Regional Environmental Change (2019) 19:879–892
https://doi.org/10.1007/s10113-018-1448-x

ORIGINAL ARTICLE

Actor-specific risk perceptions and strategies for resilience building in different food systems in Kenya and Bolivia

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Received: 8 April 2017 / Accepted: 28 November 2018 / Published online: 14 December 2018

Abstract

Food system sustainability depends, among other aspects, on the *resilience* of different components of food systems. By resilience, we mean the ability of a food system to withstand stress and shocks, recover, and adapt to change. In this study, we examined the resilience of food systems, firstly, by compiling the risks perceived by different food system actors in the Santa Cruz Department, Bolivia, and the northwestern Mount Kenya Region, Kenya—two regions that are important to their respective national food supply. Secondly, we evaluated whether and under what circumstances these perceptions translate into adaptive or preventive strategies that benefit food system resilience. Among all actors, the most frequently perceived risks relate to production levels. Further, the many (sometimes contradictory) perceptions of risk and uncertainty among different actor groups do not necessarily translate into adaptation strategies. Reasons for this include structural factors as well as the "risk perception paradox", particularly regarding preventive strategies. However, we also observed many implicit strategies illustrating how different actors develop responses within their possibilities. However, most such strategies were insufficient to mitigate, much less to adapt to, the perceived risks. To build resilience, existing innovative policies need to be enforced in both countries. These include disaster risk reduction programs and programs to reduce the vulnerability of marginalized groups who are crucial to food systems, such as smallholder farmers, pastoralists, and food workers.

Keywords Food systems · Resilience · Risk perceptions · Strategies · Bolivia · Kenya

Editor: Shuaib Lwasa.

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s10113-018-1448-x) contains supplementary material, which is available to authorized users.

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Introduction

United Nations Sustainable Development Goal number 12 seeks to "Ensure sustainable consumption and production patterns". Target 2.4 of Goal 2 ("Eliminate hunger") seeks to "Ensure sustainable food production systems". In this way, the UN points towards a food system approach. In addition, it calls for placing food production and consumption in a sustainability framework. However, it is not clear what, exactly, is meant by food system sustainability or what is needed to achieve it. Based on a food sustainability approach developed by Rist et al. (2016), we regard resilience as one important pillar of sustainable food systems. In order to develop in a sustainable way, food systems must be capable of cushioning against stress and shocks (Jones and Tanner 2016), recovering from them, and adapting to change over time (see Ifejika Speranza 2010; Rist et al. 2016).

Scholars have conceptualized food systems as social-ecological systems (e.g., Ericksen et al. 2010; Hodbod and Eakin 2015; Prosperi et al. 2016). Rastoin and Ghersi

(2010:19) define food systems as "interdependent networks of stakeholders (companies, financial institutions, public and private organizations, and individuals) in a geographical area (region, state, multinational region) that participate directly or indirectly in the creation of flows of goods and services geared towards satisfying the food needs of one or more groups of consumers in the same geographical area or elsewhere". A social-ecological food system approach implies looking at different actors along agri-food value chains and examining their specific links with the *natural resource* subsystem, the subsystem of *information and services*, and the *political* subsystem of the respective food system (Rist and Jacobi 2016).

Available literature focuses on risks and vulnerability related to different aspects of food systems (Prosperi et al. 2016). In line with the four common food security dimensions of availability, access, utilization, and stability (FAO 2013), research has assessed, for example, the risk of food shortages, food inaccessibility due to high prices, health risks from under- and overnutrition, and food safety (Esnouf et al. 2013; Haddad and Hawkes 2016; Hodbod and Eakin 2015; Prosperi et al. 2016; Sukhdev et al. 2016). Further, there is increasing research on climate change-related risks and uncertainty of food production (Aubin et al. 2013; Candy et al. 2015; Rigolot et al. 2017); health risks from pesticides (Aubin et al. 2013; IPES 2015; Rodrigues et al. 2018); economic and ecological vulnerability resulting from uniformity in industrial food systems (Altieri and Nicholls 2012; Candy et al. 2015; IPES 2015; Rotz and Fraser 2015); risks from dependency on external inputs, especially fossil fuels, and technology (Altieri and Nicholls 2012; Candy et al. 2015; Hodbod and Eakin 2015); and environmental risks from resource depletion and contamination related to food systems (Altieri and Nicholls 2012; IPES 2015). Finally, research is increasing on the social aspects of food systems, including working conditions along food value chains (IPES 2015) and the decline in farming populations globally (Candy et al. 2015).

According to Blaikie et al. (1994), conventional views assume that disasters are departures from "normal" functioning and that recovery means a return to normal. In contrast, using a resilience approach means emphasizing adaptation and evolution in adaptive cycles (Holling 2001). Ericksen et al. (2010) echo this view in concluding that a resilient food system should have the potential to create opportunities for doing new things to innovate and develop.

Classically, risk has been conceptualized as the potential for loss, as a function of exposure (likelihood) multiplied by vulnerability (place/preconditions), and diminished by mitigation strategies and response capacity (Prosperi et al. 2016; Tierney 2014; Altieri and Nicholls 2013). While risk can be expressed in terms of likelihood, uncertainty cannot. In order to capture food system actors' perceptions and understand their strategies of action, we incorporate uncertainty as a complementary concept to risk and refrain from assessing statistical likelihoods or whether a given risk is "real" or not. This type of approach implies viewing risk as socially constructed (Scherer and Cho 2003; Steg and Sivers 2000). While risks exist independently of our ability to observe and assess them, people's ideas concerning risk—including those developed through putatively scientific risk assessments—are socially constructed and influenced, and corresponding actions are taken (or avoided) based on these constructions and influences (Tierney 2014). Even though people may be aware of risks, they do not necessarily feel at risk (Wilkinson 2001) or take action (Wachinger et al. 2013). Analyzing perceptions of risks in food systems may help to better understand the influencing factors relevant to implementation of risk-mitigation strategies and thus resilience building in food systems.

Perceptions of specific risks—e.g., climate impacts—are embedded in a range of influencing factors. Referring to agroecosystems, Altieri and Nicholls (2013) emphasizes (1) *socio-cultural* influencing factors (e.g., community dynamics, demography, education levels, health, opportunities, history); (2) *political-economic* factors (e.g., product and input prices; institutional support such as research, extension, credit, markets; agricultural policies); (3) *environmental* factors (e.g., pressures from pests and diseases); and (4) *technological* factors (e.g., availability of biomass, organic matter, adapted varieties). This way of understanding how risk and strategies are constructed can be applied to food systems by taking Altieri's framework of adaptive strategies and applying it, for example, to climate risks, taking into account possible events, influencing factors, perceptions, responsive capacity (referring to strategies of action, or combination of activities and meaning), and specific responses (Fig. 1).

Risk-mitigation strategies that build (or fail to build) resilience in social-ecological systems are influenced by what different groups of actors perceive not only as risks and uncertainties, but also as opportunities (Jones and Tanner 2016; Wachinger et al. 2013). Perception, valuation, interpretation, and methods of coping with uncertainty about the outcomes of activities—taken together as "meaning"—are at the core of understanding how strategies are developed (Wiesmann 1998). The resulting "strategy of action" refers to all the actions of an individual actor or household and includes the dynamic relationship between the network of activities and the structure of meanings (aims of actions). In this view, the importance of perceptions in shaping people's strategies means that perceptions represent an explanatory variable for different configurations of food systems (e.g., production systems and consumption patterns). Finally, adopting a perception-based approach to risks and resilience building in food systems acknowledges that local actors must be taken into account in order to co-develop proactive risk

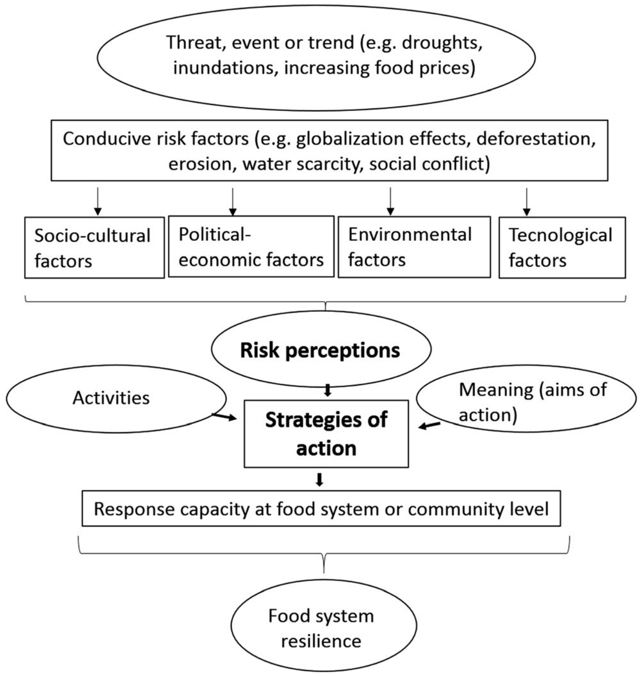

Fig. 1 Conceptual framework of perceived risks and related strategies in food systems. Adapted from Altieri and Nicholls (2013) and combined with Wiesmann's strategy of action concept (1998)

management strategies that build on local rationales regarding trade-offs between risks and opportunities (Blair et al. 2014; Tanner et al. 2015).

Despite the extensive literature on risks in food systems, few scholars have focused on assessing perceptions regarding risk, uncertainty, vulnerability, or resilience according to different stages of existing food systems, from production to consumption and beyond. In a separate study (Jacobi et al. 2018), we assessed resilience indicators for some of the food system contexts presented here. In the present study, we sought to compile and understand the risk perceptions of different actors in food systems as possible drivers of resilience building along food value chains. To do so, we gathered data from six case studies of different food systems in Kenya and Bolivia. A better understanding of how risks are perceived and by whom, and respective strategies employed, may provide important lessons for policies (Slovic 1987) on risk reduction and building sustainable and resilient food systems.

Study sites and food systems

This study formed part of a larger research project[1] and took place in two study areas: the northwestern Mount Kenya region in Kenya and the Santa Cruz Department of Bolivia (Fig. 2). Both regions are important to their respective national food supply, feature the strong presence of an export-oriented agriculture as well as coexisting food systems that compete for natural resources.

In Bolivia, we gathered data in three municipalities of the Santa Cruz Department: San Pedro in the north, Samaipata in the west, and Cabezas to the south of the department's capital of Santa Cruz de la Sierra. Most of the area forms part of the Amazon watershed. The tropical climate is sub-humid to the north, and semi-arid to the south of the department, with a rainy season between November and March. Samaipata lies at 1670 m asl in the eastern foothills of the Andes. It has a humid sub-tropical climate and produces fruits and vegetables sold at the national level. The northern alluvial floodplains of the department (about 200 m asl) were originally home to tropical rainforests, but are now densely cultivated with cash crops (e.g., soybean, sunflower, sesame, sugarcane). In the Cabezas municipality further south, where the dryer Chaco region begins—characterized by a hot climate with seasonally strong winds (Navarro and Maldonado 2002)—cash crops are less densely cultivated but still abundant. Population density in the Santa Cruz Department is low at 9.2 inhabitants per km^2 (National Institute of Statistics 2018). Official documents such as development plans focus almost exclusively on environmental risks, including high or very high risks of droughts and floods[2] (Plurinational Ministry of Planification 2016), compounded by high deforestation rates in the study area (Gobierno Municipal de Cabezas 2010; Gobierno Autónomo Municipal de San Pedro 2013). Contamination of soil and water from solid waste (e.g., pesticide bottles) is another environmental risk (Gobierno Autónomo Municipal de San Pedro 2013), as is the expansion of large-scale monocultures (McKay and Colque 2015; Suárez et al. 2010; Urioste 2012). Socio-economic risks include the replacement of food crops with soybeans (Suárez et al. 2010), and the exclusion of locals from benefits (McKay and Colque 2015). In Samaipata, wildfires are listed as a risk in addition to droughts and floods, but the overall risk level is deemed low (Gobierno Autónomo Municipal de Samaipata 2016). Oil extraction companies play an increasingly important role in social and environmental conflicts, particularly to the South of the Santa Cruz Department (Humphreys and Bebbington 2010). Finally, Bolivia was highly impacted by the food price crisis of 2007/2008 relative to other Latin American countries (Cuesta et al. 2013), pointing to the risks of abandoning local food production (McKay and Colque 2015; Castañon Ballivián 2014).

In Kenya, we conducted our study in Laikipia, Meru, and Nyeri counties. At the center of the study area is Nanyuki, the

[1] Swiss *r4d* project "Towards food sustainability: reshaping the coexistence of different food systems in South America and Africa", led by the Centre for Development and Environment (CDE), University of Bern, and its partners, 2015–2020.

[2] E.g. La Razón 31 January 2018: Lluvias afectan mayor producción cruceña (http://www.la-razon.com/index.php?_url=/sociedad/lluvias-afectan-mayor-produccion-crucena_0_2866513345.html)

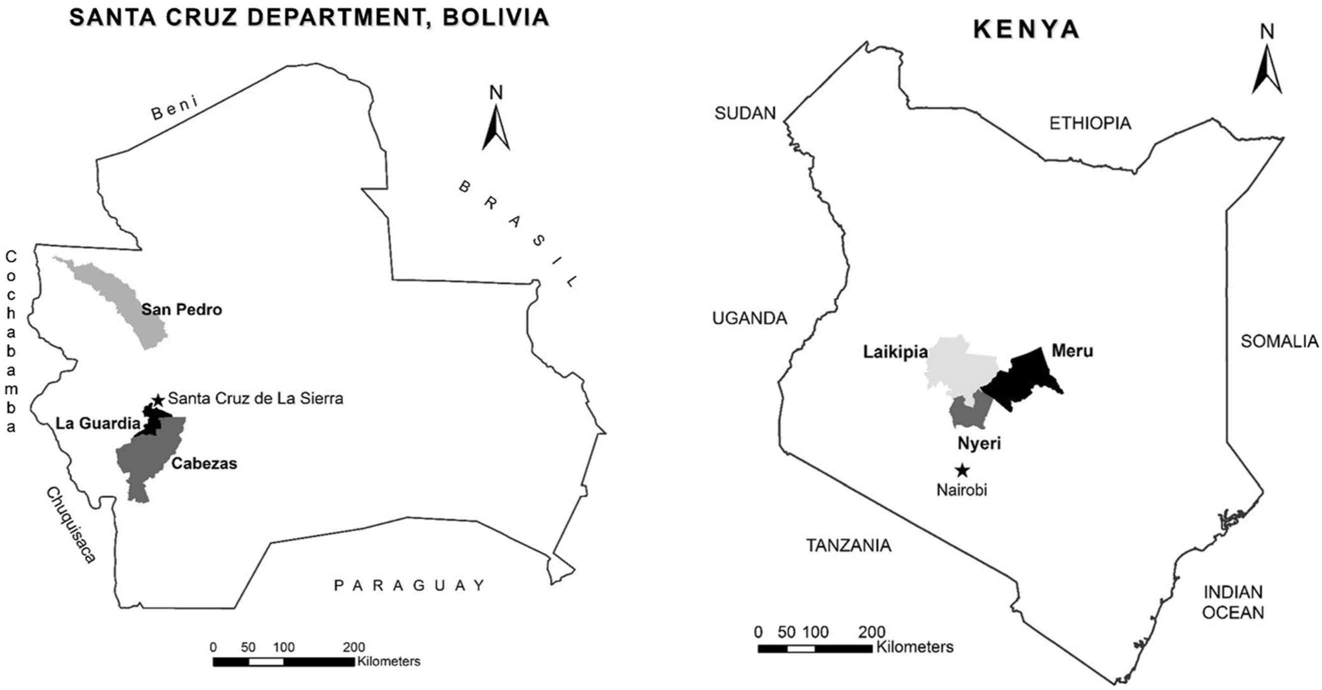

Fig. 2 Left side: Santa Cruz Department of Bolivia (study areas: Municipalities of San Pedro, La Guardia and Cabezas); right side: Kenya (study areas: Laikipia, Meru, and Nyeri counties)

capital of Laikipia County located at 1986 m asl. The region's tropical savannah climate is strongly influenced by the proximity to Mt. Kenya, with precipitation decreasing markedly at increasing distances from the Mountain. There are two rainy seasons: March–May and October–December. The agroecological zones vary from semi-arid in the lowlands of Laikipia to sub-humid and humid on the slopes of the mountain. Population density is high in the fertile areas of Meru County (320 inhabitants per km^2) and lower in semi-arid Laikipia (42 inhabitants per km^2). Alinovi et al. (2010) describes a long history of shock and crises in Kenya based on four main, often intertwining, causes: droughts, floods, diseases, and political crises. Kenya is particularly susceptible to droughts, including documented cases in our study area (Aeschbacher et al. 2005; Ifejika Speranza 2013; Wiesmann et al. 2000). Droughts in Kenya are often followed by floods, which have intensified with climate change (Government of Kenya 2013). In addition to the direct environmental risks and hazards associated with climate change, Kenya is vulnerable to climate change-related fluctuations in the price of staple foods, including droughts that impact crop and livestock productivity and constrain access to affordable food. Drought cycles—often associated with famines—have shifted from occurring every 20 years (1964–1984), 12 years (1984–1996), and 2 years (2004–2006) to occurring yearly (2007–2012) (Ministry of Environment and Natural Resources 2016). In both Bolivia and Kenya, food *insecurity* is still a reality for many households (FAO et al. 2018).

In our study areas, we identified five different food systems according to the typology of Colonna et al. (2013):

(1) An *agro-industrial food system*, present in both Kenya and Bolivia and thus studied in both regions. In Kenya, it involves the production and commercialization of green and leafy vegetables, and links the study region with consumers in Europe. In Bolivia, the agro-industrial food system studied mainly produces soybeans for global export and vegetable oil for the national market, but it also produces some wheat and other annual food crops in rotation with soybean.
(2) A *regional food system* in our study area in Kenya, with wheat, barley, milk, and meat as the main value chains and involving medium-scale landholders on the one hand, and semi-nomadic pastoralists, on the other. They are part of a larger network of actors in rural, peri-urban, and urban sites involved in processing, trading, retailing, and consuming food in the county capitals of Meru, Laikipia, and Nyeri; neighboring towns of Isiolo and Karatina; and Kenya's capital, Nairobi.
(3) A *local food system* in Kenya consisting of short value chains of smallholder farmers, artisanal processors, traders, and consumers of maize, potatoes, fruits, and vegetables. It makes up a significant portion of the local informal trade sector, connecting smallholder households and local markets.

(4) A *domestic food system* in Bolivia comprising the traditionally subsistence-oriented agriculture of the Guaraní indigenous people in the Chaco region of Santa Cruz. This food system involves a diversity of maize, cassava, peanuts, peppers, beans, fruits, and vegetables and is subject to significant changes. Over the last two to three decades, Guaraní families have shifted from being net sellers and barterers of food to being net buyers, mainly due to work migration related to fossil-fuel exploitation in the region. Nevertheless, traditional agricultural knowledge and cultivation-related identities remain present.

(5) A *differentiated quality food system* in Bolivia comprising several rapidly growing initiatives that offer healthy, ecologically produced food in the urban and peri-urban areas of Santa Cruz de la Sierra. An example for this food system is a network of agroecological food producers and like-minded processors, traders, retailers, municipal officials, non-governmental organizations (NGOs), and consumers' organizations, collectively called the "Agroecological Platform".

Research methods

In a pre-assessment consisting of participatory food system mapping in both study areas, we identified the main activities and actors involved. We traced the 1–3 most important value chains in each food system using a snowball sampling approach (Patton 2002), visiting different sites and actors (input suppliers, farmers, middlemen, processing plants, vendors, NGOs, policymakers, supermarkets, carriers, etc.; see Online Resource 1 for Bolivia and Online Resource 2 for Kenya). We followed a value chain approach (Kaplinsky and Morris 2001), which may be considered case study research. As such, our studies of specific value chains are best regarded as exemplary and not statistically representative. We sought to reflect the distribution of actor types in the sample, since some of the food system stages featured large populations (e.g., producers), while others were rather small (e.g., retailers). Representative studies compiling socio-economic information on producers and consumers within the same food systems were carried out in the framework of the larger research project (Mutea unpublished, Catacora Vargas 2017).

For the main assessment, we visited, interviewed, and accompanied the main actors of each food system identified in the pre-assessment (Online Resources 1 and 2). We interviewed the different food system actors about the risks they perceived—including uncertainties—in regards to their food system activities, as well as what they thought more generally about risks associated with the food system they were most connected to. We also asked about potential, planned, or implemented risk-mitigation activities.

In Bolivia, this included carrying out 27 interviews in total with seven input suppliers, ten producers, three processing actors, four retailers, six consumers, and eight actors who provided analysis and advice (NGOs and policymakers). Some of these actors were interviewed in different roles and therefore appear twice in Online Resource 1. We further conducted participant observation in five workshops with different groups of actors from the domestic and the differentiated quality food systems, and we attended four events with members of the agro-industrial food system (three organized by the private sector, and one by an NGO). In the workshops, we discussed food system-related topics that different groups of actors (e.g., a Guaraní women's group representing a producer and consumer point of view) found especially important, such as the implementation of kitchen gardens or the processing and use of local medicinal plants. We used these workshops to discuss the food system-related risks these groups faced and ways of mitigating them, for example, issues of family health related to access to medication, and, more generally, to healthier food.

In Kenya, we administered a questionnaire to 25 smallholders who produced food crops (maize, beans, and potatoes) around the towns of Laikipia and Meru, as well as 20 pastoralists (mainly Maasai) who rear cattle in villages around Illipolei town, and on two cattle ranches. These groups are represented in their roles as producers, distributers, and consumers in Online Resource 2. Additionally, we held a focus group discussion with a women's group to represent the consumers' point of view, and on the topic of mutual support during water shortages in Mirichu village, Laikipia East. We further conducted interviews with five managers of horticultural farms, five managers of large-scale wheat farms, and four managers of flower farms who are important employers in the region and simultaneously compete with food producers for water and land resources. We also collected data from four millers, five retailers/middlemen, three wholesalers, six butcheries, and five restaurants in towns in the study area. Finally, we collected data from 14 organizations that deal with risk mitigation; this included interviews with relevant NGOs, a nutritional health expert, the national government and county governments of Laikipia and Meru, relevant ministries, and research organizations.

We recorded interviews, workshops, and focus group discussions. During participant observation, we recorded the presentations and discussions of event organizers, noting the risks they mentioned, as well as their proposed mitigation strategies. We transcribed the qualitative material and codified it in the program Atlas.ti (version 5.0) in preparation for further qualitative content analysis following Patton (2002).

Results

Perceptions of risks and related strategies in the different food systems

The following section describes the risks identified in each of the different food systems. Table 1 and Table 2 summarize the most important risks and strategies according to the actors who mentioned/employed them in Bolivia and Kenya, respectively.

Agro-industrial food systems (Bolivia and Kenya) In both settings, farmers and organizations viewed pests and diseases as a major, increasing problem. Farmers also named the high costs of seeds and agrochemicals as a risk. Further, in both countries, NGOs and consumers perceived degradation of natural resources in the agro-industrial food systems—especially soils (Kenya), forest loss (Bolivia), and biodiversity (both settings)—due to input-intensive monocultures. The same actors rated the agro-industrial systems as vulnerable to climate impacts such as droughts, inundations, and extreme weather events. In Bolivia, farmers perceived themselves as being exposed to hazardous agrochemicals, though most viewed their occupation as a soybean farmer as something temporary. The Ministry of Labour cited cases and showed us pictures of pesticide poisoning, but also said that employees of the agro-industrial food system were generally afraid to complain. NGOs perceived risks due to the countries' export-orientation combined with a decrease in area and diversity of local food crops and resulting dependency on international markets. Bolivian agribusiness enterprises saw export restrictions on soybeans as hurting their business, and they anticipated risks from a new law requiring labeling with a yellow triangle all foods with transgenic ingredients as of December 2017. In Kenya, agribusiness experts and exporting actors cited fluctuating currency values as threatening profit margins. Further, agribusiness experts, exporters, and input providers emphasized the challenge of strict export market standards. For example, GlobalGAP[3] enforces maximum residue levels (MRLs) for agrochemicals on vegetables, fruits, and herbs, requiring significant investment in efficient production and monitoring of pesticide use. Stringent monitoring of MRLs has resulted in a rejection rate of about 20% of the vegetables produced by contracted smallholders we interviewed. Producers also mentioned risks from water shortages, climate change, human–wildlife conflicts, droughts, floods, and pests and diseases. In two studies related to the larger research project, residents in Laikipia County expressed major concern about the health risks of pesticide residues in their food (see Hertkorn 2016) and air pollution from pesticides (see Zaehringer et al. 2018) sprayed at agro-industrial farms.

Domestic (indigenous) food system (Bolivia) Traditionally, Guaraní families carried out all food system activities on their own. The two Guaraní communities in the Cabezas municipality where we conducted research (Yatirenda and La Ripiera) were divided with regard to political and religious questions. Usufruct rights to plots on communal land were distributed according to the social status of the families, but interviewees reported that authorities illegally rented out community land to neighboring agribusinesses cultivating soybeans and sesame. According to Guaraní interviewees and workshop discussions, agro-industrial enterprises have been putting pressure on Guaraní land over the last 10 years. Further, Guaraní families reported not using their own seeds and not cultivating much maize anymore due to climate risks (prolonged droughts) and labor migration—mainly of men—to oil and gas extraction plants. Women produced some food around their homes, including maize, beans, cassava, sweet potato, acerola, mandarins, and vegetables, as well as chicken and pigs. However, they described these habits and related agrobiodiversity as gradually disappearing. During our research, we witnessed how dependency on external food led to shortages; for example, during the 2016 drought, there were no vegetables available that would reportedly be consumed under normal circumstances. NGOs perceived risks of declining production, food traditions, related knowledge, and independence due to rapid loss of crops and dietary diversity. They also named the risk of assimilation into surrounding agro-industrial food systems, even though reciprocity mechanisms and knowledge on traditional and diverse foods were still alive in the two Guaraní villages studied. According to one expert interviewed, the main risk was that of losing a food system comprising a large body of knowledge that had evolved and adapted to the ecosystem over centuries. One adaptation strategy we observed was the participation of several young Guaranís in an agroecology school in the nearby village of Cabezas, where local knowledge was taught as well as practices of production and preparation of local food. We identified some of these practices replicated in the garden of Yatirenda's village school ground, in particular use of soil cover crops, raised beds, and composting.

Differentiated quality food system (Bolivia) Producers and consumers who formed part of the Agroecological Platform perceived a multi-layered crisis comprising the environment, alimentation, and health of Bolivians. Consistent with NGOs interviewed, they perceived a corporate food regime that influences people's views of what constitutes a good diet, resulting in unhealthy and unsustainable consumption patterns. In terms of their own developing network of producers and consumers, the associated producers and traders perceived a lack of established value chains. They mentioned its small share in local markets and emphasized the challenge of competing with conventional produce whose socio-environmental

Table 1 Actor-specific risk perceptions and mitigation strategies, Bolivia

	Actor group and risks perceived	Strategies developed
Agro-industrial food system	Soybean farmers: Pests and disease outbreaks are the main risk followed by droughts and floods	Soybean farmers: Increase/improve pesticide applications Agrochemical companies: Advise large-scale farmers directly and build relationships of trust. Medium- and small-scale farmers are advised via local shops
	Soybean farmers: High prices of genetically modified organism (GMO) seeds; soil degradation	Informal market of soybean seeds: Small- and medium-scale farmers replanted or bought informally reproduced GMO seeds; more fertilizers and more efficient soybean seeds; moving to new plots
	NGOs, women's group, one input provider: Environmental degradation through deforestation, monocultures, excessive pesticide use	NGOs: Awareness-raising projects on climate change and integrating trees into agricultural systems; production and dissemination of information materials on agroecological methods. Women's group: Agroecological kitchen gardens
	NGOs: Dependency on international commodity-trading prices at the cost of own production of food crops	Promote local and/or national markets
	Ministry of Labour: Workers rarely come to us with their problems – they are afraid of losing their jobs	Information campaigns on workers' rights
	Health expert: Diabetes, cancer, and renal insufficiency in intensive soybean areas higher than national average	Advocates for a sugar tax and pesticide bans (particularly glyphosate); very few consumers change their habits; state distributes monthly food packages to pregnant and breastfeeding women (nationally)
	Soybean producing families of San Pedro: Transgenic soy and agrochemicals affect health	Farming families do not eat soybeans, but buy >95% of food they consume
	Bolivian Institute of Foreign Trade (IBCE): Unfavorable public opinion on GMOs	Public forums on the economic, social, and ecological benefits of GMOs in La Paz, Bolivia
	Transnational companies and soybean producing families: Export restrictions on soybeans	Public forums on the economic, social, and ecological benefits of GMOs in La Paz, Bolivia; soybean farmers' syndicates
Domestic (indigenous) food system	Internal division and conflict (Catholics vs. Protestants, pro-government vs. anti-government groups, gender conflicts)	Internal rules (e.g. in cases of domestic violence)
	Guaraní women: Loss of customs and knowledge; "All the food is bought now. Nothing is natural anymore."	Some plant fruit trees and implement kitchen gardens; several families plant traditional crops around the house (e.g. sweet potato); exchange events with other indigenous groups; participation in courses on agroecological management
	Guaraní women: Prolonged droughts, floods, stronger winds, more insects	Labour migration (mainly men), e.g. to agro-industrial food system or to oil and gas industry; shift to buy maize instead of producing it, combinations of production and external sources
	Guaraní women: More and more nutrition-related diseases with limited access to healthcare; food shortages during droughts	Some use of traditional medicines; plans to apply for monthly food packages like pregnant or breastfeeding women working in the public sector receive
	Inhabitants of Yatirenda: Violent conflicts over oil extraction	Village chief who favors fossil-fuel extraction elected
Differentiated quality (agroecological) food system	Agroecological Platform: Multiple crises (climate, environmental, economic, social, dietary, health)	Development of an agroecological product label and corresponding regulation Producers: Avoid deforestation and use of agrochemicals Consumers: Buy from reliable sources; trust; avoid/peel certain fruits and vegetables
	Agroecological Platform: Power concentration in the corporate food regime; uncertainty about possible adverse health effects of GMOs	Organization of fairs and sales points, seed exchange; direct producer–consumer trade relations; rejection of GMOs (production as well as consumption)
	Producers: Production costs raise prices; competition with conventional produce, no recognition in the market	Identity label "Agroecological product", mutual low-cost certification
	Producers/restaurants: Few functioning value chains established	Organization of monthly fairs for ecological products, aims to establish a weekly fair; direct sales and producer–consumer relations
	National Counsil of Agroecological Production (CNAPE): Lack of extension in agroecology. Universities teach "green revolution" instead of agroecology	Some education programmes launched (Master in Agroecology, Master in Agroforestry at La Paz University (UMSA)
	Agroecological Platform: Lack of recognition by policymakers	Interaction with municipal governments; press releases; media appearances; strong use of and attention to social media (Facebook, Twitter, WhatsApp and Wordpress)
	NGOs: Risk of becoming an exclusive food system "only for the rich"	Co-organization of direct trade relations and low-cost certification

externalities were not reflected in the shelf price. Indeed, consumers regarded the produce as comparatively expensive and thus only accessible to a minority, hampering their overall network goal of transforming local food systems. Finally, producers as well as consumers of the network mentioned that decision-makers were not interested and did not pay attention

Table 2 Actor-specific risk perceptions and mitigation strategies, Kenya

	Actor group and risks perceived	Strategies developed
Agro-industrial food system	Horticultural farms: Strict export market requirements governing maximum pesticide residues on vegetables	Government action via Horticulture Crops Development Authority to create awareness on Good Agricultural Practices (GAP); horticultural farms convert to flower farms; integrated pest management; integrated soil fertility management (use of organic and chemical fertilizers); use of biopesticides
	Horticultural farms: Pests and diseases (produce needs to look perfect for European markets, otherwise it is rejected without compensation)	Producers: increased use of agrochemicals; KEPHIS: need to provide high-quality seeds Trials of integrated pest management
	Horticultural farms: Declining rainfall and frequent droughts contribute to water shortages	Rainwater harvesting, drip irrigation, boreholes, formation of water project groups, Water Resource User Associations (WRUAs) for conservation of riparian areas, water reuse systems; maintaining a minimum of 10% tree cover
	Horticultural farms: High freight costs and expensive inputs (most from Europe)	Formation of associations to increase bargaining power (e.g. Fresh Produce Exporters of Kenya)
	Input providers: Cannot sell the whole range of products due to restrictions on residues in export countries	Information and training for small-scale farmers who produce for local markets
Regional (rural-urban) food system	Pastoralists, wheat and dairy farmers: Climate variability and change – droughts, floods, declining rainfall, change in onset of rains, increasing temperature; water is the most pressing issue; soil erosion	Coping strategies, e.g. bringing livestock to graze in other areas towards Mt. Kenya, diversification of livelihoods through farming, ecotourism, and businesses (pastoralists). Wheat and dairy farmers: Shift to minimum tillage systems, adoption of early maturing varieties, diversification of crops, e.g. rotation of canola and peas with wheat; conservation agriculture techniques
	Wheat and dairy farmers: Human–wildlife conflicts	Employment of scouts, collaboration with conservancies
	Pastoralists: Invasive cactus affecting quality of rangelands	Developing income-generating activities from invasive species, e.g. making juice from cactus fruit, manual removal
	Wheat and dairy farmers: Necessity to use large amounts of pesticides	
	Wheat and dairy farmers: Price fluctuations, dumping of goods from EU and Russia	
	Millers: Poor quality of wheat supplied by smallholder farmers (fetches low prices due to amount of work it takes to improve quality of flour)	Millers resort to buying imported wheat from the port of Mombasa and sourcing from Nakuru and Narok which are major wheat producers
Local (small-scale farming families) food system	Farmers: Water scarcity, frequent droughts, floods	Intercropping, conservation agriculture, use of fast-maturing varieties, drought-resistant crops, rainwater harvesting systems, shifting from crops to dairy producing; small-scale irrigation systems with solar power (uptake still rather low); early-warning systems for droughts and floods via National Drought Management Authority as well as use of indigenous knowledge; government cash transfers
	Competition over resources creates conflicts (between farmers and pastoralists; between large-scale farms and small-scale producers); pastoralists invade farms near Mt. Kenya during droughts	Common action to increase access to scarce resources (e.g. joint water projects of communities and companies); government enforces regulations to allow all parties to access water, which has reduced conflicts; County, NGOs: promote haymaking among pastoralists
	Farmers: Loss of biodiversity (due to production for markets, and climate change) means loss of food security throughout the year	Small-scale farmers increasingly planted trees on their plots and implemented agroforestry systems. Main trees planted include the genera *Cupressus, Grevillea*, *Croton*, and *Pinus*
	Farmers, organizations: Land degradation/declining soil fertility, health risks from pesticides	Mix of conservation agriculture and conventional agriculture (some mentioned improved soil fertility), agroforestry, use of organic manure
	Farmers: Decreasing farm sizes due to subdivisions	Plots in different regions
	Nutritional expert: Modern diet very unhealthy compared with traditional food	Awareness creation on better nutrition, especially for children and breastfeeding mothers
	Farmers: Limited access to markets – farm gate prices according to produces are very low and unjust. Selling via middlemen forces farmers to accept uncompetitive prices, resulting in lost profits	Establish weighing systems to sell produce per weight instead of volume; National Potato Council has lobbied for selling potatoes in 50 kg bags instead of 120 kg; however, the situation on the ground has changed very little; social organization in women's groups, self-help groups, common interest groups, e.g. potato growers, dairy farmers, and cooperatives especially for milk producers
	Farmers: Post-harvest losses due to pests and diseases	Establishment of potato cooling plants, use of chemicals and ash during storage

to such alternative food system initiatives, which was also reflected in education and extension, where agroecology was marginalized. In three interviews, these actors described the heavily mechanized agro-industrial food system as being supported by diesel subsidies—subsidies estimated at USD 20 million annually in the case of soybean production, for example (see Urioste 2012). The NGOs interviewed reported policymakers as failing to appreciate the contribution of alternative food systems to human health, the environment, and the economy. In response, the network actively engaged with policymakers from the national to the local level—e.g., negotiating a space for their agroecological fair—and put a lot of effort into cultivating social networks.

Regional (rural–urban) food system (Kenya) The main risks perceived by farmers and input providers linked to this food system were pests and diseases affecting both crops and livestock. As a result, use of chemicals was deemed necessary, but these, in turn, imposed a heavy financial burden for farmers and pastoralists. Relevant livestock diseases included East Coast fever (*theileriosis*) and foot-and-mouth disease, while crop pests included millipedes and white flies. In addition, soil erosion was seen as a common risk contributing to loss of soil fertility, while wheat farmers associated declines in soil fertility with implementation of monocultures. All five mentioned implementing Conservation Agriculture (CA) practices such as contour plowing, terraces, and grass strips, but only two implemented minimum tillage and crop rotation. Both crop producers and pastoralists perceived lack of direct links to markets as a serious risk. This necessitated selling farm products at the farm gate to middlemen who bought the products at low prices. Milk producers mentioned dependency on middlemen as a risk to their business. To mitigate disadvantages for milk producers, the Laikipia County government installed milk coolers (with a total capacity of 30,000 l) where farmers could sell their milk for central collection and transport to processing facilities. Farmers have been generally encouraged to form cooperatives to increase their bargaining power. Pastoralists faced risks from an invasive cactus (*Opuntia stricta*) that made rangelands unsuitable for grazing. Overall, however, water scarcity was the main risk to pastoralists and agro-pastoralists, since they lived in the drier lowlands where river discharge was low due to excessive abstraction of water by larger farms upstream (see Dell'Angelo et al. 2016). Other risks included human–wildlife conflicts affecting both pastoralists and wheat farmers. One wheat farmer cited losses of KSH 12 million (USD 115000) per year due to wildlife invading his farm, which borders a large conservancy in Laikipia County. To deal with the risk, he was permitted to radio conservancy authorities that would help him scare the animals away. In cases where compensation of crops or livestock was concerned, managers contacted the Kenya Wildlife Service. An ongoing drought (late 2016/early 2017) had intensified conflicts due to animals leaving protected areas in search of water and food, on the one hand, and pastoralists invading farms and ranches to save their livestock from starving, on the other. In some cases, agreements were reached between pastoralists and authorities for ranchers to set aside some sections of their rangeland for grazing. The county government has planted 4000 acres of grasslands for hay in Laikipia County as a drought mitigation strategy (interview with County Livestock and Fisheries Director 2016). Another risk to wheat farmers was importation of cheap wheat into the country, which forced price reductions on locally produced wheat. Millers mentioned droughts and the inadequate supply of wheat and maize as the main risks for them. Further, diseases and pests, such as weevils that infested maize, contributed to poor quality of wheat and maize.

Local food system (Kenya) This food system, mainly consisting of smallholder farmers, exhibited the highest susceptibility to risks due to limited mitigation and coping capacities (see Ifejika Speranza 2013). Actors reported frequent crop failures due to long dry spells (January–March; September–October). Smallholder farmers cited lack of access to water as the most serious problem during these months. They attributed water scarcity—causing some rivers to run dry—to declining rainfall as well as to intensive water use by horticulture and flower farmers upstream (see Aeschbacher et al. 2005). One 70-year-old smallholder farmer stated that in 2016, the river near his farm had run completely dry for the first time in his lifetime. Further, both crops and livestock were reported to be increasingly affected by pests and diseases, resulting in major losses. Additional economic losses were reported due to poor post-harvest management on the part of farmers, middlemen, and millers. Limited access to markets typically forced smallholders to sell their produce to middlemen at the farm gate. Further risks mentioned by farmers were biodiversity loss, decreasing farm sizes, resource conflicts between pastoralists and smallholder farmers, and health problems related to pesticides and "modern" diets (see Hertkorn 2016). In response to these risks, smallholder farmers sought to diversify their income sources by means of casual labor on larger farms and enhancement of on-farm income sources, e.g., keeping chicken and livestock (goats, sheep, and cattle such as Borana and Zebu). Interviewed farmers cited low rainfall levels necessitating shifts in planting dates to coincide with changes in the onset of rains, and the use of early maturing crops (potatoes, onions, beans, and maize varieties such as Katumani). Also, smallholders planted grass for their own use and as a source of income (selling hay to pastoralists). Both national and county governments have undertaken programs to reduce post-harvest losses by means of innovative storage facilities, e.g., by promoting small silos for grain storage at the household level. Efforts to improve access to water have included sharing of water-harvesting techniques (roof catchments, water ponds, and pans for harvesting runoff water), and water projects conducted by members of Water Resource User Associations. Additionally, smallholder farmers have embraced CA practices, increasing maize yields from 1 to 5 bags per acre to 10–18 bags per acre (interview with CA expert, 2016). An estimated 5000 acres of land owned by smallholders was under CA in Laikipia. One farmer said that he had always required bank loans before adopting CA methods, but now, his income had more than tripled and he never suffered crop failures. He explained that he had been working for 14 years to build the CA capacity of smallholders in his neighborhood, but that uptake had been low, since CA is a long-term investment. Government cash transfers to the most vulnerable households helped to mitigate the risk of drought. People aged 65 years or older, living with a severe disability, and orphan-headed households were given cash payments of Ksh 2000 (USD 19.40) per month or Ksh 4000 (USD 38.8) every 2 months within a program called *Inua Jamii* ("lift up a community"). Another important strategy observed, especially in the local food system, was social organization. We identified religious groups, women's groups, groups related to specific food products (e.g., potato-grower or dairy-farmer groups), and merry-go-round self-help groups (characterized by regular contributions and payouts on a rotating basis), and cooperatives. We observed the maintenance of important social capital, enabling actors to exchange information, money, and credit, among other benefits. This played a crucial role in production and consumption during famines, droughts, floods, and funerals. The groups persevered by means of trust, reciprocity, and mutual understanding. The women's group mentioned benefits like working for each other on the farms, and exchanging farm tools.

Diverging strategies for commonly perceived risks

In comparison to people's risk perceptions, their implemented or envisioned strategies varied largely. For example, smallholder farmers concerned about the risk of soil depletion in the local food system in Kenya sought to address it with CA measures such as the maintenance of soil cover, crop rotation, and minimum tillage. By contrast, producers and businesses in the agro-industrial food system in Bolivia sought to address soil depletion by applying more mineral fertilizers, using more efficient crop varieties, and shifting to new plots. Currently, Bolivia has one of the highest deforestation rates in the world (FAO 2015, Global Forest Watch 2017). Concerns about pesticide overuse provide another example of divergent strategies. Risks from pesticide overuse were mentioned by consumers and producers in the differentiated quality food system; by an input provider in the agro-industrial food system in Bolivia; by producers in all three food systems in Kenya; and by consumers in the local food system. However, whereas actors in the differentiated quality food system responded by using only fungi- or bacteria-based bio-pesticides or avoiding pesticide use altogether, the input provider emphasized continual improvement of seeds' genetic traits to make pesticide use unnecessary. Finally, consumers concerned about pesticide residues in their food did not display a clear strategy. Some tried to buy from providers they found trustworthy (one of the main consumer motivations to form part of the Agroecological Platform in Bolivia) or avoided certain foods. However, health experts in both countries stated that most did not change their shopping or consumption habits based on risk perceptions.

Discussion

Our findings indicate a variety of risks perceived by different food system actors. Some coincide (e.g., climate risks in all food systems; pests and diseases in all but the agroecological food system in Bolivia), while others contradict one another (e.g., soybean farmers' view that consumption of transgenic food is bad for human health, while simultaneously criticizing export restrictions on soybeans; see Table 1). Most of the risks mentioned by all actor groups involved the production level. Production-related risks frequently mentioned (other than risks from climate impacts and pests and diseases) include pesticide exposure, declining soil fertility, unequal competition in markets, and temporal food shortages. The latter affected families linked to the indigenous food system in Bolivia as well as pastoralists and smallholder farmers linked to the national and local food systems in Kenya. High dependence on degrading natural resources combined with socio-economic pressures, climate-change impacts, and low adaptive capacity produces high vulnerability among such actor groups (Ifejika Speranza 2013).

In all food systems assessed, we noted perceived risks for which no strategies were proposed or implemented as well as perceived risks for which seemingly contradictory strategies were proposed or implemented. This was the case in the following exemplary situations:

- In the agro-industrial food systems in both countries, there was an apparent gap between farmers' perception of pesticide risks (both in production and storage) and actual implementation of corresponding strategies to diminish pesticide use or shift to agroecological alternatives. In Bolivia, relevant actors regarded their involvement in this type of agriculture as strictly temporary. Another contradiction could be seen in the widespread perception of environmental degradation occurring side by side with widespread lack of enforcement of environmental laws (see Gonzales Soto 2016). Finally, consumers (including farmers) expressed concerns about health risks from pesticide residues and consumption of transgenic plants, but, according to the health experts we interviewed, few consumers respond by changing their existing consumption patterns.

- In the domestic (indigenous) food system in Bolivia, a loss of agrobiodiversity and associated knowledge and identity was strongly perceived by many families. At the same time, however, we observed very few attempts (e.g., a school garden) to maintain such knowledge and practice. This loss was even more pronounced in people's consumption patterns: almost no traditional Guaraní dishes were regularly consumed anymore and almost all food was purchased, despite the fact that the Guaraní food culture traditionally provides great independence (Toledo 2016).
- The differentiated quality food system in Bolivia exhibited a paradoxical situation whereby food system transformation was striven for, yet the movement risked becoming accessible solely to medium- and high-income households.
- In the regional food system in Kenya, high use of agrochemicals was viewed critically by those who applied them, yet deemed necessary and without alternatives.
- Smallholder farmers in the local food system in Kenya faced various difficulties: The shifting onset of rains required changes in crop varieties and planting strategies. The farmers reported (and we observed) efforts towards soil cover maintenance, crop rotation, tree planting, compost preparation, etc. However, despite interviewees' awareness of the need for CA and experts' reporting CA-related fivefold yield increases of maize, in reality very few (six of 25 smallholder farms; and two of five large-scale wheat farms) reported implementing CA practices—mainly minimum tillage. Farmers in all food systems were practising some crop rotation. Further, smallholder farmers mentioned risks from pesticides, but nevertheless used WHO-class I (highly hazardous) agrochemicals (Ottiger 2018).

In order to better understand the differences in risk perception and related strategy development observed in the different food systems, we applied the framework described in Fig. 1. To explore the link between risk perception and resilience building, we also incorporated the "risk perception paradox" of Wachinger et al. (2013). According to Wachinger, increasing numbers of people believe that human actions are causing or amplifying the extent and frequency of natural disasters. At the same time, however, this perception of risk does not necessarily prompt them to take steps in response. Studies show that while individuals may experience and perceive risks, they often fail to take appropriate actions (ibid.). Regarding the question of what leads to resilience-building strategies, Wachinger et al. (2013) provide an explanatory approach indicating that willingness to act depends on preparedness and personal experiences, influenced by trust, responsibility, and ability. This framework helps us to consider possibilities for change in regards to structural influencing factors as well, taking the agro-industrial and the differentiated quality food systems in Bolivia as examples. Farming families in the agro-industrial food system strongly perceived risks—both as food producers and consumers—but did not appear to perceive responsive strategies or possibilities for change. Taking into account political-economic influencing factors, we relate this apparently contradictory situation to the phenomenon of "productive exclusion", whereby actors—in this case those in the agro-industrial food system of soybean production in Bolivia—are bound by surrounding political-economic structures to adapt to prevailing patterns, but cannot profit from them equally (Hirsig and Märki 2016; McKay and Colque 2015). Related findings (ibid.) indicate that even when the right variables for willingness to act are present, the most important limiting factor is the ability of relevant actors—including their self-perceived ability—to effect change. The concept of subjective resilience (Jones and Tanner 2016) describes people's understanding of the factors that contribute to their ability to anticipate, buffer, and adapt to disturbances and change. If households systematically underestimate their adaptive capability, this can be just as limiting as political-economic, environmental, or technological factors. People's overestimating their capability, by contrast, can erode preparatory incentives (Elrick-Barr et al. 2016). In the case of farming families in the soybean areas of San Pedro, Bolivia, the "meaning" of the actions taken (Wiesmann 1998) points to "more of the same", rather than transformation, due to an apparent lack of opportunity resulting from productive exclusion.

There is also evidence of risk perceptions leading to successful transformation of food systems in response, however, including in our case studies. Sage (2014: 16) studied the transition movement in Great Britain and described it as a "cosmology that can bring together perceived external threats with a set of responsive activities", eventually increasing local resilience as well as global engagement among its members. According to the author (ibid.), the transition movement was driven by the question of what could be done about a perceived multi-pronged crisis—similar to the driving sentiment behind the differentiated quality food system we studied in Bolivia. Though much smaller and still in its starting phase, the differentiated quality food system we observed in Bolivia a consistent with Sage's description (2014:262) of a movement based on local people's wish to regain "control over essentials (food, water, energy); and [to] work with others to build social capital, resilience, and community security". Sage (2014) adds that such local food systems do not automatically lead to greater social justice; however, by building understanding and appreciation of territorial attributes, they can help reconnect local people to ecological and seasonal patterns as well as enable a common vision of what good and appropriate food means.

What are the implications of these considerations for sustainable, resilient food systems? If we take the differentiated quality food system as an example—motivated, as it is, by perceptions of a multi-layered food system crisis—we see that, as long as the abilities of relevant actors are not too constrained (e.g., according to the structural factors in Wiesmann's Theory of Action, or political-economic factors in Altieri's framework of perceived risks and related strategies), such perceptions can indeed be a driver of transformation. Similarly, other factors identified as crucial to food system resilience in the literature are local identity and place attachment, which function as forms of social capital (Bahadur et al. 2013; Hendrickson 2015) and provide the basis for senses of community and civic participation. In order to address the risk perception paradox, Wachinger et al. (2013) suggest that public participation measures are likely the most effective means of creating awareness about potential disasters, enhancing trust in public authorities, and encouraging citizens to take more personal responsibility for safety and disaster preparedness. This is an important observation with respect to the differentiated quality food system: According to members of the Agroecological Platform, lack of recognition from public authorities was a major limiting factor and a key reason why their movement has remained small.

With regard to food system risks frequently mentioned in the literature on food systems in general—and on Bolivia and Kenya specifically—there are several social-protection mechanisms and food- and nutrition-related mechanisms that may be used to address the risks. Examples in Kenya include grain storage facilities for small- and medium-scale farmers and, in Bolivia, a crop-insurance system at the production level, as well as monthly food packages for pregnant and breastfeeding women. Finally, government-run cash payments and food aid represent further relief systems capable of supporting communities affected by natural disasters. Going beyond risk mitigation and food aid, food systems must actively build resilience in order to cushion against shocks and recover from them. Our six case studies revealed certain similar risk factors, perceived by different actors, which indicate possible adaptation strategies capable of enhancing elements of resilience. In a separate study, we assessed elements—or distinct indicators—that contribute to resilience in food systems (Jacobi et al. 2018). In that study, we concluded that more attention and better support (e.g., policies and regulatory enforcement) are needed to achieve ecologically sustainable, economically viable, and socially just food systems (see Hodbod and Eakin (2015) who ask "resilience for what?") that possess sufficient *buffer capacity*, *self-organization*, and *capacity for learning and adaptation* (Jacobi et al. 2018). Further, we found that resilience thinking applied to food systems research can help to overcome simplistic (e.g., productivist) approaches by shedding light on the multidimensionality of risks and opportunities in food systems (ibid.).

Conclusion

This study analyzed food system-related risk perceptions as an important influencing factor in a complex set of interactions that may explain people's risk-related strategies. Many of the food system risks identified primarily affect the production level, especially in relation to smallholder farmers and pastoralists (see IFAD 2016; IPES-Food 2016). Shocks and trends in this food system stage affect all other stages, since at least 70% of the world's food calories are produced by smallholder farmers (Leah et al. 2016). At the same time, about half of the world's hungry are smallholder farmers (IPES-Food 2016) and many others are pastoralists or landless workers. Taken together, this indicates that food system actors at the production level are particularly at risk, highlighting the need for political focus and creation of structural opportunities for resilience building on their behalf. Indeed, production is likely the most important—though not the only, and not in isolation—stage upon which to focus efforts towards resilience building. This could include promotion of conservation agriculture, and, going further, emphasis on social-ecological systems thinking, agroecology, social organization, and social protection. Certain civil society and government efforts in Bolivia and Kenya point in this direction, but remain in an embryonic stage, lacking the necessary budget and political commitment for full realization.

Acquiring knowledge of current and emerging risks and opportunities will be crucial to enhance food system resilience. Based on our analysis of the differentiated quality/agroecological food system in Bolivia, the Water Resource Users Associations in Kenya (see Dell'Angelo et al. 2016), and the transition movement in Great Britain described above, we conclude that risk-mitigation strategies should be derived via bottom-up approaches and actor participation in order to overcome structural inhibiting factors and the risk-perception paradox. In this sense, Wachinger et al. (2013) highlight how people are more motivated to act if they are involved in participatory adaptation measures and suggest that working together with authorities increases people's trust and sense of responsibility. These insights are especially important when we consider that risk perceptions sometimes fail to prompt mitigation strategies—as indicated by the example of pesticide use in Bolivia (agro-industrial food system) and in Kenya (agro-industrial, regional, and local food systems). The gravity of the risks demands that we scale up our efforts towards disaster risk reduction, preclude emergency situations, and facilitate adaptive measures. Additionally, measures are needed that safeguard the livelihoods of the most vulnerable households, for example, by means of social protection systems that respond to changing socio-economic environments and ultimately reduce syndromes of dependence.

Finally, one key overarching challenge to resilience building within food systems—identified in the literature—is the traditional separation of governance between production, distribution, and consumption (Hodbod and Eakin 2015). In our study, we observed that actors develop a range of risk-mitigation strategies within their (perceived) possibilities, but can seldom ameliorate all the risks sufficiently on their own—much less build preventive strategies. Food system approaches are needed that operate at every level, for example, reducing emergencies via disaster-risk reduction programs, or reducing people's vulnerability via targeted social-protection systems. Multi-level food system approaches must be enhanced and scaled up to comply with UN Sustainable Development Goal numbers 2 and 12.

Acknowledgements The authors wish to thank all the participating food system actors, and Anu Lannen for language editing.

Funding information This work was carried out within the Swiss Programme for Global Issues on Development (r4d programme) funded by the Swiss Agency for Development and Cooperation (SDC) and the Swiss National Science Foundation (SNSF) [Grant number 400540_152033].

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