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Learning and Adaptation in Food Systems: Insights from Four Case Studies in the Global South

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ABSTRACT

This article presents empirical results on learning and adaptation to risks among different groups of actors in food systems in two countries of the global south (Kenya and Bolivia). Using a resilience approach, the study sought to assess knowledge about risks perceived by actors, forms of learning that actors in food systems have access to and use, and how this knowledge and learning has contributed to adaptation and resilience building. Data were collected through questionnaires, interviews, farmer meetings, workshops, and participant observation. The target population was different groups of actors in agroindustrial food systems in both countries, a regional food system in Kenya and an agroecological food system in Bolivia. The results show that knowledge on threats came from the actors' experience and interaction with external actors. The main risks identified in Kenya and Bolivia included climate change impacts – particularly extreme climatic events (floods and droughts) –, price fluctuation of food products, declining soil fertility, deforestation, and –in Kenya– human-wildlife conflicts, and conflicts between actors over resource use. The most important forms of learning were experiential learning through demonstration farms, social learning exemplified in group approaches, and learning at individual levels through information exchange between farmers and external actors such as extension personnel, research organisations and non-governmental organisations. There is potential to enhance adaptation strategies whose knowledge has been acquired over the years, to build resilient food systems necessary for dealing with current and future shocks and stress.

Keywords: *Food systems; Learning; Adaptation; Resilience; Global South*

1 Introduction

Food systems across the world face various risks that stem from social, ecological, economic and political factors, and their complex interactions. Such risks can occur at different stages of agri-food value chains and may affect extensive regions such as in the food price crisis of 2008, or specific regions e.g. through natural hazards (Wiggins et al., 2010). Natural hazards and disasters have affected 1.9 billion people and cost economies of developing countries USD 494 billion from 2003 to 2013 (FAO 2015). In Sub-Saharan Africa, droughts affected 150 million people costing the agricultural sector (crop and livestock production) USD 23.5 billion, representing 77% of all losses experienced globally during the same period (ibid). As climate change intensifies, more extreme climatic events are likely to occur with adverse effects on water and food security and general livelihoods of urban and rural poor in developing countries (Sivakumar, 2005; IPCC 2007; Mueller and Osgood, 2009; McGuire, 2015; Miyan, 2015).

Jacobi et al. (2019) documented the risks that affect food systems in the two countries Kenya and Bolivia, as part of a larger research project (Rist et al., 2016). Both Kenya and Bolivia pursue a similar political-economic focus of exporting agricultural goods, while being net-food importing countries with a high Global Hunger Index, prevalence of malnutrition, a high Gini coefficient and persisting poverty (Global Hunger Index, 2019; World Bank, 2020). The two countries face similar challenges in the food and agricultural sector due to the pressure of international food and commodity prices, the loss of subsistence farming, and of traditional crops and knowledge, and an excessive use of agrochemicals (Jacobi et al., 2019). Other risks that both countries face include extreme climatic events such as floods and droughts, pests and diseases, declining soil fertility, land degradation, social conflicts and demographic changes (IPCC 2007; Cordell et al., 2009; Deressa et al., 2009; UNEP, 2011; FAO 2011). These risks and shocks may affect the stability of ecological and social systems limiting their capacity to provide food security and wellbeing. Generally, risks can be grouped into natural disasters, resource scarcity and environmental variability (water scarcity, declining water quality, climate variability); social change (demographic change, migration, urbanization, health risks, economic crisis); institutional change (change of policies and legal frameworks); economic change (price fluctuation), and political change (politically instigated conflicts) (Turner et al., 2003; Perz et al., 2010; Bouzarovski et al., 2011; Schwarz et al., 2011; Gooch et al., 2012).

In both Kenya and Bolivia, access to and availability of production assets is becoming increasingly difficult for the local population. Furthermore, challenges such as land concentration, population pressure, soil degradation and the resulting competition, especially regarding land and water, by different actors are affecting many communities in their ability to provide food security and recover from shocks (Castañón Ballivián, 2014; Kiteme and Wiesmann, 2015).

According to Colonna et al (2013:69), food systems are interdependent networks "of stakeholders (companies, financial institutions and public and private organizations), localized in a given geographical area (region, state, multinational region) participating directly or indirectly in the creation of flow of goods and services geared towards satisfying the food needs of one or more group of consumers, both locally and outside the area considered". Resilience in food systems is the capacity of actors and agroecosystems to maintain their functions and structure after a shock and for social actors to learn and adapt (Ifejika Speranza et al., 2014; Jacobi et al., 2018). Resilience measures the amount of change a system can undergo and still retain its function and structure, the degree to which the system is capable of self-organization and its ability to build and increase its capacity for learning and adaptation (Folke et al., 2010; Cabell and Oelofse, 2012). In other words, resilience is the system's ability to rebound, return, or recover to its original state, structure, equilibrium, or state of nature or to persist, maintain or retain its ability. What this means is that a socio-ecological system has "the capacity to change in order to maintain the same identity" (Folke 2006; Folke et al., 2010). Since resilience relates to disturbances or risks, the social system, in this study the different groups of actors, must have the capacity and be willing to learn about the risks, adapt and self-organise. Social-ecological resilience thus encompasses adaptive capacity, transformability and learning innovation (Folke 2006).

Learning is crucial to building resilient food systems since it contributes to adaptations and sometimes innovations that are necessary in dealing with uncertain, changing social-ecological environments. To learn and adapt is to a large extent determined by the institutional context for knowledge sharing, learning, and management, and partly by the social capital that people possess, and by social actors' interactions with those who possess the knowledge (De Kraker, 2017). According to Osbahr (2007), successful adaptation is a learned process in which there is some form of communication through which information is passed. Actors in food systems may learn from past mistakes and events and make informed decisions to deal with risks (Adger, 2003; Berkes et al., 2003). Learning means taking stock of past, present and potential risks; getting the right information, reflecting and innovating practices and making decisions that reduce potential harm from risks (Tschekert and Dietrich, 2010). Actors learn from local knowledge through interaction with elders who pass on a wide range of knowledge including farming methods, weather dynamics, management of pests and diseases, food preservation and processing among others. According to Warburton and Martin (1999), local knowledge is based on experience, often tested over centuries of use, adapted to local culture and environment, embedded in community practices, institutions, relationships and rituals, held by individuals, and dynamic and changing with time.

In this study, we examine both learning at an individual level (experiential and transformative learning) as well as at a group level (social learning). The objectives of the study were a) to assess the knowledge on risks and forms of learning that groups of actors in food systems have access to and use, b) to assess how this knowledge and learning has contributed to adaptation and resilience building, and c) to examine how learning and adaptation determines resilience of food systems in Kenya and Bolivia.

2 Literature Review

Several studies have looked at factors that promote resilience against risks and disasters. They include community connectedness (Batch et al., 2010; Thornley et al., 2015), infrastructure (Hallegatte, 2009; Thornley et al., 2015), support from government agencies (Adger, 2000a; Adger, 2000b), governance (Rist et al., 2007), social protection systems (Holmes and Bhuvanendra, 2013), and social self-organisation (Mukhovi et al., 2020). Other studies have looked at effects of globalization and livelihood resilience (Tanner et al., 2015; Ifejika Speranza et al., 2014) and food sovereignty (Sage, 2014). In this study, we looked at how learning contributed to adaption and resilience by using learning and adaption indicators. Although resilience has been studied in natural ecosystems such as coral reefs and forests (e.g., Nyström et al., 2000; Chapin, 2004), it has only started to be studied in food systems. Food systems are as dynamic as natural systems, hence the importance of resilience also as a way of cushioning actors against risks and maintaining provision of supplies of food, fodder and fibre, as well as incomes of rural communities.

Adaptation can be regarded as adjustment that is deliberately taken to deal with observed or expected changes in order to build resilience (Wilder et al., 2010; Tendall et al., 2015). The purpose of adaptation is to maintain the capacity to deal with actual and potential risk, reduce vulnerabilities and enhance resilience. Two main types of adaptation are identified in the literature, reactive adaptation and anticipatory adaptation (de Bruin 2011; Kuruppu and Willie, 2015). In reactive adaptation, social actors cope with and overcome immediate threats using available resources. In other words, individuals and groups are able to maintain some level of wellbeing after a disaster, without making significant changes in their food system (Tschakert and Dietrich, 2010; Wambui Ngaruiya, 2014). Anticipatory adaptation is a deliberate effort to reorganize the food system through self-organization, building livelihood assets, and learning in order to deal with risks (Boyle and Dowlatabadi, 2011; Jacobi et al., 2018; Mukhovi et al., 2020). Anticipatory adaptation is a more long-term effort geared towards building resilience (Tschakert and Dietrich, 2010). Anticipation is an attempt to imagine, forecast, and benefit from the future (Boyd et al., 2015). Anticipation helps to raise awareness about the future, and to sensitize society to the consequences of choices and actions that individuals and societies should take to deal with change, a characteristic that is important in building resilient communities and food systems (Berkes et al., 2003; Almedom et al., 2007; Krasny et al., 2010; Martin-Breen and Anderies, 2011).

To anticipate, one must have relevant skills, experience, and knowledge (Boyd et al., 2015; Himanen et al., 2016). In food systems, adaptation involves multiple social actors making decisions about multiple risks that affect them. The essence of making changes is to avoid crossing into an undesirable state of vulnerability or disaster. Another term that has become important in adaptation is transformability (Folke et al., 2010). According to Walker et al. (2004), transformability refers to the ability to create new systems when conditions (socio-economic, political and ecological) become unsustainable. In other words, transformability is a process that 'alters the fundamental attributes of a system to form a completely new system' (Walker et al., 2004; Folke et al., 2010). Decision-making is important in both adaptation and transformation and involves learning to deal with changes that adversely affect food systems (Osbahr, 2007; Osbahr et al., 2010).

Several forms of learning can be differentiated: experiential learning (learning by doing to create knowledge); transformative learning (leaning as a reflective process); and social learning (learning by sharing experiences, ideas and environments with others) (Keen and Mahanty, 2006; Armitage et al., 2007; Mukhovi et al., 2020; Mezirow, 2000; Leeuwis and Pyburn, 2002; Keen et al., 2005). Three theories help to explain these forms of learning, namely**:** social learning theory (Argyris and Schon, 1978; Keen et al., 2005; Armitage et al., 2007)**,** transformative learning theory (Mezirow, 2000), and experiential learning theory (Kolb, 1984). Social learning theory explains the learning that takes place in a group context such as organizations, in this study farmer groups (King and Jiggins, 2002; Fazey et al., 2005; Armitage et al., 2008; Mukhovi et al., 2020). We define social learning as creating space for transforming strategic action into communicative action, oriented towards a common understanding of the situation in which actors are finding themselves, as a basis for collective action

(Rist et al., 2006). According to Woodhill (2010:63), social learning is a ‘‘process by which society democratically adapts its core institutions to cope with social and ecological change in ways that will optimize the collective wellbeing of current and future generations’’. Keen et al. (2005) looks at social learning as a process of iterative reflection that occurs when we share our experiences, ideas and environments with others. Social learning is about individuals and groups (actors) making decisions together about the direction to move, meant to bring about social change in a community or society (Woodhill, 2002; Diduck, 2004; Mukhovi et al., 2020).

Transformative learning on the other hand, involves a change in individual’s perceptions to the extent that they are able to come up with completely different ideas about their condition-including agro-ecosystems (Mezirow, 1995; Mezirow, 2000; Armitage et al., 2007; Christie et al., 2015). Transformative learning leads to a total shift in the way activities are carried out while experiential learning is “task-oriented, problem-solving actions to improve the performance of current activities, while communicative learning relates to the ability of individuals to examine and reinterpret meanings, intentions and values associated with actions and activities” (Mezirow, 1995; Armitage et al., 2008).

3 Materials and Methods

3.1 Study sites

The study was carried out in the Northwest Mt. Kenya region, which is located on 0^0 7’North and latitudes 37^0 40’ East, and in the Santa Cruz Department in Bolivia, whose capital city, Santa Cruz de la Sierra, is located at 17°48’South and 63°11’West. The study was conducted among actors at different stages of food systems, from production to consumption.

The two case studies from the global south allow us to compare how food systems actors are approaching threats emanating from climate change to provide lessons for the two regions. Kenya and Bolivia both have a large bio-cultural diversity, which is expressed in food systems as agrobiodiversity and food traditions. At the same time, both have significant agribusiness development ongoing in the study areas. Even more important is the fact that both countries are among the few countries that have the right to food in their constitutions (Bolivia, 2009; Kenya, 2010), which allows to take aspects into account such as access to land and water, or women's rights in food and agriculture. Therefore, even though the countries are in very different contexts, they are comparable external drivers and policy environments shaping their food systems (Jacobi et al., 2019; Mukhovi et al., 2020).

In both countries, agriculture plays important role in the economy contributing 26% and 13% of the GDP in Kenya and Bolivia respectively (Cuesta and Svetlana, 2011; Poulton and Kanyinga, 2014). Additionally, the majority of the people in the rural areas of the two countries depend on agriculture as main source of livelihood. The main crops include maize, beans, potatoes, cassava, fruits and vegetables, while livestock production also forms an important part of agricultural production.

3.2 Research Methods

This paper is part of a series of papers on research project; “Towards food sustainability: Reshaping the coexistence of different food systems in South America and Africa”. In this paper we discuss learning and adaptation in four food systems; an agroindustrial food system based on horticulture, and a regional based on milk, beef wheat and barley in Kenya, and an agroindustrial food system based on soybeans and an agro-ecological food system (“differentiated quality”) food system in Bolivia (Table 1). The food systems were defined following Colonna et al., (2013) who distinguishes five prototypes of food systems (agroindustrial, regional, domestic, local and agroecological food systems). This classification is reflected in the context of the study areas in the two countries.

Table 1.
Food systems in Kenya and Bolivia

Country	Food system	Characteristics
Kenya	Agroindustrial food system: Horticulture	Production of vegetables for export to European markets
	Regional food system: Beef, milk, wheat and barley	•Products sold beyond county boundaries •Beef produced by ranches and pastoralists and to a small extent smallholders •Milk largely produced by smallholders •Wheat largely produced by large scale farmers and smallholders
Bolivia	Agroindustrial food system: Soy bean value chains	•Production and processing of transgenic soy beans; export-orientation •Some production of wheat for the national market, •Characterized by land concentration and foreignization (Urioste 2012); •highly dependent on external inputs
	Agroecological food system: "Agroecological Platform"	•About 30 members (from producers to consumers, including local policy makers) in and around the city of Santa Cruz with their own "identity label" ("agroecological product"), •Organizing monthly fairs and selling points for agroecological produce.

In Kenya, data were collected using a semi-structured questionnaire administered to 20 pastoralists (mainly Maasai) rearing beef cattle in villages around Illipolei , 25 smallholders producing milk and two cattle ranches, all in Laikipia County. The information was complemented by interviews with five managers of horticultural farms and six large-scale wheat farms. We also collected data from relevant institutions that deal with resilience building, food security and livelihoods through interviews with relevant non-governmental organizations (NGOs), and with the County governments of Meru and Laikipia, Departments of Crops and Livestock in the Ministry of Agriculture, Livestock and Fisheries, Horticulture Development Authority, Kenya Agriculture and Livestock Research Organisation (KALRO), Agriculture Sector Development Support programme (ASDSP), Kenya Plant Health Inspectorate Services (KEPHIS), Fresh Produce Exporters Association of Kenya, and representatives of County governments of Meru and Laikipia among others.

In Bolivia, research was carried out in the Santa Cruz Department and involved 1) an agro-industrial, export-oriented food system consisting mainly of soybean value chains. The system also produces wheat and other annual crops in rotation with the soybeans; 2) an agroecological food system, represented by an initiative called "Agroecological Platform", a network of producers and consumers who produce, distribute and consume organic food (fruit, vegetables, and processed food) with their self-defined rules and certification system, and their own label. We conducted 29 interviews on different aspects of resilience including learning and adaptation with a variety of food system actors from producers to market vendors, restaurants, consumers, and local politicians, as well as research organizations and NGOs. The topics were deepened by participant observation in four fairs (one in the agroindustrial, and three in the agroecological food system), and in two information events of the agroindustrial food system and one assembly in the agroecological food system, bringing together producers, consumers and other actors of the respective food system.

In this study, we focus on sources of knowledge for threats, forms of learning, and indicators for adaptation in our study areas (see Cabell and Oelofse, 2012; Berkes, 2000; Jacobi et al., 2018) (Table 2). In addition, we examined the types of lessons learned from risks and whether this informed new ways of food production, processing, storage, consumption and lastly how this affected resilience. In other words, this means that we are interested in linking the resilience of the food production side of the food systems with its other food activities, represented by processing, storage, and consumption. This implies taking into account that resilience of the food activity of production interacts positively, neutrally or negatively with factors emerging from how food is processed, stored or consumed.

Table 2.
Indicators for learning and adaptation

Learning Capacity	**Knowledge of threats and opportunities (Exposed to disturbance)**	**Ability to assess, manage, and monitor risks / threats/potential opportunities (e.g. threats to production and opportunities to increase production over the last 12 months)**
	Social and human capacities	Support for social events in farming communities, programs for preservation of local knowledge, knowledge production/sharing/accessibility
	Reflective and shared learning	Individuals and institutions learn from past experiences and experiment to anticipate change and create desirable futures; Shared societal/collective vision, commitment to learning, awareness programs (Jacobi et al., 2018)
	Functioning feedback mechanisms	Information sources and access; frequency of interaction with key actors (e.g. farmers, extension officers, district agricultural officers, local politicians, ministry directors, researchers, input traders, others), new ideas and practices farmers learnt from these actors (Jacobi et al., 2018)
	Knowledge legacy, identit	Biological and cultural memory embodied in a system and its components. Engagement of elders, incorporation of traditional cultivation techniques with modern knowledge. Culture and traditions, local knowledge, and institutions. The knowledge of elders is another form of legacy (Orlove et al., 2010; Altieri and Nicholls, 2017; Jacobi et al., 2018)
Adaptation	Diversification of Income sources	Diversified sources of income including diversification into non- farm sources (Brooks and Adger, 2005)
	Irrigation	Presence of irrigation activities to reduce vulnerability of rainfed food production systems (Pitesky et al., 2014)
	Rainwater harvesting technologies	Presence of rainwater harvesting technologies as a way of dealing with risk of water shortages
	Drought tolerant crops and animals	Presence of drought tolerant crops and animal breeds
	Changes in cropping patterns	Shifting of planting dates and changes in crop varieties and combinations (also agroforestry)
	Soil erosion control measures, agroforestry, planting of trees	Presence of soil erosion control measures (terraces, soil bunds, grass strips, gabions), agroforestry, and planting of trees shows actors response to declining soil fertility as a risk and evidence of this is an indicator of adaptation
	Integration of livestock with crop production	Evidence of integration in food production system activities

4 Results

The results are organized in four sections: 1) Threats to food systems and sources of information about threats, 2) forms of learning, 3) knowledge legacy and identity, and 4) contribution of learning to adaptation and resilience.

4.1 Threats to food systems and sources of information

In Kenya, the actors in the agroindustrial food system identified several, mainly ecological risks (droughts, floods, pests, frost), and those related to natural resource scarcity and environmental variability (climate change and variability, water scarcity, land degradation). The knowledge about the threats came from the actors' experience, interaction with external actors, and mass media (radio and television) (Table 3). In the agroindustrial food system, all actors interviewed largely depended on external knowledge, which they received from suppliers of chemicals, fertilizers and seeds. They maintained contacts with consumers and breeders who updated them on new developments by use of e-mails and telephone calls.

The actors at transport and processing levels of food systems in Kenya reported a reduction of food transported and processed during times of risks and shocks. The most important threat to millers were droughts. During droughts, millers sought for imported maize and wheat from the Mombasa port along the coast of Kenya.

However, wheat producers complained about flooding of the market with imported wheat, sold at cheap prices, indicating that millers preferred to buy imported wheat to make profit. However, sometimes the government provided a subsidy on maize flour (used to make staple food) to cushion consumers against high prices set by the Cereals Millers Association. At the consumption level, the nutrition status was adversely affected as people consumed food of low nutritional value that was cheaply and readily available (Hertkorn, 2016[1]). For instance, maize, beans, potatoes and vegetables were reported to always be in short supply during droughts and therefore expensive, hence people consumed traditional food crops that survived long dry spells such as sweet potatoes, sorghum, millet, bananas, cassava and arrowroots and those who could afford bought sifted maize flour from the shops at higher prices (Hertkorn, 2016). However, such traditional foods, although acknowledged by actors to have been more nutritious, were not widely consumed due to the preference of "modern" diets (especially by young people and urban dwellers) comprising of rice and wheat-based foods.

In Bolivia, the actors regarded the agroindustrial food system as ecologically and economically vulnerable, but regarded the soybean industry as "too big to fail" (i.e., so big that it will persist). NGOs calculated that in 1985, around 15 kg of pesticides per ha were used, which has risen to more than 60 kg per ha in 2015. They also estimated that more than 70% of the adjacent communities of the soy fields drink contaminated water (NGO Probioma, personal communication). Non-communicable diseases were on the rise; people sold what they produced for export and bought imported food of low nutritional value. Inputs as well as purchase of yields were controlled by few transnational companies (McKay et al., 2015) who established production models where local farmers provided them with their land and work force (Hirsig and Märki, 2016). According to local NGOs, nutritional health of the communities in the soybean zones was poor. Although non-communicable diseases and parasites were among the highest in the country, nutritional awareness was also described as very poor (NGO Fides, personal communication).

The differentiated quality or agroecological food system "Agroecological Platform" in contrast, was established out of an awareness and concern of dietary uniformity, pesticide overuse, and a loss of traditional crops and dishes. Connections with markets were described as difficult, but knowledge inputs came from international networks and learning events within the network. Producers in this food system reported, for example, that they were tired of seeing other producers spraying pesticides on their tomatoes every day, and that they were aiming at providing alternatives to producers and consumers.

The results show that in Kenya, the main source of information was the radio followed by farmer groups and other farmers and extension service (Table 3). The agroindustrial and regional food system mainly interacted with private companies especially those that deal with supply of inputs as well as government regulatory agencies. In agroindustrial food system, the companies that delivered vegetables at the airport for export received feedback from the Kenya Bureau of Standards (KBS) and the Kenya Plant Health Inspectorate Services (KEPHIS) on rejected vegetables that did not meet the phytosanitary requirements, Maximum Residue Levels (MRLs), optical perfection (e.g. shape and color), and other standards set by importing countries. Phytosanitary certificates were issued for export consignments of vegetables meeting the quality standards (hygiene, workers' safety including pesticide storage and handling, waste management and transparency, among others). Vegetables failing to meet the GlobalGAP and other regionally imposed (e.g. EurepGAP) standards were destroyed or prohibited from leaving the country, the feedback provided was important for enhancing the quality of vegetables produced (Ministry of Trade and Industry, 2005). Rejected vegetables were reported to be around 20% of the total (Jacobi et al., 2019), and the risk of the rejection was borne by farmers including smallholders participating in contract farming. In addition, a Quality Management System (QMS) developed by Horticultural Crops Development Authority (HCDA) in collaboration with other actors in horticulture sector ensured adherence to safe use of recommended pesticides, traceability and remedial measures for sustainable vegetable value chains.

The agroecological food system in Bolivia had a feedback-based certification system: The producers themselves were the certifiers and the rules were open to adaptation upon the feedback from the members. Expenditures for certification were covered by a subscription fee. Certification of producers in remote areas was a challenge, but some municipalities had designated some budget to support agroecological production and certification. The producers of the Agroecological Platform were rather sources of knowledge for others than demanding extension services for themselves.

[1] Marie-Luise Hertkorn-Master Thesis in the project "Towards Food Sustainability: Reshaping the coexistence of different food systems in South America and Africa."

All of them were frequently visited by other producers, schools, interns and other groups. These visits were organized informally, and because the producers were locally and nationally renowned. Producers of the Agroecological Platform also mentioned ecological feedback mechanisms, e.g. in terms of pests and diseases.

They reported not having many problems with pests and diseases as their production systems were very diverse, which caused less pressure from pests and diseases, while in the other two food systems, pest and disease outbreaks were a major problem.

Comparing the situation observed in Kenya as well as Bolivia, we see that climate change was frequently mentioned as a major risk, but while actors of the agroindustrial food system in Bolivia suggested to use better adapted seeds (including genetically modified), the regional food system based on wheat in Kenya had adopted conservation agriculture. We observed similarities in agroindustrial food systems in the two countries with regard to information sources and feedback mechanisms. The strong link with external actors created a system of information exchange that informed decision making on improvement of performance of seed and agrochemicals. For instance, actors at the production level informed the input suppliers about emerging pests and diseases, resistances to agrochemicals and performance of seeds and agrochemicals. In the agroindustrial and agroecological food system in Kenya and Bolivia respectively, an elaborated monitoring system allowed for feedback between producers and regulators (Kenya), and between producers and consumers (Bolivia).

Table 3.
Sources of information for farmers in Kenya and Bolivia

|Food system	Main sources of information	Common sources across food systems and Countries
Kenya		Middlemen/brokers Private companies Other farmers Workshops Mobile phone
Agro-industrial food system: Horticulture	Internet, workshops, mobile phone, private companies, television, newsletters, newspapers,	
Regional food system: Wheat, barley, meat and dairy	Workshops, elders, private companies, workshops, middlemen, other farmers/pastoralists, television, own experience	
Bolivia		
Agroindustrial food system: Soybean value chains	Private companies, middlemen, other farmers, farmer field schools, mobile phone	
Differentiated quality food system: "Agroecologial Platform"	NGOs, Radio, workshops, other farmers, farmer field schools, mobile phone, internet, own experience	

4.2 Forms of learning

Learning through experimentation is an important process through which shared reflective and learning can take place. There was shared learning between the external actors and the farmers through exchange of local knowledge (by farmers) and scientific knowledge (from experts). Demonstration farms were found to be important avenues through which smallholders acquired new knowledge. Some wheat farms collaborated with the Kenya Agricultural and Livestock Research Organization (KALRO), which had a demonstration farm where they grew wheat varieties on trials. There were also field days organized by one of the farms where actors from small, medium and large farms visited to learn about emerging technologies. During such field days, companies that supply inputs demonstrated their commodities and showcased good agricultural practices in demonstration farms. In one of the field days, 700 participants from large wheat farms in Mt. Kenya region, and 500 participants from small scale farms participated (interview with an extension personnel in the farm where the field school was held).

Reflective and shared learning was strong in Bolivia in the agroindustrial and the agroecological food systems. By contrast, we found a range of actors in the agroindustrial food system who engaged in reflective and shared learning. For example, the nation-wide rural womens' group *Bartolinas* in Santa Cruz (most of the Santa Cruz members form part of the agroindustrial food system) visited schools to influence the composition of the school meals and to teach the children on healthier diets (Mukhovi et al., 2020). As responses to previous droughts, we learned that producers had installed water harvesting ponds (which they had learned from Japanese settlers) on 10 000 ha, some with the help of the government. NGOs reported success where they taught people not only to produce, but also to cook vegetables, and reported much interest in planting leafy vegetables, root vegetables and fruit trees in villages in the soybean areas, where access to such food products was extremely scarce. More in the sense of the agroecological food system, Slow Food Bolivia reported how a critical mass of food movements began to form in Bolivia. They reported successful projects such as "zero kilometres food" or the organization MIGA (Bolivian Movement of Gastronomic Integration).

Social learning through group approaches was also mentioned by actors in all food systems especially at the production level. There were various groups of actors based on single crops such as potatoes, tomatoes, fruit crops among others who exchanged knowledge on best practices in production, control of pests and disease and access to markets (Mukhovi et al., 2020). In the agroindustrial food system, learning was exemplified in workshops organised by companies themselves as well as agro-chemical companies. There was at least one workshop every month in horticultural farms. Among the benefits of belonging to groups were learning of new technologies and use of machinery, access to water, and access to information (Mukhovi et al., 2020). Additionally, there were several events in which farmers participated where knowledge was shared. These included school events, tree planting, water projects meetings, field days and environmental days. Among the farmers/pastoralists interviewed at least 50% have attended such an event in the year preceding the study. Some of the technologies used in wheat farms included conservation agriculture, use of Global Positioning System (GPS) and traffic control farming. During one agricultural event attended by one of the authors, in Kenya, various actors showcased different ways of production, processing, storage of crops and animal feeding, rainwater harvesting technologies, conservation agriculture, fish farming and emerging high value crops and fruits as a way of teaching farmers on how to deal with challenges of climate change. Students from neighbouring schools visited the event to learn about the vision for the County in terms of the food and agriculture sector. The most interesting thing about such agricultural events, was that they were held on farms of progressive (innovative) farmers on a rotational basis, and extension personnel were mandated to select the farmers in the wards under their jurisdiction. This way, farmers learned from each other, and from external experts.

In Bolivia, the agroecological food system formed part of a larger international network where knowledge was self-organized, sometimes with the support of NGOs. In Bolivia, already more than 5000 ecological producers were certified with a state-organized Participatory Guarantee System, which had some extension programs but was still very small (10 staff for the whole country). There were several organizations related to international food movements such as Slow Food Bolivia, who organized cooking lessons and awareness raising for “forgotten fruits”, such as chillto (*Physalis peruviana*), ajipa (*Pachyrhizus ahipa*) and yacón (*Smallanthus sonchifolius)*. They and the owner of a restaurant which forms part of the Agroecological Platform confirmed that people were increasingly interested in trying new things, and grateful for a high quality of the food. The agroecological food system shared knowledge on environmental friendly production and consumption by organising monthly and sometimes weekly farmers’ markets, where they showcased their products. This determination of the actors in this food system had led to the declaration of the Samaipata municipality as an “Ecological Municipality”, pointing to political support of this food system. Transformative learning was mainly experienced through external actors who provided new innovation in terms of seed varieties, new crops, greenhouse farming, farming methods and irrigation techniques. In Kenya, this knowledge was acquired from extension personnel, researchers and non-governmental organisations. In the agroindustrial food system, some producers had changed to environmental-friendly production methods such as the use of bio-pesticides as a result of pressure from the consumers.

4.3 Knowledge legacy and identity

With the goal of determining the extent and roles of knowledge legacy and identity, we looked at engagement of food system actors with elders, incorporation of traditional cultivation techniques, use of culture and traditions in production and processing, local knowledge and institutions. The results from Kenya show that scientific knowledge is the most preferred especially among more than 95% of actors in horticulture and large scale wheat farms. On one of the wheat farms, the manager said he learned farming from his grandfather-indicating the relevance of knowledge from elders as an important aspect of learning. In addition, local knowledge was common among the pastoralists, who used traditional medicines to treat livestock diseases.

Although we could not identify any particular identity in the agroindustrial food system in Bolivia certain identity-movements were taking place e.g. of rural faming women’ groups who tried to promote women’s’ autonomy and inform rural women about their rights and laws to enforce them (see Mukhovi et al., 2020). Traditional dishes seemed to be completely replaced by nutrient-poor, “modern” dishes and fast foods in urban areas in both countries.

4.4 Contribution of learning to adaptation and resilience

Due to numerous threats, the actors have learned to store food and water (to use during droughts), control soil erosion (to deal with land degradation), weather monitoring (agroindustrial and regional food systems), retain livestock and sell later (regional food system based on beef-pastoralists), conservation agriculture (regional food system based on wheat). The majority of the actors mentioned the following adaptation strategies: small-scale irrigation, planting drought resistant local varieties, use of bio-pesticides and integrated pest management, buying and storing grains, use of conservation agriculture technologies, and storage of harvested grains until prices improve (Table 4).

Based on the study from the two countries, we observed that learning was an important process that contributed to adaptation and resilience. The actors made decisions whether they could put into action what they had learned or not and there were several variables that contributed to the ability to adapt to changes. In the agroindustrial food system in Kenya, learning has been a continuous process through strict certification systems based on hygiene and workers' safety. Several certifications were identified namely; Export licences from HCDA, phytosanitary and conformity certificates from KEPHIS, Euro 1 Certificate (For EU Markets), GlobalGAP Certification, MRL limit compliance (EU), and BRC certification for UK markets. Other certifications included Fair for Life, MPS, and ISO. However, a lot still needs to be done to ensure also workers' welfare and environmental standards. Consumers increasingly demand certain standards of vegetables, hence feedback on quality and safety standards ensures pressure on producers and possibility for changes towards more sustainable production in the future. Crop rotation and field rotation have been increasingly used as a measure against deterioration of soil fertility, while integrated pest management and integration of bio-pesticides has been adopted to improve the safety of vegetables and herbs supplied to consumers. In Bolivia, the agroindustrial food system is trying to deal with environmental risks by the introduction of genetically modified varieties of soybeans and other crops that are resistant to droughts and diseases, and by an ever-increasing use of agrochemicals (Bascopé et al., 2019).

The regional food system in Kenya, although 100% rainfed, was struggling with declining and unreliable rainfall which they attributed to climate change. Conservation agriculture has been found to be useful in dealing with the constraint of declining and variable rainfall. One wheat farmer reported that he had not experienced any crop failure since he began practicing conservation agriculture. However, he said "*I have been trying to transfer conservation agriculture technology to local smallholder farmers for fifteen years with zero success*". He attributed the "zero success" to short-term economic needs that did not allow for the implementation of long-term adaptation measures on the part of small scale farmers –that the technology must be used for at least five years to realize sustained benefits. High cost of inputs and low costs of wheat in the domestic market attributed to flooding of imported cheap wheat had been overcome through social self-organisation among wheat farmers who had formed an association-facilitating selling and purchasing inputs in bulk. Furthermore, establishment of silos (for wheat and barley farms) provided opportunities for disposing off the commodities when prices were competitive. In Bolivia the agroecological food system was re-introducing diversified cropping systems such as the traditional Milpa systems, i.e. mixed cropping of corn, pumpkin and beans, as well as traditional, locally adapted corn varieties as a response to risks and shocks.

Table 4.
Risks and adaptation strategies in different food systems

	Food System	Challenge/risks	Main adaptation strategies identified
Bolivia	Agroindustrial food system	• Climate change impacts (prolonged droughts, more frequent inundations, extreme weather events)	• Irrigation systems • Water harvesting systems • Provide external inputs to more favorable conditions (coping) • Promote transgenic corn
	Agroecological food system	• Small market shares • Insecurity of supplies (restaurants etc.)	• Awareness raising programs • Ecological fairs, new selling points • Restaurants: varying dishes “of the day” according to what producers can deliver
Kenya	Agroindustrial food system	• Pests and diseases (e.g. white flies and aphids) • Declining soil fertility • Inadequate water • High flight costs • Unpredictable markets	• Crop rotation • Diversification • Integrated soil fertility management • Rain water harvesting • Drip Irrigation • Integrated pest management
	Regional food system	• Price fluctuation • Pests and diseases • Frost • Declining soil fertility • Unpredictable rainfall • Droughts • Hailstones • Invasive species of cactus • Lack of market access	• Diversification of crops. livestock and income sources • Conservation agriculture (wheat) • Introduction of new crops • Introduction of new livestock • Bee keeping • Planting and storage of hay • Crop rotation • Field rotation

Source: Modified from Jacobi et al., 2018

5 Discussion

Comparing Kenya and Bolivia, we observed similarities with regard to diversification of production systems especially in regional food systems (Kenya) and the agroecological food system (Bolivia). There was a blend of livestock production and crop farming as well as crop and livestock diversity at least in non-industrial food systems in both countries. In addition, in both countries there were attempts to promote environmental sustainability by use of conservation agriculture and bio pesticides (especially in agroindustrial food systems) as a way of enhancing food safety. An example in Kenya was the effort of a network of farmers under the Kenya Organic Agriculture Network who played the role of promoting organic agriculture, advocacy, and certification of organic foodstuffs, capacity building and marketing. Increased production of organic food has also been accelerated by a high demand with some restaurants specializing in organic food. In Bolivia, the agroecological food system was an example of producers’ and consumers’ joint efforts to promote sustainable agriculture and healthy food.

Differences between food systems in Kenya and Bolivia could be observed in the cultivation of genetically modified soybeans exemplified in the agroindustrial food system as an attempt of coping with environmental constraints. Soybean production was based on the use of transgenic seeds (Castañón Ballivián, 2014) and herbicides such as glyphosate, atrazine, paraquat and others, most of which are listed as “highly hazardous” and prohibited in other countries (Jacobi et al., 2020, Bascopé et al., 2019). On the contrary, in the study area in Kenya, the regional food system was characterized by an increasing use of conservation agriculture technology as a way of dealing with scanty and unreliable rainfall and frequent droughts. Another difference was the deliberate effort by the Bolivian Government to promote agroecological food production systems including building capacity at college and university levels, while in Kenya there were efforts to promote organic agriculture in both horticulture as well as among smallholders. Furthermore, there was increasing use of drip irrigation technology in agroindustrial food systems in Kenya, while in Bolivia the agroindustrial food system was rainfed, facing frequent problems with droughts.

It has also become clear that conflict between people and wildlife and between different land users over resources such as water and grazing land -which often intensifies during droughts- was more common in Kenya (Gichuki, 2002; Kiteme and Gikonyo, 2002). Conflicts between smallholders and pastoralists or between ranchers and pastoralists over water and grazing land, and between smallholders and horticultural and flower farms over water was a major risk in Kenya often appearing during droughts (Mutiga et al., 2010), while in Bolivia, foreignization and 'productive exclusion' were prevalent (Urioste, 2012; McKay and Colque, 2016).

Learning for resilience has emerged as an integral part of adaptation literature due to the dynamic nature of environments and the opportunities that such changes create (Walker et al., 2004; Folke 2006). As observed in other studies under the project this study was affiliated to, farmers are not equally equipped to cope with and adapt to changes affecting food systems and their learning capacities vary due to the resources they have (Hertkorn, 2016). Access to resources and more income created opportunities for diversification of technologies, crops and production techniques hence increasing adaptive capacity to cope with risks (Brenda, 2011; Castañón Ballivián, 2014; Himanen et al., 2016).

In both countries, frequent exposure to risks has contributed to emergence of semi-commercial as well as purely commercial farming systems based on high value farm products. A study conducted in the valleys of Santa Cruz found a proliferation of commercial farms that have emerged due to a relatively even distribution of land, increased access to irrigation and favourable municipal policies (Jaldín, 2012). On the other hand, in Kenya, there is increasing use of irrigation in food systems as a way of reducing the overreliance on rainfed agriculture that is susceptible to climate change impacts. Hertkorn (2016), in a recent study on perception of smallholder farmers on nutrition, observed that local institutions together with County government were promoting drip irrigation as an adaptation strategy. Farmers were using water from rivers through water projects made possible by Water Resources Users Associations (WRUAs), boreholes and water pans. It was interesting to find that large scale horticulture farms were also members of the WRUAs although power relations played out with regard to decision making.

Actors in food systems who are prone to frequent extreme climatic events and that exists under harsh economic and environmental conditions have found ways of dealing with risks through a partial transformation of their food system activities. For example, the pastoralists in northern part of Laikipia were partially shifting to crop production and diversifying livelihoods including raising poultry -an enterprise that was initially out of question for the Maasai community. The Maasai initially had the cultural belief that eating chicken causes stomach problems and that chicken is livestock for the poor (Kirwa and Ndathi, 2010; Kirwa et al., 2010). Indigenous knowledge and diversification were also found to be important adaptation strategies against droughts and floods (Anderies et al., 2006; Mavhura et al., 2013). Additionally, soil and water conservation techniques, crop diversification, change of planting dates and agroforestry have also been found to be important adaptation strategies in sub-Saharan African countries (Obayelu et al., 2014; Onyeneke and Madukwe, 2010), as well as in South America (Altieri et al., 2015). Other important practices that promote resilience include irrigation, multiple cropping and integration of crops with livestock, water conservation and rainwater harvesting technologies and insurance against climate risks (Hassan and Nhemachena, 2008; Nhemachena et al., 2014). Some of the factors that enhance adaptation especially among poor farmers include better and fairer access to markets, extension and credit services, technology, and farm assets (labor, land and capital). Mobile phone innovations are useful tools for learning processes: they complemented face to face knowledge exchange by facilitating access to information, inputs, credit, and markets, and have potential to transform food systems and build resilience of small-scale farmers (Holdereiath, 2012; Krell et al., 2020).

6 Conclusion

We have observed that social and experiential learning were the most dominant forms of learning in both countries and different knowledge on natural and social environments was acquired that formed an important basis for making decisions on adaptation and building resilience. However, it is clear that some decisions that actors made as a response to shocks were through trial and error. It means therefore, that there still exists opportunity to increase the social and human capacities of actors at all levels in dealing with uncertainty especially those related to climate change. Although actors in the food systems under study (agroindustrial, regional and agroecological) have made significant efforts in enhancing the capacity of ecological systems to adapt, a lot still needs to be done, for example to transform agricultural models that rely on the intensive use of agrochemicals and monocultures. We conclude that the learning processes by actors in food systems in the two countries have been both reactive and anticipatory in nature, and are an important step in building resilient food systems. More quantitative and qualitative research is required to test whether the adaptation strategies adopted by actors in food systems significantly reduced their vulnerability to climate change impacts and other risks, and which political-economic frameworks allow for the best forms of adaptation to be implemented.

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