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SUSTAINABLE FOOD AS A THREE-DIMENSIONAL SYSTEM

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Abstract

While it has become clear that a system approach is important to improve not only the sustainability of agriculture but also nutrition, the analysis of food systems suffers from overcomplexity. In this context, the aim of the paper was to find ways to reduce the overcomplexity of food systems, using a new system approach which is essential for making our food production and nutrition more sustainable. The method was to structure the sustainability food as a three-dimensional system, by grouping and structuring the scientific approaches existing up to now in the specialized literature, searching and compiling through most of the paper having sustainable food as the main subject. The results were structured by creating a system through a set of four interrelated questions. It argues that the 'how' of food production and consumption, including the 'how much', is as important as the question "what" is produced and consumed. The 'who' dimension is of relevance for the socioeconomic pillar of sustainability, while the 'where' dimension puts our attention to geographical questions.

Key words: *system, target, transformation, food, farming*

INTRODUCTION

Academic interest in sustainable food systems is mounting, as indicated by the exponentially rising graph in Figure 1. This increasing interest is a necessity for solving the most pressing global problems. Obesity and undernutrition, for example, are both due to deficiencies in our food systems, as are 26 per cent of greenhouse gas emissions and 78 per cent of global eutrophication [65]. However, the majority of the large body of literature still does injustice to the system approach. Even the papers with the largest citation numbers often take the perspective of either the production [25, 39, 75] or the consumption side [85, 16, 24]. Decisions about how to organise a farm's production and about how to feed one's family may seem unrelated. The added value of the system approach, however, consists of linking only these perspectives but also those of the pesticide producing company, the dairy factory, the supermarket, fast-food chains and a host of other actors.

Still, the understanding of food systems and their sustainable management suffers from overcomplexity. It may appear as an insolvable contradiction that the many linkages between the actors in the system make a single-actor perspective of limited use, but that these interlinkages are too diverse to be usefully united.

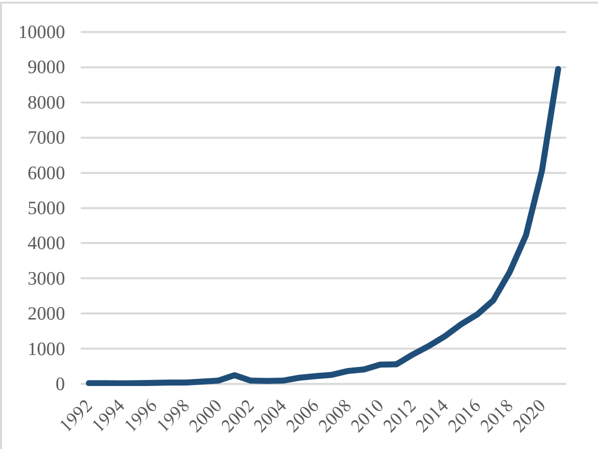

Fig. 1. Annual papers containing the term 'sustainable food system'
Source: Google Scholar.

However, this tension necessitates the development of categorising frameworks. To meet the need to structure the complexity of systems to meaningfully advance in sustainability transitions, both general suggestions of categorisations have been made [37, 30], but also systems applicable to fields like urban planning [67] or energy technologies [54].

This paper builds on the proposal for knowledge structuring by Jerneck et al. [36], our first dimension, and on the 2016 Chicago Consensus on Sustainable Food System Science [15], our second dimension.

In this context, their propositions and our suggested adaptation for sustainable food systems on a global level are targeted in this paper.

MATERIALS AND METHODS

In their seminal publication to structure sustainability science, Jerneck et al. [36] suggested to improve problem-solving capacities by structuring sustainability sciences in three different dimensions. One dimension would involve sustainability challenges, such as land use or biodiversity; the second dimension would distinguish between problem solving and critical research; and the third dimension would introduce the distinction between scientific understanding, sustainability goals and pathways, strategies and implementation.

This framework has been successfully applied, among others, to such issues as urban development [83] and land use planning, where Messerli et al. [50] have summarised Jerneck et al.'s [36] contribution and developed them towards the distinction between system, target and transformation. This categorisation system helps to distinguish between different dynamics in tackling today's food systems and will be used here as well.

For others, however, 'the four main domains of sustainable food systems science can be described as health, economics, society, and the environment' [15]. The latter three categories – the economic, the social and the environmental - are often described as the three pillars of sustainability [51]. Therefore, many scholars (e.g. Drewnowski, 2018), acknowledge the central role of health when defining sustainable food systems [15].

This paper suggests that it additionally helps to structure sustainable food systems if we use four categories of questions that all cover all actors in the food system. These questions are as follows:

-How should we produce, process, trade and consume our food?

-What food should we produce, process, trade and consume?

-Who should produce, process, trade and consume our food?

-Where should we produce, process, trade and consume our food?

While the importance of this third dimensions with the four questions will be justified within the paper, our proposition also implicitly includes omitted questions, and these omissions also need to be motivated. An obvious case for that would be the question of 'when'. Should it not also be important for the sustainability of food systems when food items are produced and consumed?

It seems that this is less the case than for other production systems, such as the energy system. In terms of energy, we make use of resources that were produced millions of years ago. In the food system, however, few items can be stored for more than a few years. Therefore, the possible variation of the timing of production is limited. Other questions concerning 'when', such as the supply of food outside of local seasons, can be subsumed under the question of 'how'.

The omission of the 'why' question is slightly more complex. However, the question why we need a food system at all is answered by our biological needs. The question why it should be sustainable, however, is a question that raises philosophical issues, although they have been mostly tackled independent of the special case of food [57, 64]. Figure 1 illustrates the broad consensus that exists about how sustainability is a global priority for food systems.

There will, of course, be interdependencies among these four remaining questions. The subsequent part of the paper will show if the resulting problems nullify the added value of our approach. Overall, we suggest a structuring system according to Figure 2. The subsequent sections, however, will solely focus on the horizontal axis of the systems because these other two dimensions have already been explored elsewhere.

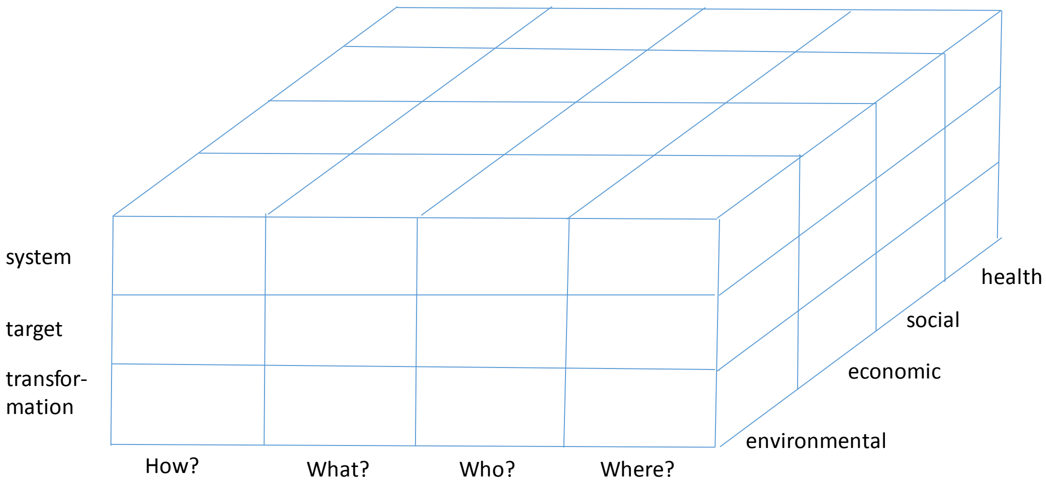

Fig. 2. The three-dimensional system
Source: Authors' own concept.

RESULTS AND DISCUSSIONS

Geography matters: the where

Our degrees of freedom with respect to the ‘where’ touch both on production and consumption. Starting with the latter, the whereabouts of food consumption are largely determined by today’s settlement structures. People eat where they live. However, several studies indicate that eating out is less likely to create sustainable food choices, both in terms of product categories [66] and production methods [6]. Consumers and other actors in the chain seem to devote more attention to sustainability if food is prepared at home.

On the production side, climatic conditions in connection with market forces largely steer agricultural production so that Canadian farmers, for example, are more likely to grow canola than mangoes, whereas the opposite applies to farmers in Mali. However, agricultural subsidies also play a role. By incentivising farmers in wealthier countries to produce more intensely, they increase the environmental footprint of global agriculture [87]. However, as ‘support is not systematically biased towards high-emission products’, as Laborde et al. [42] remark, the extent of this impact is limited, and an increasing number of agri-environmental schemes partly counterweigh the deteriorating effect of farm subsidies [79]. Other studies on the division of responsibilities for the food system between the global North and the global South illustrate that the emphasis in transformative processes should lie rather on the ‘how’ than on the ‘where’ [7].

A number of scholars have considered adapting the location of production to the location of consumption. Choosing between more or fewer closed local food systems has optimistically been said to revitalise communities [21], secure the freshness of food [20] and provide authenticity [80]. Rigorous analyses of such local food systems, however, have indicated that most effects are bidirectional and entail a lot of trade-offs [71] while reducing the available range of food [68]. In their case studies on lamb meat and orange juice, Schlich and Fleissner [69] demonstrate the relative irrelevance of transport and the importance of ecologies of scale. Food miles are, as Edwards-Jones et al. [17] state, a poor indicator of sustainability.

The issue of urban agriculture may be a more decisive component of the ‘where’ question [48]. Ackerman et al. [1] emphasise the positive social and environmental effects of urban farming. It provides opportunities for community building and has educational benefits [14] while providing green infrastructure and protecting against heat islands [62]. According to a literature review by Nogeire-McRae et al. [56], the impact of urban agriculture on nutritional quality and the economy is, however, less clear.

Finally, the possibility to rate and map the sustainability of food systems is a totally different component of the 'where' dimension. Chaudhary et al. [9], for example, show that the carbon and the blue water footprint of food consumption are inadequately high in many American and European countries, whereas the indexes for food safety, food availability and food adequacy score poorly in such countries as Congo, Haiti, Malawi and Madagascar.

Humans matter: The who

Even more than 'where', the 'who' dimension is not too useful for the consumption side: we are all food consumers. For the production side, however, the ones actively participating in the system in many cases stand out in the way that they belong to the most vulnerable parts of the population. Levitte [45], for example, shows that 75 per cent of all farm workers in the US are Mexican born. Many scholars have documented the precarious labour conditions of immigrant workers in the farming systems of even developed countries. For instance, Arici et al. [4] compared the working conditions of the locally born and immigrants in Italy and Spain, concluding that immigrants faced higher physical demands, poorer working conditions, more exposure to occupational risks, a greater risk of occupational injuries and worse general and mental health.

Such socioeconomic issues also affect self-employed farmers. Even in the richest countries, poverty among farmers may strongly affect the sustainability of food systems [12]. However, the lack of resources for peasants in the Southern hemisphere is an even greater obstacle for food system sustainability. Ségundo-Metay and Bocco [72] have called this group both 'vulnerable and invisible', as they are exploited by both governments and businesses [10]. If peasants are landless, the situation is even worse [49]. While case studies indicate that other parts of the value chain also suffer from issues regarding social sustainability [35, 63], it appears clear that the greatest obstacles for social sustainability in food systems lie in primary production. La Via Campesina [41] reminds us that half of the global population are peasants.

Women are, in general, more vulnerable than men, and the food system is no exception. The strive to empower women includes agriculture, the food industry, retailing and catering [44]. Differing gender norms continue to limit the access to resources that women have [55].

While it is crucial for the socioeconomic pillars of sustainability to protect the vulnerable groups that legitimately earn their living within the food system, it may be even more important to focus on the group that should be protected from becoming part of the production system: children. The International Labor Organisation reports that 60 per cent of all child labourers between 5 and 17 years, or 98 million children in total, work in agriculture, most of them as unpaid family members [33]. While child labour is more prevalent in the global South than the global North [78], it also occurs in advanced countries, such as the US [2]. Protective policy mechanisms that prevent the food produced by the help of children to be traded are still lacking.

The dimension of the 'who' parallels to urban agriculture in the 'where' dimension in the way that the early inclusion of consumers turned 'prosumers' into the basics of the food system increases trust and competences among the non-agricultural population. School food gardens [8] and community supported agriculture [84, 32], for example, may close the gap between food producers and food consumers.

Diet matters: the what

The environmental dimension of sustainability is strongly affected by consumer choices. It applies also for this aspect that the choices by producers and consumers are strongly interlinked. However, political economists usually consider that our market economies are much more demand than supply driven [52], and in the vast majority of countries, it is food consumption trends, not food production trends, that steer the portfolio of the agri-food chain.

Scholars agree that the balance between crop-based and animal-based calories is the core criterion for environmental performance. It has been shown repeatedly that the environmental efficiency of animal products lies several factors below the environmental efficiency of crop products [13, 43, 58]. Thus, the substitution of an animal by crop products offers synergies for several impact categories [23].

In fact, altering the balance between animal-based and crop-based calories can be considered as one of the biggest levers for a systemic improvement of the food system's environmental sustainability. When looking for ways to extend organic agriculture to the entire global farmland, Müller et al. [53] show that the resulting calorie deficiency could be compensated by substantially reducing the share of animal-based products in the diet and by reducing food waste.

Of course, also within the groups of animal- and crop-based food items, the environmental footprint differs. Potter and Röös [61], for example, show that the environmental impact of organic apples lies well below that of conventional bananas. These differences pale, however, when creating an environmentally optimised diet in which animal products play hardly any role, being substituted by a broad range of different crop products [82]. This has led to calls to take into account the different environmental footprints between crop and animal products through taxing the latter [46, 47].

Finally, the packaging of food [27] can play a major role in reducing food waste [86]. With respect to the environmental impact of food, however, Schönberg et al. [70] conclude that the component of food packaging is rather negligible.

Processes matter: the how

The previous part has steered our attention towards the environmental dimension of sustainability. Historically, however, the first attempts to reduce the environmental damage of agricultural production were concerned with the 'how' instead of the 'what' dimension. In particular, generations of environmentalists have pressed for lower nutrient loads [88] and lower pesticide application rates [59] on farmland, which would tackle a large range of environmental variables, from biodiversity to ammonia and phosphate emissions to toxicity.

In recent years, the debates surrounding the intensity of farming have gained a systemic component by extending to a debate between land sparing and sharing. Provided that a certain number of calories are produced, less intensive land uses (through reduced chemical inputs) will require a larger area for cultivation than more intensive production systems. While Phalan [60] emphasises 'that most species will have larger populations if food is produced on as small an area as possible, while sparing as large an area of native vegetation as possible', it is unlikely that there is a right and a wrong side in this debate describing trade-offs. However, it is certainly a merit of this debate that it has shifted attention from the degree of intensity to the degree of eco-efficiency [81, 74].

Agricultural science has brought forward many ways to improve the eco-efficiency of production. They include biological progress, such as improved crop varieties [22], and managerial changes, such as pig feed being adapted to the animal's age [28]. More attention, however, has recently been devoted to the potential of digital solutions in agriculture for improving the efficiency of resource uses. Many scholars hope that the digitalisation of agriculture may improve the spatial targeting of agriculture [19]. To date, however, 'the prospects and effects of digitalisation in the agri-food sector and in agricultural policymaking are uncertain' [18], and the digitalisation of agriculture has created more questions than answers [34]. It may be better to more closely examine the social factors that affect eco-efficiency, such as the lower degree of eco-efficiency for part-time farms [29].

Most issues raised within the pillar of socioeconomic sustainability itself also fall under the category of the 'how'. In this respect, the low income of both peasants and farm employees is one of the most important issues. Christiaensen et al. [11] have shown that involvement in agriculture benefits the poorest of the poor (reflected in the $1/day threshold), but that the non-agricultural sectors do a much better job to lift people above a $2/day income. More strongly related to the ‘how’ is that there is a broad consensus that labour in agriculture should be voluntary [26], that workers should be allowed to organise in unions [77] and that sustainable food systems should not pose any health hazards to either farmers [73] or consumers [3].

Different production systems may have affect both the environmental and the socioeconomic pillar of sustainability. Bandanaa et al. [5], for example, conclude, based on a case study of Ghana’s cocoa production, that organic systems fare better in terms of land degradation, greenhouse gases, profitability, and gender equity than conventional agriculture. Other forms of institutionalisation may also help to increase the sustainability of the food system, as Holt Gimenez and Shattuck’s [31] introduction into food movements indicates.

Finally, the ‘how’ dimension also includes the question of ‘how much’, leading to two additional issues of great importance to the sustainability of food systems. The first issue is the amount of food that is produced but not appropriately used. Avoiding food waste [38], or valorising it where avoidance is impossible [40], is key for more sustainable food systems. The second is the amount of food that we actually consume. Steiner et al. [76] show how both hunger and obesity are indicators for non-sustainable food systems.

Two attempts in order to simplify the complexity of the food systems have already been made. One was the early distinction between the environmental, economic and social dimension of sustainability, which later extended to health for food realm. The other was Messerli et al.’s [50] distinction between system descriptions, target formulations and transformative research. Figure 3 shows how a few of the relevant research questions, most of them mentioned above in a more general way, make their way into the three-dimensional system.

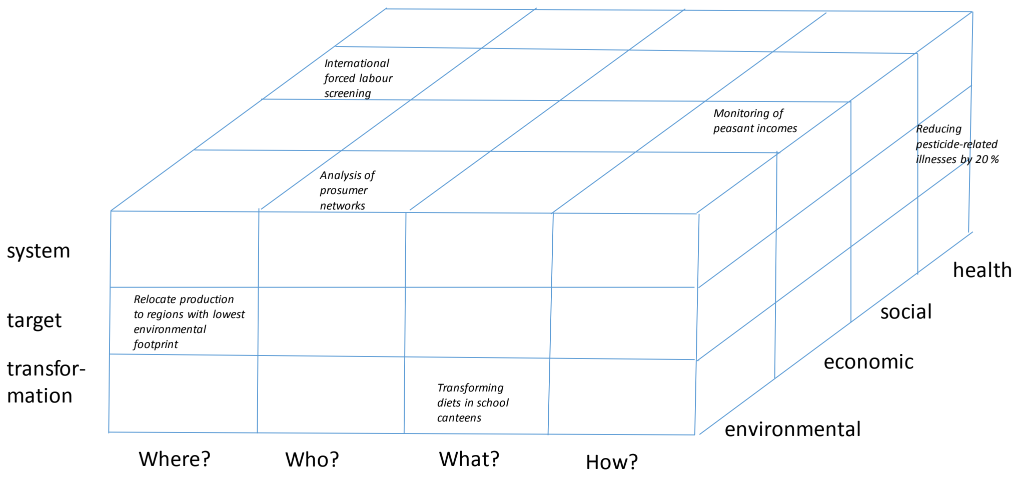

Fig. 3. Examples for research topics in the three-dimensional system
Source: Authors' own concept.

CONCLUSIONS

The increased interest in a system approach is a crucial prerequisite for making our food production and nutrition more sustainable. To fully utilise the potential of a systemic view, however, it will be necessary to find ways to reduce the overcomplexity of food systems, which can range from commercial farms in the American Corn Belt to urban food merchants in African cities.

The three-dimensional system that we proposed underline the main aspects that should be approached in relation with the sustainable food. One side of the system underline the necessity of the international forced labour screening, the importance of prosumer analysis and of peasant incomes monitoring. The second dimension is related with the necessity of reallocating production to regions with the lowest environmental footprint and also with the necessity of taking into account the transformation of the diets within schools. The third dimension, which is more difficult to quantify, is to reduce pesticide related illnesses by 20 %. A thorough, worldwide analysis of forced labour in agricultural production seems to be unrelated to the vegan option in a school canteen. Yet it is still crucial to recognise that both things are part of the same system and that interdependencies may well exist. Eventually, every reader will have to decide by themselves if the system of three different dimensions that includes four guiding questions contributes, together with the two other dimensions introduced above, to reduce the overcomplexity of food systems to contribute to their transformations towards sustainability. In any case, thought models will be needed that shift analytical levels and contribute to the formulation of helpful questions as well as to the identification of appropriate answers.

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