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Linking sustainable diets to the concept of food system sustainability

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Abstract

Based on insights from an ongoing research project on food sustainability, we argue that discussing sustainable diets in isolation from food systems poses risks. Among these risks are making healthy diets exclusive, or ignoring externalities like biodiversity loss, land concentration, and encroachment on commons. Case studies from Bolivia and Kenya show how marked shifts from traditional to more uniform diets rich in sugar, salt, and fatty acids come with a radical transformation of food systems. Systems formerly based on local knowledge, local inputs, and local labor relations become dependent on external inputs, heavy mechanization, and productive specialization. Making diets more sustainable requires policies that protect existing and strengthen new forms of family and community farming. We discuss critical links between sustainable diets and sustainable food systems with reference to five principles of food sustainability: food security, the right to food, reduction of poverty and inequality, environmental performance, and resilience. Our analysis provides a basis for more comprehensive research and policies that minimize trade-offs and maximize synergies between sustainable diets and food systems.

Introduction

Over the last decades, the world has seen a shift from diverse, traditional, and locally-based diets to more uniform, standardized, and place-independent modes of food consumption and production (La Trobe & Acott, 2000; Tilman & Clark, 2014; Traill, Mazzocchi, Shankar & Hallam, 2014). Nowadays, wealthy consumers worldwide have the possibility to purchase food from faraway places and to adjust their diets to personal preferences as well as to "mainstream" trends. This development was enabled by doubling international food trade since the 1980s (D'Odorico, Carr, Laio, Ridolfi & Vandoni, 2014), and it has had wide-ranging effects. On the production side, these effects include structural changes in many parts of the world (from agricultural societies towards service-based societies), a decreasing number of people working in food production, and a concentration of power along food value chains.

On the consumption side, the change in diets with increased consumption of sugar, salt, and fatty acids in processed food has led to an epidemic prevalence of obesity and related cardiovascular diseases in many parts of the world (Lifshitz & Lifshitz, 2014; Müller-Riemenschneider, Reinhold, Berghofer & Willich, 2008). Related health costs are rising (Allison, Zannolli & Narayan, 1999; Dee *et al.*, 2014; Konnopka, Bodemann & Konig,

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2011), and due to its epidemic dimension, the problem is moving up on the political agendas of many states. Different authors suggest various remedies for the problems that come with the shift in how we produce and consume food. While some studies address the production side and emphasize the importance of increasing food production (for a critical discussion see Godfray *et al*., 2010; Tomlinson, 2013), others focus on the consumption side and place individual diets at the center of the discussion (e.g., de Boer, Schösler & Aiking, 2014). We argue in this article that focusing on one side only means neglecting the problem's complexity, and therefore, it is crucial to take a comprehensive food systems approach (Ericksen, 2008). Such an approach should consider human health and environmental impacts as well as regulatory, trade, and rights-based aspects. There is a need for reflexive processes that consider the complexity of entire food systems.

Reflexive processes aiming at sustainability solutions involve various scientific and non-scientific actors and perspectives and have a strong normative component. They have the objective to produce not only systems knowledge (which often involves disciplinary modes of knowledge production) but also target knowledge (about the desired future state of a system) and transformation knowledge (on how to arrive at this desired state) (Hirsch Hadorn, Bradley, Pohl, Rist & Wiesmann, 2006). Accordingly, such processes usually include various forms of inter- and transdisciplinary research (Pohl & Hirsch Hadorn, 2007).

In this contribution, we propose to integrate the discussion on sustainable diets into the concept of food system sustainability. We discuss the links between the two in light of the findings of a transdisciplinary research project aimed at assessing the sustainability of different food systems in Bolivia and Kenya and at implementing interventions for increasing that sustainability. Both countries are affected by hunger and food insecurity while legislation on the right to food is well advanced. Therefore, our discussion will focus prominently on the realization of the right to food, based on examples from the project's case studies.

In the following sections, we give an overview of existing literature on problems of today's global food system; introduce the transdisciplinary approach applied in our project; and, present and discuss some of our findings from three years of research by highlighting the links between dietary aspects and overall food system sustainability.

Today's global food system in the literature: An overview

The globalization of diets and its impacts on food systems

The massive changes in food production and consumption have led to an increasing disconnect between food producers and food consumers (Boehlje, 1999). Many consumers have grown used to finding a similar standardized food offer around the world. This can be seen as a globalization of diets. While this development is much more advanced in industrialized countries, it is increasingly affecting people in developing countries as well (Reardon, 2015). The extension of markets and the related increase in potential customers promise income and business opportunities, but intensified food production practices also pose risks of adverse environmental and societal impacts (Tilman, Cassman, Matson, Naylor & Polasky, 2002). Such risks include high levels of pesticide and fertilizer use, which cause pollution and degradation of water and soils (Carpenter *et al*., 1998; Matson, Parton, Power & Swift, 1997; Novotny, 1999); advancing agricultural frontiers, which destroy forests and other natural habitats (Morton *et al*., 2006; Richards, 2015); monoculture; and the increasing replacement of diverse agricultural crops with few hybrid and genetically modified varieties, leading to biodiversity loss (Altieri, 2005; Fahrig *et al*., 2015).

Furthermore, there are socio-economic impacts on people's living conditions. Such changes include increased dependency on one or few goods for export (La Trobe & Acott, 2000); substantial changes in land use and the related social contexts (Fearnside, 2001); progressive concentration of land in the hands of fewer people, often linked with a shift from food production for local consumption to other uses, such as production of food for export or agrofuels (Oliveira, McKay & Plank, 2017); and a tendency of healthy and varied diets becoming less affordable for people with low buying power.

There is evidence that efforts to increase agricultural productivity by means of sustainable intensification does not, as a general rule, reduce the need for new land, but instead fuels expansion of the agricultural frontier (Ceddia, Bardsley, Gomez-y-Paloma & Sedlacek, 2014). The described adverse impacts of the increasing globalization of diets on food systems are fueled by a productivist paradigm which implies that feeding a growing world population will only be possible by spreading intensified agricultural practices, advancing biotechnology, and massively increasing food production (Fouilleux, Bricas & Alpha, 2017). However, there is no scientific ba-

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Table 1: Different frameworks for sustainable diets

Authors	Addressed dimensions	Objective of framework
Downs, Payne, & Fanzo, 2017	Socio-cultural and political Markets, trade and value chains Environment and ecosystems Food security and agriculture Nutrition and health	Assessment of individual policies in terms of sustainability
Mason & Lang 2017	Health Environment Culture and society Quality Economy Policy and governance	Addressing diets in a comprehensive way
Von Koerber, Bader, & Leitzmann, 2016	Health Society Environment Economy Culture	Definition of sustainable diets

sis for this predominant focus on increasing production. Indeed, we are already producing enough food to feed the projected population in 2050 (Moore Lappé, 2013). The total of food calories produced in 2015 amounted to over 2800 kcal per capita per day (FAO, 2015). Another study even mentions 4600 kcal per capita per day, but notes that fairly large shares are wasted during production (~13%) and consumption (~20% at household level in wealthier countries) (IPES, 2016).

From sustainable diets to sustainable food systems

Different measures to address the health implications of changed diets have been discussed (Kersh, 2009; Reisch, Sunstein & Gwozdz, 2017; Ries, Rachul & Caulfield, 2011), and governments have started to think more about how to influence people's diets. Several authors have assessed the effectiveness of various proposed methods to do this, including taxation and subsidies, the regulation of ingredients used in the processing industries, and prominent labelling of packaged food as healthy and unhealthy (Lobstein & Davies, 2009; Loughnane & Murphy, 2015; Lustig, Schmidt & Brindis, 2012; Mytton, Eyles & Ogilvie, 2014; Ni Mhurchu ., 2015; Niebylski, Redburn, Duhaney & Campbell, 2015). Health issues caused by globalized diets are increasing. At the same time, the problem of malnutrition in many parts of the world remains unsolved, with an estimated 800 million people still suffering from hunger, and an even higher number from nutrient deficiencies (Ingram, 2017).

In conclusion, diets and nutrition deserve special attention for two main reasons: First, because they form the basis for an active and healthy life, and second, because they fail to do so for a large share of the world population. However, diets have substantial implications for entire food systems. In order to avoid spreading environmental and societal problems, efforts to improve diets must generally consider sustainability concerns. We therefore argue that the paradigm of "healthy diets" should be rephrased to "sustainable diets" and related to the concept of food system sustainability, with the aim of eventually finding appropriate measures to promote and support sustainable diets within sustainable food systems.

There are three aspects which require consideration when defining sustainable diets. First, sustainable diets are a question of receiving the required macro- and micronutrients to sustain an active and healthy lifestyle (McCalla, 1999). Second, the consumed food should come from sustainable production systems. This implies that production and processing activities should meet social, environmental, and economic sustainability criteria. Third, when we ask what food is adequate, we are dealing primarily with a normative question that reflects social and cultural backgrounds (Anderson, 2005).

Several authors have made suggestions for integrative approaches to sustainable diets by including different dimensions (e.g., Downs, Payne & Fanzo, 2017; Mason & Lang, 2017; von Koerber, Bader & Leitzmann, 2016). Table 1 summarizes the aims and dimensions addressed by the proposed frameworks.

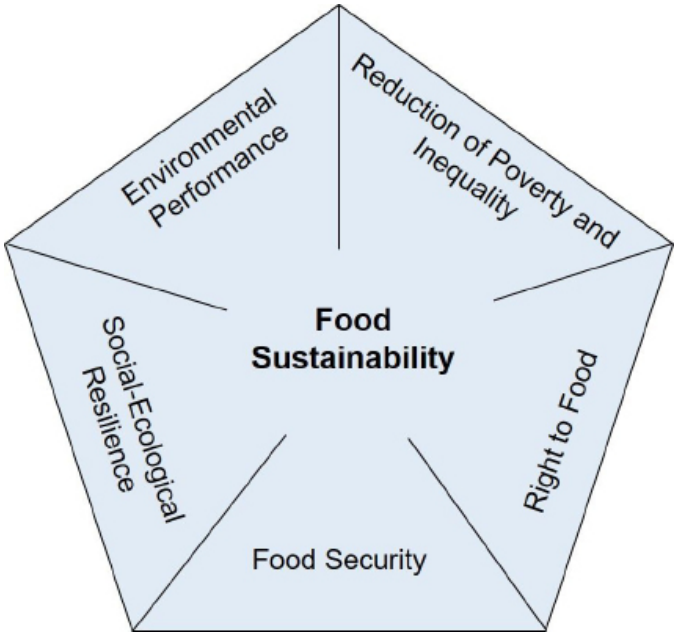

Figure 1: The five dimensions of food sustainability (Source: Rist *et al*. 2016)

All three studies place diets at the center of the discussion while simultaneously considering value chains. We argue, however, that diets need to be integrated into a more comprehensive food systems approach in order to capture the complexity of these problems. Food systems include not only value chains but also the natural resource base, the political context, and flows of information and services. Moreover, food systems encompass many interlinkages at and between different scales from local to global. They connect activities in distant places. This poses challenges when analyzing them as well as when trying to advance them towards greater sustainability. Our food sustainability framework focuses on entire food systems and is constructed as an intervention tool to analyze food system weaknesses and find ways of increasing the sustainability of these systems. Sustainable diets are an integral part of food systems, therefore, we treat them as such when discussing their interrelations.

Our understanding of food sustainability has several foundations. One is the concept of food systems, comprising all activities along the food value chain, from production – including the required resources and inputs – through transport, trade, processing, and retailing to the consumption of food. Furthermore, a sustainability assessment of food systems must also include their links to food system drivers, such as changes in the natural environment and the social context, as well as to food system outcomes in terms of their availability, accessibility, utilization, and the possibilities they offer to achieve prosperity (Ericksen, 2008). A second point is that food system sustainability includes human rights, in particular the right to food, which, though not legally binding, entails the obligation of states to support this right with the means they have at their disposal (De Schutter, 2014). A third important part of food system sustainability is that the food system should contribute to more equitable conditions and improved livelihoods for actors involved (Christiaensen, Demery & Kuhl, 2011; Ribot & Peluso, 2003). This part is often addressed by discussing properties of value chains, such as their structure (Taylor, 2005), their governance (Gereffi, Humphrey & Sturgeon, 2005), and their impact on poverty reduction and inequality (Stoian, Donovan, Fisk & Muldoon, 2012). Finally, food system sustainability means protecting environmental goods and services and increasing resilience within food systems (Aubin, 2013; Berkes, Colding & Folke, 2003).

In an ongoing, transdisciplinary research project called "Towards Food Sustainability: Reshaping the Coexistence of different Food Systems in South America and Africa", we have based our definition of food sustainability on five dimensions (Figure 1): food security, the right to food and other related human rights, reduction of poverty and inequality, environmental performance, and social-ecological resilience (Rist *et al*., 2016).

Making food systems more sustainable: a transdisciplinary approach

How do we move from this theoretical concept of food sustainability to an actual improvement in the sustainability of food systems and diets within these systems? Improving the sustainability of food systems is an explicit goal of our research project. Besides an assessment of the current sustainability of a given food system, this requires collaborative reflection and implementation of

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innovation strategies and policy options that introduce and support the proposed changes. We define innovation strategies and policy options as changes to the current food system that may be initiated by public administrations, civil-society actors, and private initiatives that do not a priori involve changes to the legal framework. However, they might lead to such changes in due course. When searching for policies that can support sustainable development of food systems, it is necessary to examine existing power structures and the ways in which they perpetuate unsustainable activities within the system. Such activities include, for instance, pressure on smallholders from international competition and subsidies in developed countries, or dependencies on multinational companies and international trade (Lapatina & Ploeger, 2013). These structures and mechanisms need to be considered when aiming to improve current food systems.

The explicitly normative and contested nature of interventions in food systems necessitates a transdisciplinary approach that involves scientific as well as non-scientific actors in the knowledge production process (Bouma, van Altvorst, Eweg, Smeets & van Latesteijn, 2011; Dentoni & Bitzer, 2015; Lang *et al*., 2012). Our research project addresses all three forms of knowledge presented in the introduction: systems, target, and transformation knowledge. The food sustainability concept with its five dimensions represents target knowledge, that is, normative knowledge on desirable development pathways. Empirical assessment of food systems creates systems knowledge from different disciplinary perspectives. Innovation strategies and policy options defined in a multi-stakeholder transdisciplinary process represent transformation knowledge, that is, knowledge on how to achieve the desired developments.

A transdisciplinary approach to research supports the production of knowledge that is based on compromises between actors' different interests and expectations, addresses key questions asked by the actors involved, and is implementable in real-world situations. Thus, it is likely to produce salient, credible, and legitimate results (Chaudhury, Vervoort, Kristjanson, Ericksen & Ainslie, 2013). Furthermore, a transdisciplinary approach can give a voice to actors who might otherwise have difficulties to make themselves heard. A transdisciplinary approach is particularly appropriate for finding effective innovation strategies and policy options and for accompanying their implementation towards the proposed changes in food systems and diets (Ernesto Méndez, Bacon & Cohen, 2013). Transdisciplinary research processes profit above all from the diversity of participating actor groups. In the case of our research project, these include academic and non-academic specialists and other food system actors in the five key dimensions of food sustainability.

Our project applied a transdisciplinary research process (Rist *et al*., 2016). This consisted of the following steps: (1) sustainability assessment of a specific food system according to a previously developed set of indicators; (2) identification, together with a group of scientific and non-scientific experts as well as other food system actors, of possible innovation strategies and policy options for improving the food system's sustainability; and, (3)

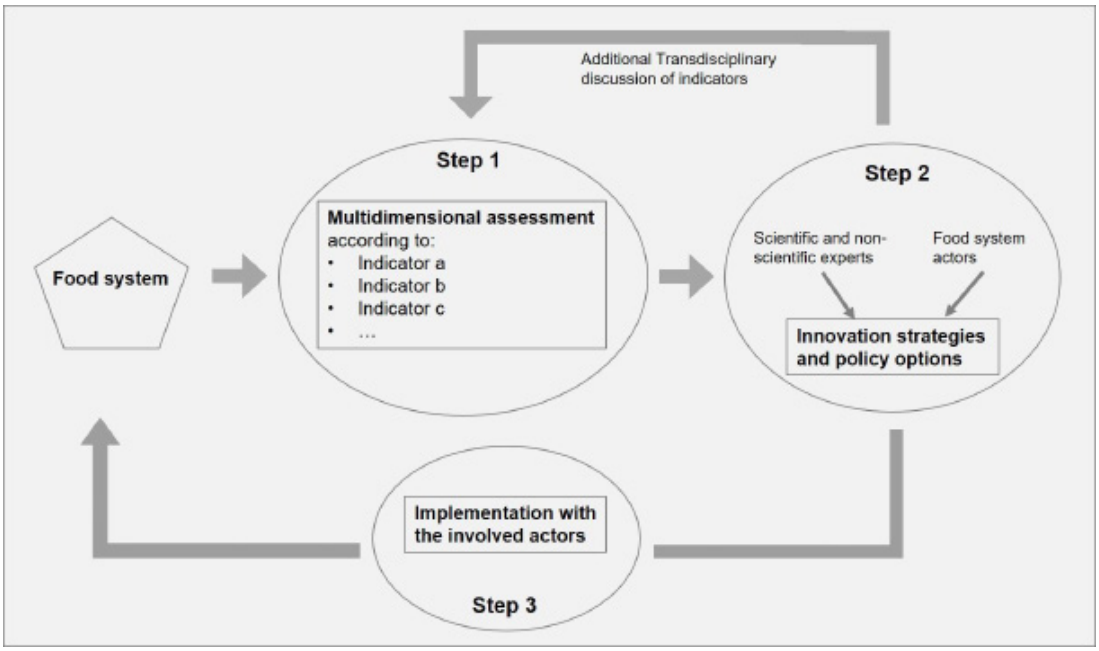

Figure 2: Procedure of food system assessment and improvement (Authors' illustration)

implementation of the proposed interventions in close collaboration with and under the supervision of the same group (Figure 2).

Each of these steps is transdisciplinary in nature. Transdisciplinary co-production of knowledge in step (1) occurs mainly in the form of networking and soliciting of advice from involved actors. In contrast, steps (2) and (3) comprise the use of explicitly transdisciplinary methods to identify feasible innovation strategies and policy options for the specific food system and to then implement them together with the actors. The most prominent of these methods is participatory workshops that engage actors in solution-oriented discussions with policymakers (Salter, Robinson & Wiek, 2010).

When exploring ways to improve the sustainability of diets within the food systems that our project focuses on, we look at diets as an integral part of food systems. Consequently, we discuss measures that specifically target the dietary context within those systems. The following section provides more detailed insight into this dietary context.

Sustainable diets and food system sustainability: key insights from three years of research

In the case studies, we used the above-mentioned steps to achieve greater sustainability in food systems and diets. The thorough assessment of a food system along the five dimensions of food sustainability in the first step led to a ranking of the system on an ordinal scale between 0 and 4. Data were collected for 11 to 30 indicators in each of the dimensions. With respect to diets, the indicators included consumers' perceptions regarding health impacts of different types of food, the source of their food, and what they considered to be "good food", among others. Data on the indicators were collected over two and a half years of interdisciplinary research within different master's-level, doctoral, and post-doctoral studies for each of the five dimensions of food sustainability in different food systems in Bolivia and Kenya. Data collection methods depended on the research questions, and included structured and semi-structured interviews, surveys, focus groups, observation, participant observation, life cycle inventory assessments, 24-hour dietary recall, and participatory mapping.

In the third year of research, we began to hold data synthesis workshops to integrate knowledge from individual projects and to agree on the most relevant indicators for each dimension, following detailed discussions among all involved researchers. The results of this assessment point to problems in the food system that were addressed in the second step of the transdisciplinary process, where the aim was to identify innovation strategies and policy options. In the currently ongoing second and third steps of the process, discussions with different groups of scientific and non-scientific actors are leading the way from initial ideas to actual interventions that are feasible in terms of their goals, realistic in relation to the available personnel and material resources and supported by the involved governmental and administrative units in the food system. It is advantageous to include national and international policy experts in the process in order to profit from their expertise and to refine interventions and ensure their applicability in the specific food systems' context. Once specific and agreed intervention proposals are on the table, actions for implementation can start, with support from researchers and in close collaboration with the involved group of actors.

First stakeholder workshops in Bolivia and Kenya showed that food system sustainability could be improved with seemingly small interventions, such as providing a marketplace for agroecological produce that is protected from rainfall or investing in rainwater harvesting to improve water availability during the dry seasons. Other proposed interventions require more effort, commitment, and time of all actors involved. Examples include water and irrigation forums aimed at achieving a more equitable and fair distribution of available water resources among the different food systems, and governmental support for suitable soil improvements.

The applied set of indicators also provided information about the dietary habits of actors in the assessed food systems. These included the availability of food in the system, its acceptance by consumers, its diversity, and its safety. We therefore suggest that a food system assessment includes a dietary assessment and enables reflection on innovation strategies and policy options that improve the sustainability of consumers' diets. In order to highlight possible ways of promoting diets that are sustainable in terms of overall food system sustainability, in the following sections we discuss examples from our research project of existing measures that increase food system sustainability in each of the five dimensions, underlining their relevance to diets. For each of the examples, we suggest ways of further increasing the given food system's sustainability. Linking the five dimensions of food sustainability to the debate on sustainable diets means looking for measures that support sustainable food consumption. These are instruments that encourage a certain behavior among consumers who have a

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choice or support poorer parts of the population in accessing better and more sustainable food (Pretty, Morison & Hine, 2003; Reisch, 2013).

The right to food

The right to food refers to General Comment No. 12 of the United Nations Committee on Economic, Social and Cultural Rights, which affirms that every person living in a state has the right to adequate food at any time and that its availability must be ensured now and for future generations. The right to food must not be restricted or inhibited by anyone, and states have the obligation to fulfil it where it is not given (CESCR, 1999; De Schutter, 2014).

Regarding the right to food, Bolivia offers an interesting example of a measure to improve food system sustainability, namely a governmental initiative that offers subsidized school meals to schoolchildren (Bolivia, 2015; Gonzales, 2016). These meals must be sourced from local small-scale farmers and small enterprises, and must consist of nutritious ingredients and local varieties, for example of banana or amaranth (which is not yet always the case). Bolivia is thus making an effort to fulfil its obligations (as stated by the UN in terms of the right to food) to provide adequate food (food that fulfils dietary as well as cultural requirements) to all schoolchildren. By doing so, it is potentially improving the nutritional situation of vulnerable people.

The sustainability aspect (adequate food must be available now and for future generations) of this example is illustrative, because beyond providing food for schoolchildren, this governmental initiative supports local supply chains and provides a fair and stable income for small-scale producers without distorting prices. In addition, it provides monetary relief for parents in vulnerable population groups.

This governmental initiative could be further improved through policies specifying environmental requirements for production of the sourced food. At present, such policies are lacking; consequently, some of the food is produced with heavy inputs of pesticides, the health impacts of which on both producers of the food and on the children who consume it are not monitored. In a second step, the government could extend this initiative to other canteens that it maintains, such as in police stations or hospitals. The benefits of sustainable public procurement have also been highlighted by other authors and represent an effective way of supporting certain production standards (Oruezabala & Rico, 2012; Preuss, 2009; Walker, Miemczyk, Johnsen & Spencer, 2012).

Food security

Our definition of food security follows McCalla (1999) and includes the availability of food supplies, access to these supplies, adequate utilization of food in nutritional terms, and stability of these three aspects over time. Another example from Bolivia shows how the dimension of food security can be addressed through non-monetary food subsidies that are targeted specifically at pregnant women and newborns. Niebylski *et al*. (2015) confirm that food subsidies can contribute to making diets healthier.

It is widely acknowledged that the first 1000 days, from conception to completion of a child's second year living, present a window of opportunity for healthy development of a child in general, especially development of the brain, if the child receives adequate nutrition (IFPRI, 2015). In our example, women receive food subsidies in the form of food packages during six months of pregnancy and the first year after birth. The packages contain nourishing food, such as milk, amaranth products, and honey. Compared to the example described with regard to the right to food, this example addressing food security is a measure that specifically targets the fairly short window of opportunity in which children can be provided with the necessary nutrition to support a healthy development.

The contents of these packages must be produced locally (although this is not yet always the case), similar to the previous example of locally procured school meals. However, there are no environmental requirements for their production. More research into the sustainability of the supply chains of these packages would be needed to assess in detail how environmental standards could be improved.

Reduction of poverty and inequality

With respect to reduction of poverty and inequality, it is important to consider what financial means people have at the end of the month and how access to resources is distributed. An example from a large, industrial, export-oriented food system in the Mount Kenya region shows how private food subsidies can increase the financial means of agricultural workers. These workers belong to the more vulnerable parts of the population due to their low income.

In this example, a company that produces vegetables for export to a European market offers its workers subsidized meals for lunch and dinner, depending on their working shift. The cost of these meals is 10 Kenyan Shillings (~ one Euro Cent), which is very cheap by Kenyan

standards. The total cost of meals is deducted from the workers' salaries at the end of each month. The meals consist of ingredients that cover necessary nutrients, such as carbohydrates, fibers, proteins, and vegetables, but workers have complained about lack of variety in the menu, the size of portions, and the quality of ingredients as the canteen uses leftovers from sold vegetables.

In terms of poverty reduction, the subsidized meals provide necessary nutrients and help the workers save money. However, this company initiative performs poorly in terms of inequality, as managers and supervisors already earn more by comparison with workers. Moreover, they are not charged for their meals although they could more easily afford them. This unequal treatment provokes resentment among workers.

In terms of reducing inequality, this measure could be improved by introducing equal or income-related subsidies for all employees. This would mean only a small change for managers and supervisors, but it would constitute an important signal towards workers. Such signals should not be underestimated, as perceived inequality plays an important role in generating inequality in general (Reygadas, 2015).

Use of leftovers from the company's own production can benefit sustainability if these leftovers are good food that would otherwise be composted or, even worse, brought to a landfill. However, this should be explained and discussed with the employees, who currently consider the food to be of substandard quality. More appreciation for this procedure could be generated by involving workers in the selection and preparation of food and assuring them that they are not being served low-quality food.

Environmental performance

Environmental performance in our project comprises several aspects, such as the total amount of land, energy, and water required for food production (according to Gerbens-Leenes, Moll & Schoot Uiterkamp, 2003); the use of seeds, fertilizers, and pesticides (Altieri, 2009); the use of other material inputs, human influence on landscapes and biodiversity (Peterseil *et al*., 2004); and key actors' perceptions regarding the food system's influence on degradation, including health risks and conservation.

When it comes to addressing environmental performance via diets, we see that transport has a substantial impact on the environment in food systems both in Bolivia and in Kenya. The impact increases if transport of inputs is included in the assessment. This is in line with other studies, such as Foster *et al*. (2006) and Sim, Barry, Clift & Cowell (2006). Hence, diets that are beneficial for the environmental performance of a food system should ideally include local produce grown with low inputs, diverse crops, and fresh fruits and vegetables. These requirements are generally compatible with the composition of traditional diets in both our research countries, where people traditionally consume a variety of local staples, diverse fruits and vegetables, and high quantities of legumes but low quantities of meat and dairy products. These diets are associated with site-adapted agricultural production, crop diversity, and low environmental impacts. The advantages of this type of production have been discussed in several contributions to this journal (Ciccarese & Silli, 2016; Kanaani, 2016; Reiter, Huson & Gonzalez, 2014).

We also see that knowledge about traditional crops and the preparation of meals from them is still present among the older generation but is fading away among younger people (Hertkorn, 2017). This gradual disappearance of knowledge concerns not only the preparation of traditional food but also the production of traditional crops. This is causing a decrease in crop variety, and thus indirectly increases producers' vulnerability and reduces the consumed crops' nutritional value (Gruber, 2017). While other studies do not use the term "traditional food", they are likewise interested in the relationship between "good" or "nutritious" food and sustainable food. For example, Dixon and Isaacs (2013) find that fresh and local produce is viewed as one of the main components of such food among disadvantaged population groups in Western Sidney, Australia, while Van Loo *et al*. (2017) find good associations between healthy and sustainable diets.

One way to push such diets would be to support agroecological producers in building networks and developing local markets. Participatory guarantee systems represent such an example. They help local producers who supply local markets to mutually certify their fair, local, and environmentally friendly products as fulfilling high sustainability requirements, without having to face the high hurdle of obtaining international organic and fair trade certification (Home, Bouagnimbeck, Ugas, Arbenz & Stolze, 2017). Nonetheless, participatory guarantee systems serve to assure local consumers that they are buying high-quality, diverse, local, and accessible food.

Resilience

The fifth dimension of our food sustainability concept is resilience. Resilience refers to being able to cope with and adapt to both change and pressure on the social-ecological system (Jacobi *et al*., 2018, Berkes *et al*., 2003), spe-

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cifically on the food system (Tendall *et al*., 2015). In that sense, special attention is given to food systems' buffer capacity (the ability of a food system to cushion stress and shocks), self-organization (social organization of food system actors, ecological self-regulation, and functional interaction of food system processes), and capacity for learning and adaptation (the capacity to learn from past events and to develop existing contexts further) (Carpenter, Walker, Anderies & Abel, 2001).

A high percentage of people's food consumption in rural areas worldwide depends directly on their own food production, and smallholders are responsible for a majority of global food provision (Tscharntke *et al*., 2012). Smallholders produce and thus preserve an immense diversity of crops and breeds (~1.9 million crop varieties) (Nicholls & Altieri, 2018), whereas industrial food production relies on a comparably small number of commodity crops and terrestrial breeds. In terms of resilience and sustainable diets, a high crop and breed diversity in food production, on markets, and on plates is clearly preferable to industrial monotony. A good mix of cash crops and highly diverse food production is also discussed by other authors as a way of increasing resilience (Cadena, Pond & Rattanasorn, 2014).

An example of resilience-building in Kenya highlights the creativity of an individual farmer who was faced with continuous droughts and built a highly sophisticated water harvesting, water storage, and drip irrigation system on his farm. The system enables him to save enough water during the rainy season to bridge the increasingly long months of drought. As a consequence, he is now able to irrigate his fields at times when other farmers lose their entire yields. The system guarantees the farmer's food security during droughts and ensures that he can continue to sell his produce on the market, thus serving his own and other peoples' dietary needs. In addition, his success has attracted the interest of other farmers in his neighborhood. He now helps other farmers to install such water harvesting, storage, and irrigation systems on their farms. This example shows how individual initiatives can improve resilience in a food system from the bottom up.

In order to increase the impact of such initiatives, the government could scale them up by providing targeted support to innovative farmers. In addition, it could support the creation of local farmer networks that would help to increase the bargaining power of frequently isolated individual farmers.

Conclusion : Minimizing trade-offs, maximizing synergies

The diverse problems that come with the current global food system are complex and interrelated. Accordingly, they need to be addressed through approaches that are capable of grasping this complexity. Therefore, in this contribution, we argue that it is necessary to integrate the debate on sustainable diets into discussions on food security, and into a more holistic food systems approach to improve human health and well-being, while avoiding adverse environmental impacts.

Based on the results of an ongoing transdisciplinary research project, we discuss measures that can help to support sustainable diets within in the framework of food sustainability. Examples from case studies in Bolivia and Kenya demonstrate how public food subsidies can be effective measures to implement the right to food and reduce food insecurity for more vulnerable groups of people. In addition, subsidies in the form of meals offered by local private companies can help to alleviate poverty. By contrast, the reduction of inequality is not just a question of resource distribution and access to resources but also a question of perception and how people see themselves in relation to others. Environmental performance is best supported by consuming fresh food from local production with low external inputs and a high crop diversity, which corresponds well with traditional diets in many places around the world. Last but not least, resilience can be increased by supporting people in organizing themselves within networks and developing their creative potential.

When designing interventions to improve the sustainability of food systems, disagreements and conflicts are inevitable due to the different actors' diverse objectives and strategies. Improving the sustainability of interconnected food systems requires observing and critically reflecting on potential trade-offs. Achieving agreement and consensus might not always be possible, but a transdisciplinary research process, which involves academic and non-academic experts and other actors, can help to assess how the diverging options prioritized by different actors play out in terms of sustainable diets. On the other hand, the implementation of interventions for more sustainability in food systems can also benefit from synergies between different objectives. Our framework helps to anticipate and actively support them where possible.

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Conflict of Interests

The author hereby declares that there are no conflicts of interests.

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