Drought tolerant varieties	Milk	109	*37%*	*10%*	*53%*
	Beef	48	*42%*	*17%*	*42%*
	Wheat	59	24%	28%	48%
	Potato	92	39%	11%	50%
Stocks of animal feed	Milk	206	71%	14%	15%
	Beef	71	71%	17%	22%
Irrigation	Potato	122	62%	5%	43%
Insurance	Milk	3	1%	2%	97%
	Beef	4	3%	0%	97%
	Wheat	32	13%	6%	81%
	Potato	27	12%	6%	82%
Off-farm employment	Milk	78	27%	6%	68%
	Beef	51	44%	10%	46%
	Wheat	96	39%	9%	53%
	Potato	58	25%	8%	68%

Note: source: farmer surveys; planned adoption = "I plan to implement it in the next three years"; non-adoption = "I do not plan to implement it"

Table S4: Farmer experiences with regards to value chain reactions to droughts used to evaluate adaptation gap for the value chain measures

Measures	**% of farmers (from those who have experienced droughts) reported:**		
Securing purchase of animal feed	increase of price for animal feed	Milk and beef	Concentrated feed: 28% Silage maize: 37% Hay: 59% Grass: 32%
	to have reduced their cattle livestock due to lack of feed*	Milk Beef	96 (37%) 17 (23%)
Price policy that mitigates losses due to drought	increase of price for their produce	Milk	Industrial processors (138): 4% Cheese-makers silage (91): 4% Cheese-makers non-silage (33): 3% Consumers (25): 0%
		Wheat	3% - same for top category, 1 category and 2 categories
		Potato**	Wholesalers: 34%* Processors: 21% Gastronomy: 8% Consumers: 8%
	decrease of price for their produce has decreased	Milk and beef	Cows (M+B): 42% Young cows (M+B): 29%
		Beef	Oxen: 19%
Adjustment of requirements for product's quality	that their clients relaxed quality requirements	Potato**	Wholesalers: 35%* Processors: 33% Gastronomy: 11% Consumers: 24%

Note: the categories for feed price and product price questions were suggested and validated at the pre-test interviews; *this is a likely combination of lacking stocks, increased prices and availability of feed; **yes, at least for some varieties.

8.1.4 Supplementary materials for Consumer paper

Willingness-to-pay (WTP) was measured in Swiss francs (CHF) or Swiss cents (Rappen): 1 CHF corresponded to 0.98-1 USD at the time of the survey[21]; 1 Swiss rappen (Rp.) = 0.01 CHF. The WTP was measured directly, as the recent meta-analysis by Schmidt and Bijmolt (2019) shows that direct measures reduce hypothetical bias. To introduce a real context in the WTP questions, we first asked participants about the price they currently pay for a product, using real current prices from the two biggest retailers in Switzerland – Coop and Migros (Table S5). Then the stated current price was shown in WTP question, as a reference point to the WTP. Furthermore, we used different scales for different products, because the starting price of the products of interest differs significantly, (e.g. 1 litre of milk costs about 1.3 CHF, whereas 1 kg of middle-priced beef can cost 50 CHF, or ~38 times more). The following scales were used: 0-200 Rp., 0-400 Rp., 0-10 CHF and 0-20 CHF. Table S5 summarises prices and scales. Although using different scales makes it more difficult to compare the WTPs of different products, it allows better capturing real price development. All WTP scales started from 0 CHF.

Table S5: Products, their prices and scales used to estimate WTP

Product	Min current price (CHF)	Max current price (CHF)	Scale for WTP
Milk (1 l)	1	1.8	0 – 200 Rp.
Yogurt (small cup)	0.4	1.25	0 – 200 Rp.
Cheese (200g)	2	6	0 – 400 Rp.
Beef (1kg)	20	80	0 – 20 CHF
Veal (1kg)	20	80	0 – 20 CHF
Minced meat (1kg)	10	25	0 – 10 CHF
Sausages (2 pieces)	4.5	6	0 – 400 Rp.
Bread (loaf 300g)	1	3	0 – 200 Rp.
Flour (1kg)	0.9	3	0 – 200 Rp.
Croissants (1 piece)	0.9	1.4	0 – 200 Rp.
Potato (1 kg)	0.9	4	0 – 200 Rp.
French fries (1kg)	3.5	9	0 – 400 Rp.
Potato chips (pack 300 g)	Budget, middle, high. Reference for WTP – 3.5 CHF		0 – 200 Rp.
Red wine (0.75l)	5	40	0 – 10 CHF
White wine (0.75l)	5	40	0 – 10 CHF

[21] https://www.xe.com/currencycharts/?from=CHF&to=USD&view=2Y

Table S6 reports the descriptive statistics of WTPs for 15 products. N_{obs} indicates how many respondents in each data sample reported to consume the respective product. The difference in number of observations within the product category is explained by the fact that a person filling in the milk questionnaire on milk, cheese and yoghurt did not necessarily consume all three products. The WTP distributions are negatively skewed, with a long tail and few outliers on the upper limits of scales, which indicates that respondents tended to give smaller values. The percent of respondents who stated zero WTP for a product ranged from 2% to 14%, with largest value for potato chips and the smallest for potato, flour and cheese. The WTPs are presented by quantity (see Table S5) which varies depending on the product (e.g. per 300g of cheese, 1 kg of beef, 1 standard package of meat sausages), and hence we suggest that the direct comparison between products is unreasonable and inconclusive. Although we find it important to report the WTP values for each product, in-depths analysis of WTP goes beyond the purpose of our study, and, instead, we focus on identifying factors that motivate general attitude to support farmers in case of extreme weather events.

Table S6: Summary statistics on willingness to pay (WTP) to support farmers

Product	N_{obs}	MED	MAD	0 WTP	Product	N_{obs}	MED	MAD	0 WTP
0-200 Rp.					0-400 Rp.				
Milk	149	50	44.5	4%	Cheese	164	80	59.3	2%
Yoghurt	121	20	14.8	6%	Grill	128	100	89.0	6%
Bread	187	70	44.5	4%	French fries	109	100	74.1	7%
Flour	126	50	59.3	2%	Chips	134	50	59.3	14%
Croissant	123	40	44.5	5%					
Potato	184	100	74.1	2%					
0-1000 Rp. or (0-10 CHF)					0-2000 Rp. or (0-20 CHF)				
Ground beef	155	300	296.5	8%	Beef	160	500	444.8	6%
Red wine	156	400	296.5	4%	Veal	108	550	518.9	10%
White wine	133	300	296.5	5%					

Note: MED = median, MAD = median absolute deviation