

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

3 Johanna Jacobi^{1*}, Stellah Mukhovi², Aymara Llanque³, Daniela Toledo⁴, Chinwe Ifejika Speranza^{1,5},
4 Fabian Käser⁶, Horacio Augstburger¹, José Manuel Freddy Delgado³, Boniface P. Kiteme⁷, Stephan
5 Rist^{1,5}

6

7 ¹ Centre for Development and Environment (CDE), University of Bern, Mittelstrasse 43, 3012 Bern,
8 Switzerland

9 ² Department of Geography and Environmental Studies, University of Nairobi, Po Box 30197-00100
10 Nairobi, Kenya,

11 ³ Agruco, Universidad Mayor de San Simón, Av. Petrolera km 4 ½, Cochabamba, Bolivia

12 ⁴ Instituto de Antropología y Arqueología, Universidad Mayor de San Andrés, Avenida Villazón,
13 Monobloque Central, La Paz, Bolivia

14 ⁵ Institute of Geography, University of Bern, Hallerstrasse 12, 3012 Bern, Switzerland

15 ⁶ Institute of Social Anthropology, University of Bern, Lerchenweg 36, 3000 Bern 9, Switzerland

16 ⁷ Centre for Training and Integrated Research in Arid and Semi-Arid Land Development, Buttsons
17 Complex Building, Nanyuki, Kenya

18 *Corresponding author, email: johanna.jacobi@cde.unibe.ch; phone: +591 67341152

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20 **Abstract**

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



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40 **Introduction**

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

50 Scholars have conceptualized food systems as social-ecological systems (e.g. Ericksen et al. 2010;
51 Hodbod and Eakin 2015; Prosperi et al. 2016). Rastoin and Gherzi (2010:19) define food systems as
52 “interdependent networks of stakeholders (companies, financial institutions, public and private
53 organizations, and individuals) in a geographical area (region, state, multinational region) that
54 participate directly or indirectly in the creation of flows of goods and services geared towards
55 satisfying the food needs of one or more groups of consumers in the same geographical area or
56 elsewhere”. A social-ecological food system approach implies looking at different actors along agri-
57 food value chains and examining their specific links with the *natural resource* subsystem, the
58 subsystem of *information and services*, and the *political* subsystem of the respective food system
59 (Rist and Jacobi 2016).

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

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

80 Classically, risk has been conceptualized as the potential for loss, as a function of exposure
81 (likelihood) multiplied by vulnerability (place/preconditions), and diminished by mitigation



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82 strategies and response capacity (Prosperi et al. 2016; Tierney 2014; Altieri 2013). While risk can be
83 expressed in terms of likelihood, uncertainty cannot (Ellis 1993). In order to capture food system
84 actors' perceptions and understand their strategies of action, we incorporate uncertainty as a
85 complementary concept to risk and refrain from assessing statistical likelihoods or whether a given
86 risk is "real" or not. This type of approach implies viewing risk as socially constructed (Scherer and
87 Cho 2003; Steg and Sivers 2000). While risks exist independently of our ability to observe and assess
88 them, people's ideas concerning risk – including those developed through putatively scientific risk
89 assessments – are socially constructed and influenced, and corresponding actions are taken (or
90 avoided) based on these constructions and influences (Tierney 2014). Even though people may be
91 aware of risks, they do not necessarily feel at risk (Wilkinson 2001) or take action (Wachinger et al.
92 2013). Analysing perceptions of risks in food systems may help to better understand the influencing
93 factors relevant to implementation of risk-mitigation strategies and thus resilience building in food
94 systems.

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

106 **[Figure 1 here]**

107 Risk-mitigation strategies that build (or fail to build) resilience in social-ecological systems are
108 influenced by what different groups of actors perceive not only as risks and uncertainties, but also
109 as opportunities (Jones and Tanner 2016; Wachinger et al. 2013). Perception, valuation,
110 interpretation, and methods of coping with uncertainty about the outcomes of activities – taken
111 together as "meaning" – are at the core of understanding how strategies are developed (Wiesmann
112 1998). The resulting "strategy of action" refers to all the actions of an individual actor or household
113 and includes the dynamic relationship between the network of activities and the structure of
114 meanings (aims of actions). In this view, the importance of perceptions in shaping people's
115 strategies means that perceptions represent an explanatory variable for different configurations of
116 food systems (e.g. production systems and consumption patterns). Finally, adopting a perceptions-
117 based approach to risks and resilience building in food systems acknowledges that local actors must
118 be taken into account in order to co-develop proactive risk management strategies that build on
119 local rationales regarding trade-offs between risks and opportunities (Blair et al. 2014; Tanner et al.
120 2015).

121 Despite the extensive literature on risks in food systems, few scholars have focused on assessing
122 perceptions regarding risk, uncertainty, vulnerability, or resilience according to different stages of
123 existing food systems, from production to consumption and beyond. In a separate study (Jacobi et



124 al. 2018), we assessed resilience indicators for some of the food system contexts presented here. In
125 the present study, we sought to compile and understand the risk perceptions of different actors in
126 food systems as possible drivers of resilience building along food value chains. To do so, we gathered
127 data from six case studies of different food systems in Kenya and Bolivia. A better understanding of
128 how risks are perceived and by whom, and respective strategies employed, may provide important
129 lessons for policies (Slovic 1987) on risk reduction and building sustainable and resilient food
130 systems.

131 Study sites and food systems

132 This study formed part of a larger research project¹ and took place in two study areas: The
133 northwestern Mount Kenya region in Kenya, and the Santa Cruz Department of Bolivia (Figure 2).
134 Both regions are important to their respective national food supply, feature the strong presence of
135 an export-oriented agriculture as well as coexisting food systems that compete for natural
136 resources.

137 In Bolivia, we gathered data in three municipalities of the Santa Cruz Department: San Pedro in the
138 north; Samaipata in the west; and Cabezas to the south of the department's capital of Santa Cruz
139 de la Sierra. Most of the area forms part of the Amazon watershed. The tropical climate is sub-humid
140 to the north, and semi-arid to the south of the department, with a rainy season between November
141 and March. Samaipata lies at 1,670 meters m asl in the eastern foothills of the Andes. It has a humid
142 sub-tropical climate, and produces fruits and vegetables sold at the national level. The northern
143 alluvial floodplains of the department (about 200 m asl) were originally home to tropical rainforests,
144 but are now densely cultivated with cash crops (e.g. soybean, sunflower, sesame, sugarcane). In the
145 Cabezas municipality further south, where the dryer Chaco region begins – characterized by a hot
146 climate with seasonally strong winds (Navarro and Maldonado 2002) – cash crops are less densely
147 cultivated but still abundant. Population density in the Santa Cruz Department is low at 9.2
148 inhabitants per km² (National Institute of Statistics 2018). Official documents such as development
149 plans focus almost exclusively on environmental risks, including high or very high risks of droughts
150 and floods² (Plurinational Ministry of Planification 2016), compounded by high deforestation rates
151 in the study area (Gobierno Municipal de Cabezas 2010; Gobierno Autónomo Municipal de San
152 Pedro 2013). Contamination of soil and water from solid waste (e.g. pesticide bottles) are another
153 environmental risk (Gobierno Autónomo Municipal de San Pedro 2013), as is the expansion of large-
154 scale monocultures (McKay and Colque 2015; Suárez et al. 2010; Urioste 2012). Socio-economic
155 risks include the replacement of food crops with soybeans (Suárez et al. 2010), and the exclusion of
156 locals from benefits (McKay and Colque 2015). In Samaipata, wildfires are listed as a risk in addition
157 to droughts and floods, but the overall risk level is deemed low (Gobierno Autónomo Municipal de
158 Samaipata 2016). Oil extraction companies play an increasingly important role in social and
159 environmental conflicts, particularly to the South of the Santa Cruz Department (Humphreys and
160 Bebbington 2010). Finally, Bolivia was highly impacted by the food price crisis of 2007/2008 relative

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)



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161 to other Latin American countries (Cuesta et al. 2013), pointing to the risks of abandoning local food
162 production (McKay and Colque 2015; Castañón Ballivián 2014).

163 In Kenya, we conducted our study in Laikipia, Meru, and Nyeri counties. At the centre of the study
164 area is Nanyuki, the capital of Laikipia County located at 1,986 m asl. The region's tropical savannah
165 climate is strongly influenced by the proximity to Mt. Kenya, with precipitation decreasing markedly
166 at increasing distances from the Mountain. There are two rainy seasons: March–May and October–
167 December. The agroecological zones vary from semi-arid in the lowlands of Laikipia to sub-humid
168 and humid on the slopes of the mountain. Population density is high in the fertile areas of Meru
169 County (320 inhabitants per km²) and lower in semi-arid Laikipia (42 inhabitants per km²). Alinovi
170 (2010) describes a long history of shock and crises in Kenya based on four main, often intertwining,
171 causes: droughts, floods, diseases, and political crises. Kenya is particularly susceptible to droughts,
172 including documented cases in our study area (Aeschbacher et al. 2005; Ifejika Speranza 2013;
173 Wiesmann et al. 2000). Droughts in Kenya are often followed by floods, which have intensified with
174 climate change (Government of Kenya 2013). In addition to the direct environmental risks and
175 hazards associated with climate change, Kenya is vulnerable to climate change-related fluctuations
176 in the price of staple foods, including droughts that impact crop and livestock productivity and
177 constrain access to affordable food. Drought cycles – often associated with famines – have shifted
178 from occurring every 20 years (1964–1984), 12 years (1984–1996), and two years (2004–2006) to
179 occurring yearly (2007–2012) (Ministry of Environment and Natural Resources 2016). In both Bolivia
180 and Kenya, food *insecurity* has been rated as “moderately high” (FAO et al. 2015).

181 **[Figure 2 here]**

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

184 1) An *agro-industrial food system*, present in both Kenya and Bolivia and thus studied in both
185 regions. In Kenya, it involves the production and commercialization of green and leafy vegetables,
186 and links the study region with consumers in Europe. In Bolivia, the agro-industrial food system
187 studied mainly produces soybeans for global export and vegetable oil for the national market, but
188 it also produces some wheat and other annual food crops in rotation with soybean.

189 2) A *regional food system* in our study area in Kenya, with wheat, barley, milk, and meat as the main
190 value chains and involving medium-scale landholders on the one hand, and semi-nomadic
191 pastoralists, on the other. They are part of a larger network of actors in rural, peri-urban, and urban
192 sites involved in processing, trading, retailing, and consuming food in the county capitals of Meru,
193 Laikipia, and Nyeri; neighbouring towns of Isiolo and Karatina; and Kenya's capital, Nairobi.

194 3) A *local food system* in Kenya consisting of short value chains of smallholder farmers, artisanal
195 processors, traders, and consumers of maize, potatoes, fruits, and vegetables. It makes up a
196 significant portion of the local informal trade sector, connecting smallholder households and local
197 markets.

198 4) A *domestic food system* in Bolivia comprising the traditionally subsistence-oriented agriculture of
199 the Guaraní indigenous people in the Chaco region of Santa Cruz. This food system involves a
200 diversity of maize, cassava, peanuts, peppers, beans, fruits, and vegetables and is subject to
201 significant changes. Over the last two to three decades, Guaraní families have shifted from being



202 net sellers and barterers of food to being net buyers, mainly due to work migration related to fossil-
203 fuel exploitation in the region. Nevertheless, traditional agricultural knowledge and cultivation-
204 related identities remain present.

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

210 **Research methods**

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

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

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

241 In Kenya, we administered a questionnaire to 25 smallholders who produced food crops (maize,
242 beans, and potatoes) around the towns of Laikipia and Meru, as well as 20 pastoralists (mainly
243 Maasai) who rear cattle in villages around Illipolei town, and on two cattle ranches. These groups



244 are represented in their roles as producers, distributors and consumers in Online Resource 2.
245 Additionally, we held a focus group discussion with a women's group to represent the consumers'
246 point of view, and on the topic of mutual support during water shortages in Mirichu village, Laikipia
247 East. We further conducted interviews with five managers of horticultural farms, five managers of
248 large-scale wheat farms, and four managers of flower farms who are important employers in the
249 region and simultaneously compete with food producers for water and land resources. We also
250 collected data from four millers, five retailers/middlemen, three wholesalers, six butcheries and five
251 restaurants in towns in the study area. Finally, we collected data from 14 organizations that deal
252 with risk mitigation; this included interviews with relevant NGOs, a nutritional health expert, the
253 national government and county governments of Laikipia and Meru, relevant ministries, and
254 research organizations.

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

260 Results

261 Perceptions of risks and related strategies in the different food systems

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

265 **Agro-industrial food systems (Bolivia and Kenya):** In both settings, farmers and organizations
266 viewed pests and diseases as a major, increasing problem. Farmers also named the high costs of
267 seeds and agrochemicals as a risk. Further, in both countries, NGOs and consumers perceived
268 degradation of natural resources in the agro-industrial food systems – especially soils (Kenya), forest
269 loss (Bolivia) and biodiversity (both settings) – due to input-intensive monocultures. The same actors
270 rated the agro-industrial systems as vulnerable to climate impacts such as droughts, inundations,
271 and extreme weather events. In Bolivia, farmers perceived themselves as being exposed to
272 hazardous agrochemicals, though most viewed their occupation as a soybean farmer as something
273 temporary. The Ministry of Labour cited cases and showed us pictures of pesticide poisoning, but
274 also said that employees of the agro-industrial food system were generally afraid to complain. NGOs
275 perceived risks due to the countries' export-orientation combined with a decrease in area and
276 diversity of local food crops and resulting dependency on international markets. Bolivian
277 agribusiness enterprises saw export restrictions on soybeans as hurting their business, and they
278 anticipated risks from a new law requiring labelling with a yellow triangle all foods with transgenic
279 ingredients as of December 2017. In Kenya, agribusiness experts and exporting actors cited
280 fluctuating currency values as threatening profit margins. Further, agribusiness experts, exporters,
281 and input providers emphasized the challenge of strict export market standards. For example,
282 GlobalGAP³ enforces Maximum Residue Levels (MRLs) for agrochemicals on vegetables, fruits, and
283 herbs, requiring significant investment in efficient production and monitoring of pesticide use.

³ The main pillars are environmental conservation, food safety, and workers' welfare and safety
(<http://www.globalgap.org/>).



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284 Stringent monitoring of MRLs has resulted in a rejection rate of about 20% of the vegetables
285 produced by contracted smallholders we interviewed. Producers also mentioned risks from water
286 shortages, climate change, human–wildlife conflicts, droughts, floods, and pests and diseases. In
287 two studies related to the larger research project, residents in Laikipia County expressed major
288 concern about the health risks of pesticide residues in their food (see Hertkorn 2016) and air
289 pollution from pesticides (see Zaehring et al. 2018) sprayed at agro-industrial farms.

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

315 **Differentiated quality food system (Bolivia):** Producers and consumers who formed part of the
316 Agroecological Platform perceived a multi-layered crisis comprising the environment, alimentation,
317 and health of Bolivians. Consistent with NGOs interviewed, they perceived a corporate food regime
318 that influences people’s views of what constitutes a good diet, resulting in unhealthy and
319 unsustainable consumption patterns. In terms of their own developing network of producers and
320 consumers, the associated producers and traders perceived a lack of established value chains. They
321 mentioned its small share in local markets and emphasized the challenge of competing with
322 conventional produce whose socio-environmental externalities were not reflected in the shelf price.
323 Indeed, consumers regarded the produce as comparatively expensive and thus only accessible to a
324 minority, hampering their overall network goal of transforming local food systems. Finally,
325 producers as well as consumers of the network mentioned that decision-makers were not interested
326 and did not pay attention to such alternative food system initiatives, which was also reflected in



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

335 **Regional (rural–urban) food system (Kenya):** The main risks perceived by farmers and input
336 providers linked to this food system were pests and diseases affecting both crops and livestock. As
337 a result, use of chemicals was deemed necessary, but these, in turn, imposed a heavy financial
338 burden for farmers and pastoralists. Relevant livestock diseases included East Coast fever
339 (*theileriosis*) and foot-and-mouth disease, while crop pests included millipedes and white flies. In
340 addition, soil erosion was seen as a common risk contributing to loss of soil fertility, while wheat
341 farmers associated declines in soil fertility with implementation of monocultures. All five mentioned
342 implementing Conservation Agriculture (CA) practices such as contour ploughing, terraces, and
343 grass strips, but only two implemented minimum tillage and crop rotation. Both crop producers and
344 pastoralists perceived lack of direct links to markets as a serious risk. This necessitated selling farm
345 products at the farm gate to middlemen who bought the products at low prices. Milk producers
346 mentioned dependency on middlemen as a risk to their business. To mitigate disadvantages for milk
347 producers, the Laikipia County government installed milk coolers (with a total capacity of 30,000
348 litres) where farmers could sell their milk for central collection and transport to processing facilities.
349 Farmers have been generally encouraged to form cooperatives to increase their bargaining power.
350 Pastoralists faced risks from an invasive cactus (*Opuntia stricta*) that made rangelands unsuitable
351 for grazing. Overall, however, water scarcity was the main risk to pastoralists and agro-pastoralists,
352 since they lived in the drier lowlands where river discharge was low due to excessive abstraction of
353 water by larger farms upstream (see Dell'Angelo et al. 2016). Other risks included human–wildlife
354 conflicts affecting both pastoralists and wheat farmers. One wheat farmer cited losses of KSH 12
355 million (USD 115,000) per year due to wildlife invading his farm, which borders a large conservancy
356 in Laikipia County. To deal with the risk, he was permitted to radio conservancy authorities that
357 would help him scare the animals away. In cases where compensation of crops or livestock was
358 concerned, managers contacted the Kenya Wildlife Service. An ongoing drought (late 2016/early
359 2017) had intensified conflicts due to animals leaving protected areas in search of water and food,
360 on the one hand, and pastoralists invading farms and ranches to save their livestock from starving,
361 on the other. In some cases, agreements were reached between pastoralists and authorities for
362 ranchers to set aside some sections of their rangeland for grazing. The county government has
363 planted 4,000 acres of grasslands for hay in Laikipia County as a drought mitigation strategy
364 (interview with County Livestock and Fisheries Director 2016). Another risk to wheat farmers was
365 importation of cheap wheat into the country, which forced price reductions on locally produced
366 wheat. Millers mentioned droughts and the inadequate supply of wheat and maize as the main risks
367 for them. Further, diseases and pests, such as weevils that infested maize, contributed to poor
368 quality of wheat and maize.

370 **Local food system (Kenya):** This food system, mainly consisting of smallholder farmers, exhibited
371 the highest susceptibility to risks due to limited mitigation and coping capacities (see Ifejika
372 Speranza 2013). Actors reported frequent crop failures due to long dry spells (January–March;
373 September–October). Smallholder farmers cited lack of access to water as the most serious problem



374 during these months. They attributed water scarcity – causing some rivers to run dry – to declining
375 rainfall as well as to intensive water use by horticulture and flower farmers upstream (see
376 Aeschbacher et al. 2005). One 70-year-old smallholder farmer stated that in 2016 the river near his
377 farm had run completely dry for the first time in his lifetime. Further, both crops and livestock were
378 reported to be increasingly affected by pests and diseases, resulting in major losses. Additional
379 economic losses were reported due to poor post-harvest management on the part of farmers,
380 middlemen, and millers. Limited access to markets typically forced smallholders to sell their produce
381 to middlemen at the farm gate. Further risks mentioned by farmers were biodiversity loss,
382 decreasing farm sizes, resource conflicts between pastoralists and smallholder farmers, and health
383 problems related to pesticides and “modern” diets (see Hertkorn 2016). In response to these risks,
384 smallholder farmers sought to diversify their income sources by means of casual labour on larger
385 farms and enhancement of on-farm income sources, e.g., keeping chicken and livestock (goats,
386 sheep, and cattle such as Borana and Zebu). Interviewed farmers cited low rainfall levels
387 necessitating shifts in planting dates to coincide with changes in the onset of rains, and the use of
388 early maturing crops (potatoes, onions, beans, and maize varieties such as Katumani). Also,
389 smallholders planted grass for their own use and as a source of income (selling hay to pastoralists).
390 Both national and county governments have undertaken programmes to reduce post-harvest losses
391 by means of innovative storage facilities, e.g. by promoting small silos for grain storage at the
392 household level. Efforts to improve access to water have included sharing of water-harvesting
393 techniques (roof catchments, water ponds, and pans for harvesting runoff water), and water
394 projects conducted by members of Water Resource User Associations. Additionally, smallholder
395 farmers have embraced CA practices, increasing maize yields from 1–5 bags per acre to 10–18 bags
396 per acre (interview with CA expert, 2016). An estimated 5,000 acres of land owned by smallholders
397 was under CA in Laikipia. One farmer said that he had always required bank loans before adopting
398 CA methods, but now his income had more than tripled and he never suffered crop failures. He
399 explained that he had been working for 14 years to build the CA capacity of smallholders in his
400 neighbourhood, but that uptake had been low, since CA is a long-term investment. Government
401 cash transfers to the most vulnerable households helped to mitigate the risk of drought. People
402 aged 65 years or older, living with a severe disability, and orphan-headed households were given
403 cash payments of Ksh 2,000 (USD 19.40) per month, or Ksh 4,000 (USD 38.8) every two months
404 within a programme called *inua Jamii* (“lift up a community”). Another important strategy observed,
405 especially in the local food system, was social organization. We identified religious groups, women’s
406 groups, groups related to specific food products (e.g. potato-grower or dairy-farmer groups), and
407 merry-go-round self-help groups (characterized by regular contributions and payouts on a rotating
408 basis), and cooperatives. We observed the maintenance of important social capital, enabling actors
409 to exchange information, money, and credit, among other benefits. This played a crucial role in
410 production and consumption during famines, droughts, floods, and funerals. The groups persevered
411 by means of trust, reciprocity, and mutual understanding. The women’s group mentioned benefits
412 like working for each other on the farms, and exchanging farm tools.

413

414 [Table 1 here]

415 [Table 2 here]

416 Diverging strategies for commonly perceived risks

417 In comparison to people’s risk perceptions, their implemented or envisioned strategies varied
418 largely. For example, smallholder farmers concerned about the risk of soil depletion in the local food
419 system in Kenya sought to address it with CA measures such as the maintenance of soil cover, crop



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

435 Discussion

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

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

- 451 - In the **agro-industrial food systems** in both countries, there was an apparent gap between
452 farmers' perception of pesticide risks (both in production and storage) and actual
453 implementation of corresponding strategies to diminish pesticide use or shift to
454 agroecological alternatives. In Bolivia, relevant actors regarded their involvement in this
455 type of agriculture as strictly temporary. Another contradiction could be seen in the
456 widespread perception of environmental degradation occurring side by side with
457 widespread lack of enforcement of environmental laws (see Gonzales Soto 2016). Finally,
458 consumers (including farmers) expressed concerns about health risks from pesticide
459 residues and consumption of transgenic plants, but, according to the health experts we
460 interviewed, few consumers respond by changing their existing consumption patterns.
- 461 - In the **domestic (indigenous) food system** in Bolivia, a loss of agrobiodiversity and
462 associated knowledge and identity was strongly perceived by many families. At the same



463 time, however, we observed very few attempts (e.g. a school garden) to maintain such
464 knowledge and practice. This loss was even more pronounced in people's consumption
465 patterns: almost no traditional Guaraní dishes were regularly consumed anymore and
466 almost all food was purchased, despite the fact that the Guaraní food culture traditionally
467 provides great independence (Toledo 2016).

- 468 - The **differentiated quality food system** in Bolivia exhibited a paradoxical situation whereby
469 food system transformation was striven for, yet the movement risked becoming accessible
470 solely to medium- and high-income households.
- 471 - In the **regional food system** in Kenya, high use of agrochemicals was viewed critically by
472 those who applied them, yet deemed necessary and without alternatives.
- 473 - Smallholder farmers in the **local food system** in Kenya faced various difficulties: The shifting
474 onset of rains required changes in crop varieties and planting strategies. The farmers
475 reported (and we observed) efforts towards soil cover maintenance, crop rotation, tree
476 planting, compost preparation, etc. However, despite interviewees' awareness of the need
477 for CA and experts' reporting CA-related fivefold yield increases of maize, in reality very few
478 (six of 25 smallholder farms; and two of five large-scale wheat farms) reported
479 implementing CA practices – mainly minimum tillage. Farmers in all food systems were
480 practising some crop rotation. Further, smallholder farmers mentioned risks from
481 pesticides, but nevertheless used WHO-class I (highly hazardous) agrochemicals (Ottiger
482 2018).

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



509 farming families in the soybean areas of San Pedro, Bolivia, the “meaning” of the actions taken
510 (Wiesmann 1998) points to “more of the same”, rather than transformation, due to an apparent
511 lack of opportunity resulting from productive exclusion.

512
513 There is also evidence of risk perceptions leading to successful transformation of food systems in
514 response, however, including in our case studies. Sage (2014: 16) studied the transition movement
515 in Great Britain and described it as a “cosmology that can bring together perceived external threats
516 with a set of responsive activities”, eventually increasing local resilience as well as global
517 engagement among its members. According to the author (ibid.), the transition movement was
518 driven by the question of what could be done about a perceived multi-pronged crisis – similar to the
519 driving sentiment behind the differentiated quality food system we studied in Bolivia. Though much
520 smaller and still in its starting phase, the differentiated quality food system we observed in Bolivia
521 is consistent with Sage’s description (2014:262) of a movement based on local people’s wish to
522 regain “control over essentials (food, water, energy); and [to] work with others to build social
523 capital, resilience, and community security”. Sage (2014) adds that such local food systems do not
524 automatically lead to greater social justice; however, by building understanding and appreciation of
525 territorial attributes, they can help reconnect local people to ecological and seasonal patterns as
526 well as enable a common vision of what good and appropriate food means.

527
528 What are the implications of these considerations for sustainable, resilient food systems? If we take
529 the differentiated quality food system as an example – motivated, as it is, by perceptions of a multi-
530 layered food system crisis – we see that, as long as the abilities of relevant actors are not too
531 constrained (e.g. according to the structural factors in Wiesmann’s Theory of Action, or political-
532 economic factors in Altieri’s framework of perceived risks and related strategies), such perceptions
533 can indeed be a driver of transformation. Similarly, other factors identified as crucial to food system
534 resilience in the literature are local identity and place attachment, which function as forms of social
535 capital (Bahadur et al. 2013; Hendrickson 2015) and provide the basis for senses of community and
536 civic participation. In order to address the risk perception paradox, Wachinger et al. (2013) suggest
537 that public participation measures are likely the most effective means of creating awareness about
538 potential disasters, enhancing trust in public authorities, and encouraging citizens to take more
539 personal responsibility for safety and disaster preparedness. This is an important observation with
540 respect to the differentiated quality food system: According to members of the Agroecological
541 Platform, lack of recognition from public authorities was a major limiting factor and a key reason
542 why their movement has remained small.

543 With regard to food system risks frequently mentioned in the literature on food systems in general
544 – and on Bolivia and Kenya specifically – there are several social-protection mechanisms and food-
545 and nutrition-related mechanisms that may be used to address the risks. Examples in Kenya include
546 grain storage facilities for small- and medium-scale farmers and, in Bolivia, a crop-insurance system
547 at the production level, as well as monthly food packages for pregnant and breastfeeding women.
548 Finally, government-run cash payments and food aid represent further relief systems capable of
549 supporting communities affected by natural disasters. Going beyond risk mitigation and food aid,
550 food systems must actively build resilience in order to cushion against shocks and recover from
551 them. Our six case studies revealed certain similar risk factors, perceived by different actors, which
552 indicate possible adaptation strategies capable of enhancing elements of resilience. In a separate
553 study, we assessed elements – or distinct indicators – that contribute to resilience in food systems
554 (Jacobi et al. 2018). In that study, we concluded that more attention and better support (e.g. policies



555 and regulatory enforcement) are needed to achieve ecologically sustainable, economically viable,
556 and socially just food systems (see Hodbod and Eakin (2015) who ask “resilience for what?”) that
557 possess sufficient *buffer capacity*, *self-organization*, and *capacity for learning and adaptation*
558 (Jacobi et al. 2018). Further, we found that resilience thinking applied to food systems research can
559 help to overcome simplistic (e.g. productivist) approaches by shedding light on the
560 multidimensionality of risks and opportunities in food systems (ibid.).

561 Conclusion

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

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

593 Finally, one key overarching challenge to resilience building within food systems – identified in the
594 literature – is the traditional separation of governance between production, distribution, and
595 consumption (Hodbod and Eakin 2015). In our study, we observed that actors develop a range of
596 risk-mitigation strategies within their (perceived) possibilities, but can seldom ameliorate all the
597 risks sufficiently on their own – much less build preventive strategies. Food system approaches are



598 needed that operate at every level, for example, reducing emergencies via disaster-risk reduction
599 programmes, or reducing people's vulnerability via targeted social-protection systems. Multi-level
600 food system approaches must be enhanced and scaled up to comply with UN Sustainable
601 Development Goal numbers 2 and 12.

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783 **Figure 1** Conceptual framework of perceived risks and related strategies in food systems. Adapted from Altieri
784 (2013) and combined with Wiesmann's strategy of action concept (1998).

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

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

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

789 **Online Resource 1** Food system actors studied in Bolivia

790 **Online Resource 2** Food system actors studied in Kenya

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