Food system boundaries: how they are defined and what that implies for research outcomes and policy recommendations

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Contents

1. Introduction

What determines the boundaries of a food system? What are 'internal' and what are 'external' factors and processes that drive activities and outcomes of the food system? Who is involved and who (and what) is/are excluded when boundaries are defined? These were just some of the questions during an internal workshop on food system analyzes organised by Wageningen researchers, held on 15 June 2021. The purpose of the workshop was to raise awareness of demarcation choices made in food system research and the consequences of those choices for research outcomes and related policy advice.

There are various conceptual frameworks for defining a food system (e.g. Erikson, 2008; UNEP, 2016; HLPE, 2017; Van Berkum et al., 2018; Bene et al., 2019), but a very strict demarcation between what is and does not belong to the food system is not given in literature. Studying the whole system is also very complicated, so studies looking for interventions that lead to more inclusive and sustainable food system outcomes make choices about what the research focuses on and what is 'out of scope'. Such choices are often made implicitly on the basis of what is considered most important by clients, implementers, funders and/or by researchers themselves. There is the risk, then, that the consequences of proposed interventions and recommendations may be positive for stakeholders involved, but potentially not for those who are not represented and excluded from the analysis. Or, at the request of the client, interventions may be unilaterally aimed at increasing economic efficiency while not paying attention to, for example, possible negative ecological consequences of the measures. Partial analyses provide recommendations that yield only partial solutions. If we pretend that our food system analyzes deliver systemic solutions, we must be aware of how 'the system' is defined and bounded in our studies, what our analyzes include or exclude in order to justify the scope of our research results.

The aim of this paper is to provide more insight into the consequences of choices made when defining system boundaries and designing food system research for policy and investment recommendations and to draw some lessons from relevant literature and ongoing WR food system research projects. Such lessons may be useful for future programming of food system research, and for policy makers and project implementers active in the field of food system analyses.

This paper builds on key ideas from the scientific literature on system thinking, and deduces from this how system boundary judgements can be brought to the surface. Next, the paper evaluates several food system projects of Wageningen UR for choices made about objectives, scale and scope of each project. Project objective(s) define the scope of a food system analysis and subsequently determine the focus of the recommendations that follow from the study. Awareness of the relationship between who decides on what is researched and how, and with whom involved as stakeholders and experts helps to weigh the contributions of recommendations to desired food system transformation.

The structure of the paper is as follows. Section 2 summarizes main ideas about systems thinking leading to a critical reflection on how boundaries are defined. Section 3 presents a methodological framework that can be used to reflect on system boundary judgements. This framework is used in section 4 in which boundary judgements of several selected Wageningen UR food system research projects are presented, compared and discussed for what this means for their messages and recommendations for action. Section 5 closes with key findings and concluding remarks on possible implications for research and policy.

It is important to note that this paper relies heavily for its approach and implementation on Helffgott and Midgley (2020), a report in which the authors evaluated a UK food systems research program, reflecting on boundary judgements within and across 13 projects.

2. System thinking: how to understand ‘the whole’ by boundary setting

2.1 Reflections on system thinking

Systems thinking has been around for a long time, but has taken off in the last half century due to the growing awareness that major global societal problems - such as climate change, depletion of non-renewable raw materials, environmental pollution, hunger, an income inequality - are interrelated and can only be solved by taking these socioeconomic and environmental interrelations into account. To tackle these global challenges a more holistic than an usually used one-dimensional approach is required and therefore a certain systems thinking (e.g. Schiere et al., 2004; Sterman, 2012).

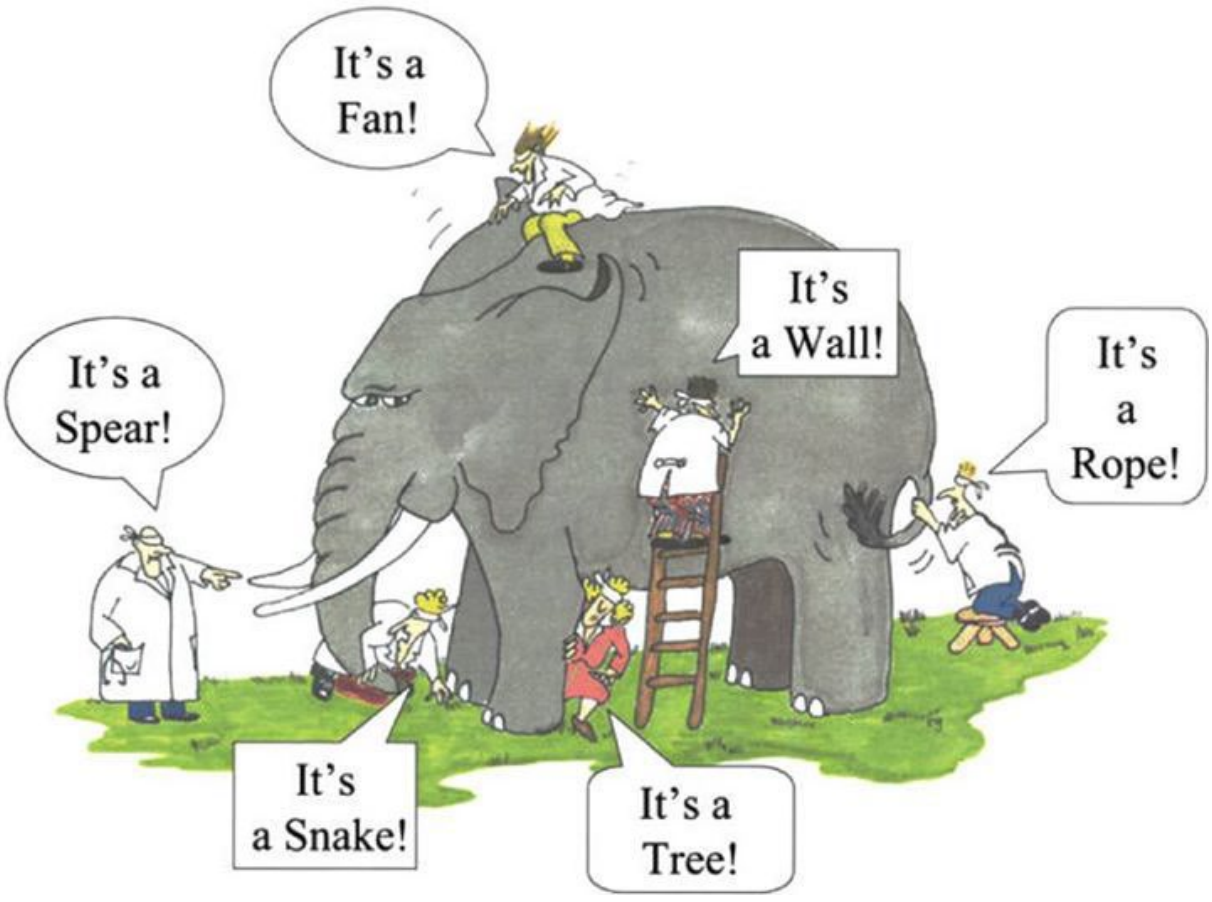
The shift to systems thinking can be understood as one that (i) facilitates understanding the complexity of the whole system rather than focusing on its components, (ii) considers interdependent relationships and (iii) views a problem as a dynamic, interdependent, and ongoing process (Jagustovice et al., 2019). This immediately raises questions, such as: what is 'the whole’ and what are its components; which 'interdependent relationships' should be considered and how; and, in which temporal and spatial dimension a problem should be analysed? Since most things or behaviour can be related in some way to everything else, systems thinking runs the risk of becoming rather abstract and all-encompassing. Besides, what's the point of 'knowing more of everything'? Knowledge must lead to something, to insights and understanding, and contribute to a solution of a problem. But establishing interrelatedness of all factors considered relevant does not necessarily lead to targeted action to solve problems (e.g. Uphoff, 2014). For that reason – and to be able to use systems thinking for practical solutions - the literature on systems thinking gives much thought to defining the boundaries of systems.

In their reflections on systems thinking literature, Helfgott and Midgley (2020) refer to the influential work by Churchman, an American philosopher who worked on operations research, systems theory and ethics. In his seminal book The Systems Approach (1968), Churchman argues that it is impossible to apprehend the whole system in any objective sense and that we make subjective choices about what belongs to it and what does not. Other influential systems thinking authors (such as Ulrich, 1983; 2002) build on these two principles, arguing that there are no natural limits to human (social) and natural (ecological) systems and claiming that limits of a system constitute a 'social reality' (a social or personal construct), that is based on what 'facts' (observations) and 'norms' (values) are considered important or not (Ulrich, 2002). What people observe and consider important is determined by many factors such as cultural background, education, and income and entails that everyone has his or her own reality - see Textbox 1 for an more often used story to illustrate this. Realizing that interests and values have a major influence on scientific research, "the way in which we delineate the relevant 'whole system' that we actually consider in intervention or research needs to be looked at very critically" (Ulrich, 1983).

Text box 1 Blind men and the Elephant

According to Indian folklore, there were once six blind men who had heard of the animal called the elephant but did not know what one was like. To satisfy their curiosity, they decided one day to use their sense of touch to determine the creature's appearance. Matters became confusing, however, when each man touched a different part of the elephant and became convinced that he alone understood its true nature.

The meaning of the story has many potential layers to it. One of the most important of these is that your mind creates your reality. What you experience in life is a reflection of your own perception and perspective. Your perception of what's in front of you is determined by the information already within your head. Your ideas, beliefs, concepts, knowledge and thoughts all influence what you see in front of you, and how you experience it. How you interpret and understand something, or someone, depends upon the thoughts and beliefs you have accepted to be true.



In recent decades, much thought has been given to how social, economic, political, biophysical and ecological systems interact with each other. But this also complicates the choices for system boundaries, and often provokes discussion. In multidisciplinary research, boundaries of a system will be differently defined than in a monodisciplinary approach: different scientific disciplines study different subjects, with different aims and often do so on different scales (e.g. at the individual level in psychology and at the group level in sociology). At the same time, the choice of system boundaries depends on individual choices and personal backgrounds, which implies that also a multidisciplinary approach will be limited to the perspectives on any system of those who are involved in the research. In the end, even with unlimited resources, no research will encompass everything that is or can be relevant. As a consequence, decisions have to be made in every project about what should be the focus of the project.

Any system analysis will therefore be no more than a partial analysis and a partial understanding of the system. This also determines the results of an analysis and the policy recommendations that follow; after all, for what is not included in the analysis, cannot be reported and no recommendations can be made. The normative (because value-dependent) way in which system boundaries are drawn also determines what is desirable and what can be improved. Helfgott and Midgley (2020) emphasize that an unavoidable partial look at the system will also lead to partial conclusions and recommendations, where important interactions in the system and problems can be overlooked.

2.2 Different ways of conceptualising food system

Over the last two decades, agricultural research has shown that more and more attention is being paid to the broader context in which agricultural production takes place. Where food security was previously explained in terms of availability - and hunger can be combated in the first place through increased production - accessibility and use also became parts of that concept (HLPE, 2017). Also, the negative influence of limited natural conditions, environmental damage and climate change on food security was increasingly recognized (Ericksen, 2008; UNEP, 2016). This has led to a shift in research and policy approaches beyond agricultural production alone to improve food security, and increasingly in the use of the food systems approach as a framework for understanding changes in food systems in relation to food security and climate change.

Food system literature has shown different ways of conceptualising the food system: some include more detail in food system activities, considering more complex interdependences and relationships between activities and outcomes than others (e.g. ShiftN, 2009 versus Van Berkum et al, 2018, see Appendix 1), some have a greater orientation on (impacts of food system activities and outcomes on) natural resource (e.g. UNEP, 2016), and others on (consequences of food system activities and outcomes for) diets (e.g. GLOPAN, 2016). Moreover, there are multiple narratives of what causes food systems failure and how to improve it (Bene et al., 2019a; Dengerink and Brouwer, 2020). These narratives suggest a consideration of the main bottleneck(s) that need(s) to be resolved as a matter of priority, and in which interventions and investments should be made.[1] At the same time, by zooming in on a perceived dominant reason for food system failure, there is a risk that the underlying analytical framework pays (too) little attention to potential trade-offs between interventions and feedback loops in the system.

Different conceptual frameworks of food systems highlight different external factors that are assumed to drive activities and outcomes. Defining factors as 'external to the food system' draws a line between core activities in the food system and important drivers of food system outcomes, but which external factors may or may not be relevant to the food system can be debated (see Bene et al, 2019b for a critical literature review on how drivers are defined and how that affects research outcomes).

[1] For instance, one narrative points at the inability of the system to feed future population prioritising actions to close yield gaps, another narrative emphasises the system's inability to deliver nutritious foods, calling for investments ensuring the quality of diets.

Full comprehensiveness of a system may be unattainable, but *greater* comprehensiveness of the food system than we currently have can be strived for. How much greater? The scope and depth of a system analysis is often the subject of practical choices related to, among other things, the available budget, time and accessibility of data – all also and especially in the light of the purpose of the study. It is important to be transparent about the arguments underlying the establishment of system boundaries and to provide insight into what a system boundary means for the scope of the analysis and the impact that recommendations from the study can have. Such transparency and explicitness of the scope of the analysis helps researchers to conduct the research, and clarifies expectations about the results and possible impact of the project among policy makers and stakeholders.

3. A methodological framework for boundary judgement

Helfgott and Midgley (2020) are relying on insights from Ulrich (1983;1987) to propose a methodological framework with which choices regarding the demarcation of a system analysis can be made explicit and transparent. We follow the same approach here in discussing food system boundaries drawn in Wageningen University and Research projects. The analytical framework for a reflection on choices and values that lead to the delineation of system boundaries in food system research is based on questions organized into four parts. These questions come from Ulrich's 12 Critical Systems Heuristics Questions (Ulrich, 1987, cited in Helfgott and Midgley) and are summarized as follows:

- Motivation: who is the client or beneficiary/whose interests are to be served? What is the purpose and should be the consequences? What is the measurement of improvement or measure of success?
- Power: who is the decision maker? What resources or conditions of success can those involved control? What conditions of success are part of the decision environment and can the decision maker not control?
- Knowledge and expertise: Who is involved as a competent provider of experience and expertise? What counts as relevant knowledge? What or who is assumed to be the guarantor of success?
- Legitimacy: who is treated as a legitimate stakeholder? What is the basis of legitimacy within the project (e.g. positional authority, scientific method, democratic processes, consensus)? What worldview is determining/what different visions of 'improvement' are considered and how are they reconciled?

In the next section we explore the ways in which the above four areas were specified in each project, how that impacted on inclusion/exclusion of different issues and stakeholders and what the consequences of these were. The exploration of the project's motivation, power, expertise and legitimacy was based on project documents explaining the objectives, scope, scale and resolution/levels of each of them, followed by consultation (verbally by telephone and by email) with project leaders to clarify the objectives and intended results of their projects and to explain which discussions have taken place with client(s)/funder(s), stakeholders and research team members.

Note that the projects included in the following overviews are randomly selected from projects that have received financial support from the KB research program Food Security and Valuing Water 2019-2022, some of which also received funding from other sources (in some cases external funding was the main financial source). The analysis does not pretend to provide a complete picture of how system boundaries are determined in the KB program nor in the wider 'Wageningen food systems research' - this is not possible given the time and resources available for this paper - but illustrates the consequences of choices regarding scope for the outcomes of the projects. Also important to note is that the following is not evaluating the projects, whether choices made were 'right' or 'wrong', but merely an attempt to understand and show how choices about what to include in projects came about and what consequences for the research outputs this may imply.

The concepts used in the comparison of projects are clarified as follows:

- Purpose: aim of the project
- Measurement of success: what has to be improved, that is the achievement(s) that show(s) the project has been a success;
- Scope: geographical focus of the project, food sector activities (from input suppliers up to consumers) included in the analyses, other stakeholders involved (e.g. producer organizations), topics specifically focused on (e.g. climate change, healthy diets);
- Scale: the scale level at which project activities and results are focused, such as individual actors, individual commodities, household, sector, value chain, national, international scale;
- Beneficiary: farmers, traders, processors, retail, other stakeholders;
- Expertise involved: discipline, specific competence in disciple (e.g. agronomist, economic modeler).

4. Results

Table 1 below summarizes purpose and expected achievements of each of the projects included in this comparison. The objectives and the way in which these should be achieved are traceable in the project documents. As one can see, the projects have very different objectives. Some projects focus on several sub-objectives at the same time, while others limit themselves to a main objective (which is sometimes formulated very broadly). Within these objectives, different narratives of food system failures and of pathways for improved outcomes can be recognized. The objectives and the metrics for achieving them determine who are directly involved as decision makers and/or beneficiaries.

Table 1. Purpose and measurements of success of the selected WR projects

Project	**Purpose**	**Achievements of the project**
Dhaka Food Systems	Overall project aim is to contribute to the development of a safe, sustainable and resilient food system for the Dhaka Metropolitan Area (DMA). Six thematic clusters: 1. Promoting Nutrition and Food Security (NFS) 2. Upgrading fresh markets (FM) 3. Reducing food loss and waste (FLW) 4. Improving food safety and consumer awareness (FLCA) 5. Strengthening food value chains (FVC) 6. Strengthening food system planning and governance (FSPG)	1. NFS: urban poor scaled up urban gardening practice in respective areas; government and stakeholders influenced for sustainable urban gardening and policy change. 2. FM: food safety and hygiene practice introduced in the city for better food choice; Strengthening of monitoring system in the food market in urban area. 3. FLW: Strengthening of capacity of city corporations and private sectors on food loss and waste and waste management. 4. FSCA: Food safety and awareness program scaled up by city corporations and private sector. 5. FVC: increased capacity of value chain actors for better value chain performance. 6. FSPG: Endorsed Dhaka Food Agenda 2041; Strengthened coordination among government and private stakeholders for FS planning
Deltas under pressure (Bangladesh)	To understand how improved water management can contribute to increased and higher quality milk and shrimp production in coastal areas of Bangladesh	• More healthy cows from feed and drinking water; • Mangroves around ponds; • Collaboration among dairy farmers
Deltas under pressure (Vietnam)	The aim is to increase resilience and improve the production systems of local farmers to make them future-proof and ready for the transition to market-oriented sustainable systems.	• A selection of resilient water management techniques to address drought and salt stress; • A selection of drought and salt tolerant crops (vegetables);

		• Drought and salinity coping crop field/farm management strategies; • Livestock adaptation strategies (drought & salinity); • Recommendations for pest resistant crops; • Supportive capacity development infrastructure; • Best practices and lessons learnt
Nyeri-Kibera fish value chain	The project addresses the (animal) protein deficit in slums by establishing sourcing fish value chains, connecting Nyeri (200 km north of Nairobi) with Kibera, a slum in Nairobi (See Soma et al., 2021)	• One ton of fish being supplied on a weekly basis by means of a slum outlet with freezers (set up by WUR) in Kibera • Profit margin for sales place, for vendors and for the small scale fishermen • Number of Kibera inhabitants consuming the fish purchased • Number of women sales vendors taking part in the businesses • Number of small scale farmers and additional counties supplying fish to the fish market outlet in Kibera • 6) Description and number of core bottlenecks handled by the local communities and by the project
Post-harvest assessment tool	Development of tools to accelerate post-harvest (PH) interventions in fresh produce value chains, with the aim of supplying more and better quality markets, achieving a positive impact on the food system (in particular improving food and nutrition security (FNS)).The project focuses on developing two PH tools, one for public actors and one for private sector.	Public tool: • Improved farmer income / inclusiveness • Improved FNS (food availability) • Reduction FLW • Stimulate private sector investments through policy incentives Private tool: • Business model • improved income • reduced food loss & quality loss
Improving FS in less-favoured East-Africa – Ethiopia	1. To identify appropriate, crop and livestock options for the main farming systems outcomes (i.e. healthy diet for household members, farm economics, GHG emissions, nutrient balance); 2. To support stakeholders in setting the R&D agenda for the transition of local farming systems towards achieving various food system goals.	Stakeholders are engaged in the research process, validate outcomes of the analyses and take outcomes into account in their decision-making
Improving FS in less-favoured East-Africa – Uganda	1. To identify appropriate, area-specific options that respond to the main drivers of the food system (population growth, low productivity systems, malnutrition, etc.), and offer solutions for the main food system outcomes (healthy diets for the population, soil nutrient balances); 2. To support stakeholders in setting the agenda for the transition of local food systems towards achieving the SDG Zero Hunger.	Stakeholders are engaged in the research process, validate outcomes of the analyses and take outcomes into account in their decision-making
Seaweed as sustainable food source	Explore the potential of seaweed to help solve world food hunger	Completion of 27 varied project deliverables among which workshops, conference participation, journal papers, reports

Table 2 summarizes the scope, scale, beneficiaries and expertise of each project. These elements already provide a first picture of choices regarding the demarcation of the food system that is included in the analyses. The demarcations lead to choices regarding the expertise deployed. Each project involves a broad expertise that includes multiple disciples. This overview shows that in each of the projects the input of different disciplinary perspectives is ensured.

Table 2. Projects' scope, scale, beneficiaries and expertise involved

Project	**Scope**	**Scale/levels**	**Beneficiaires**	**Expertise involved**
Dhaka Food Systems	Dhaka Metropolitan Area (4 city corporations); Consumer behaviour and nutrition; Value chain activities: production, food provisioning (retail and fresh markets); Urban food system planning and governance	Individual; households; communities; Dhaka city corporation (including peri-urban and production areas in the rural continuum); national	Urban poor Dhaka urban dwellers City corporations Nat gov (local governance) Market vendors/ committees Food vendors, Food retail	• Urban planning • Multistakeholder facilitation • Local governance / policy making • Value chain expertise • Food loss & waste management • GiS/environnemental expertise • Socio-economic modeling • Foresights & scenario analysis • Food safety & hygiene • Nutrition • Gender • M&E expertise, irt to learning
Deltas under pressure (Bangladesh)	Geographic: Southwest coastal Bangladesh Focus is on water management and salinity in agriculture livestock and aquaculture/shrimp systems Decision making of farmers/fishermen	Farmers/ fishermen	Farmers/ fishermen	Economic Water management Livestock Aquaculture
Deltas under pressure (Vietnam)	Geographic: Mekong Delta in Vietnam. The focus is on adaptation to climate change at the farm and field level in relation to: salinisation, drought and pests.	Farms and farm fields in the context of biophysical and socio-economic context of the Mekong Delta	Farmers Education/ research Private sector	Water purification Livestock Agronomy Crop breeding Capacity development
Nyeri-Kibera fish value chain	Nyeri and other counties joining to supply fish to Kibera, including small scale fish farmers, the value-chain, cooperatives and organizations	Local networks including public-private partnerships, local communities, individuals, households	Local communities, the informal sector, including small scale entrepreneurs throughout the whole food	Local communities often know the problems and possible solutions, but struggle with specific bottlenecks WUR has listened to local communities to

	Kibera (slum in Nairobi) including slum leads, slum fish vendors, slum consumers		system, and Kibera consumers (children, families, people coming back from work, etc) Small scale fishermen producers of small sized affordable fish	understand the core bottlenecks, contributed with insights and opportunities as well as financial support to conduct a total of 4 surveys, organise a workshop, finance travel to Kenya, payments of setting up a sales place in Kibera with 3 freezers, weighting scale desk etc, and licenses.
Post-harvest assessment tool	Based on Food system framework • Fresh food supply chain from harvest until market (retail). • Governmental policy • Enabling environment • Technology • Finance & business model Public tool is focused on the more broadly defined objectives of improving food and nutrition security and rural development (by connecting farmers to markets) Private tool aims to find attractive business models in which sustainable investments postharvest can be made, to access new markets and reduce FL.	In the project focus on two projects for validation (Rwanda and Jordan). The postharvest tool is meant for use in LMIC in general. Public tool is focused on governments, with interest in FNS and rural development at country level. Private tool: an individual company can be the initiator for postharvest reduction measures but will find that interaction and coordination with other actors in the supply are necessary to successful implementation, hence a chain perspective is always needed	Governments and development banks: to create policy, enabling environment and arrange for finance. Private sector: to create profitable market access of fresh produce through cold chain development. Beneficiaries: • Farmers • Traders / logistics companies • Consumers • Governments	Postharvest physiology & technology + supply chain development Policy & enabling environment Multistakeholder participation and inclusiveness
Improving FS in less-favoured East-Africa – Ethiopia	The use of a quantitative tool at farm level (Farm Design model) to explore options for different scenarios and support decision-making	farm	National agricultural research, extension, farmers	Livestock, plant, and soil scientists
Improving FS in less-favoured East-Africa – Uganda	The use of quantitative tools (regional optimization model, TechnoGIN model at field scale) to explore options for different scenarios	Regional/district	Local stakeholders including national and local Government agencies, national agricultural research and	Plant, livestock, soil, natural resources management, social and nutrition scientists

	and support decision-making		higher education, NGOs	
Seaweed as sustainable food source	The whole value chain, from biophysical processes, product processing, distribution and consumer attitudes	From local (Indonesia) to worldwide	Scientists, farmers, extension workers, policy officials	Farmers, Indonesian consultants and scholars from a highly interdisciplinary team involving 7 WUR institutes

In terms of 'power' and who is in control of the research activities , the funding structure and who is partner in the project should be clear. Table 3 lists the funders and the organizations (if any) actively co-operating with WR colleagues in the projects. Each of the project is funded to a greater of lesser extent by own WR investment means (KB-funds). In the Dhaka FS project FAO is lead implementor so defining the scope of the project, but basically sticking to what was agreed in the project proposal: Dhaka metropolitan area, spatially and governmental, and temporal (future outlook to 2041). On top of this, the operationalization of boundary setting in the Dhaka FS project was guided by existing (formal) governance structures, i.e. DMA comprising 4 different cities (and their city corporations; the BGD version of large cities' municipalities).

The funding structure of the projects means that the WR scientists are in the lead when it comes to the design of the research. The research focus should be in line with a strategic research agenda of a KB theme that, together with other KB themes, should build up its own WR expertise in order to be able to answer future research questions. The projects are therefore primarily an elaboration of WR knowledge needs, which is based on expected future social knowledge needs in the field of agriculture, nature and food. In this context, the subject of legitimacy must be seen: the question 'what should be investigated' and 'who should be involved' is mainly answered in these projects by WR project leaders and team leaders. They are therefore the (in Ulrich's words) 'legitimate stakeholder who argues (should argue) the case for those stakeholders who cannot speak for themselves, including future generations and non-human nature' (Ulrich, 1987).

Table 3. Funding sources and partners in projects

Project	**Funder of WR-activities**	**Participating partner(s)**
Dhaka Food Systems	EKN (Dutch Embassy) Bangladesh, KB (small amount)	FAO Bangladesh; 4 Dhaka city corporations
Deltas under pressure Bangladesh	KB program	Solidaridad (NGO)
Deltas under pressure (Vietnam)	KB program	Than Loc Phat seeds (http://www.tanlocphatseeds.com) Experimentation on site at the experimental station in the Mekong Delta. (in kind cooperation); Can Tho University
Nyeri-Kibera fish value chain		Local community leaders
Post-harvest assessment tool	KB program	n.a.
Improving FS in less-favoured East-Africa – Ethiopia	KB program	Local partners, not specified
Improving FS in less-favoured East-Africa – Uganda	KB program and Refooture (supported by the University Fund Wageningen)	Local partners, not specified
Seaweed as sustainable food source	KB program	Diponegoro University & Hasanudan University (both Indonesia); Also cooperation with private sector partner in the region:

		Kospermindo (https://kospermindo.id/)

Table 4 below maps out which food system drivers, activities and outcomes are covered in each project. The main observations from this table are:

- Most projects highlight socio-economic drivers as main factors impacting food system activities and outcomes; less projects take environmental drivers into account;
- All projects cover production, except the Post-harvest assessment tool project;
- No project other than Seaweed includes all food system activities;
- All projects deal with food security impacts of a subset of food system activities;
- A majority of project look at nutrition security (i.e. address explicitly food safety and/or quality as measures of success)
- Half of the number projects focus on either environmental or socio-economic impacts, the other half on both dimensions.

The table does not show the weight given to each of the different issues covered of the various projects. However, the strong production orientation of the project is clear from the table (note: Dhaka project includes urban gardening by urban poor households as important activity to enhance food and nutrition security). The majority of the projects are mainly focused on certain commodities, some on a specific commodity (e.g. fish or seaweed), but more often on a group of products (e.g. livestock, staple crops, fruits and vegetables), whereas all except the Seaweed project address issues related to a part of the food system activities. (note: the Nyeri-Kibera project evaluates effects of interventions on preparation activities for [fresh] fish consumption, such as salting, drying and packing of fish fish [see Ayuya et al 2021], as well as social capital [in: Koster et al 2021], but not yet processing into fish products.)

Table 4. Food system drivers, activities and outcomes included or excluded from WR projects (green is included)

	Drivers		Food system activities					Food system outcomes			
Project	Environmental	Socio-economic	Production	Storage/transport/trade	Processing	Food retail & provisioning	Consumption	Food security	Nutrition security	Environmental outcomes	Socio-econ. outcomes
Dhaka Food Systems											
Deltas under pressure (B)											
Deltas under pressure (V)											
Nyeri-Kibera											
Post-harvest assessment tool											
FS in LFA East-Africa (E)											
FS in LFA East-Africa (U)											
Seaweed											

The projects indicate multiple beneficiaries. Some highlight their focus is on the position of and implications of the research for farmers and/or fishermen (Deltas B, Deltas V, and Seaweed) whereas others consider their research to be targeted at government authorities and/or research organizations in the first place although the analyses in particular show implications for the primary sector, as is the case in the two FS in LFA East Africa projects. Consumers' needs and perspectives are central in the Dhaka and Nyeri-Kibera project and the PH tool project focuses on midstream actors. Despite these differences, most projects argue that all, if not many, food system actors, including governments and research and/or education, will benefit from the insights the research will provide.

Some project leaders indicated local government and knowledge organizations (mainly universities) played a role in the design and implementation of the research, and are involved in workshops and other project events that were held, for instance, to share results. As the Dhaka FS project leader indicates: "In DFS, it is the local governments deciding quite a bit on the scope and direction of the project. And note: DFS is not primarily defined as a research project, but as an ODA/implementation project with Wageningen as knowledge partner to contribute to FS analyses to support appropriate intervention development". Active involvement of farmers in decision-making about research topics and knowledge sharing is limited - project leaders say they have tried (through workshops organized in the countries considered), but in practice it is (or has been) difficult to involve individual or (representative of) groups of farmers in the research. At the same time the Dhaka and Nyeri-Kibera project report direct and active involvement of local consumers through conducting consumer research.

Some of the project leaders also indicate that despite the often assumed good contacts of Wageningen University & Research in the countries the project focuses on, it is not easy to find the right local partners. This proved difficult at government level, but especially at farmer and/or industry level. An important reason why stakeholders are difficult to engage, may be related to the purpose of the project. As the leader of the PH tool project indicates: "Think this has to do with the entry point of research. Companies are not so much interested in a full food system project, they have to find a niche within the supply system and focus on a narrow part within boundaries set in the system". Two project leaders (Nyeri-Kibera and FS in LFA East Africa) flag that "...FS research will be less effective if WUR acts as outsider telling local people how the system works and what needs to be done to change it". Their remarks confirm the importance of local stakeholders' involvement for both the quality of the research - by making use of local knowledge and giving it a role in validation of research results - and the chance of its spin-off (that is, that research also leads to policy implementation and/or private investments). The Dhaka FS and Nyeri-Kibera fish value chain projects show to be a successful example of local engagement in which local communities and leaders are actively contributing to project design, conduct and implementation.

The project leaders interviewed emphasize that research is largely aiming at getting better insights into and understanding of the current situations and food system relationships, with the objective to identify options for improving food and nutrition security in a sustainable way. Research outputs so far have mainly focused on the 'what', not as much on the 'how' change or transformation should come about, and 'who' should take action. This does not apply to the Dhaka FS and Nyeri-Kibera projects in which through the involvement of local counterparts research analyses turned already directly into local action. For the other projects such a link between research and practice can still be worked out – all projects continue in 2022 - as the governance of transition is a topic included in most project plans.

Regarding food system outcomes, enhancing food security is central to all projects. Several projects explicitly include a focus on safe and healthy food, that is either elaborated by identifying options to increase production of and access to protein-rich and nutritious foods (e.g. seaweeds, fish, milk; fruits and vegetables, reducing FLW of fresh produce), or through the implementation of food safety regulations (as in the Dhaka project).

5. Discussion: how boundary judgements affect research outcomes and policy recommendations

As projects are not finished yet, research results and recommendations for interventions are non-existent. Therefore, little can be said about possible tensions or synergies between outcomes of the various projects. And how these outcomes possibly relate to choices made to demarcate the scope of the system's analysis. At the same time, each project has different purposes, operates with different scopes

and scales and makes different boundary judgements. Accordingly, the projects generate different forms of knowledge that will lead to different conclusions and recommendations for action.

Food system analyses are supposed to include an integrated analysis into social, economic eand environmental impacts of proposed interventions, and take into account trade-offs between the objectives in these dimension; trade-off assessment is a critical element that distinguishes systems thinking from other approaches such as farming systems or chain approaches. Only few of the selected projects include impacts of interventions on both environmental and socio-economic outcomes, enabling insights in potential trade-offs between these two dimensions of interventions proposed. For instance, a reflection on preliminary outcomes of the FS LFA EA project makes clear that increasing livestock production lead to significant higher GHG emissions, whereas the Dhaka Food Systems project shows that stricter food safety regulations pushes informal street vendors in Dhaka from the market, highlighting the trade-off between safe food and inclusion. Interventions proposed to reduce food loss in the storage or processing phase may have negative income and thus food security impacts for farmers who market part of their output as they may see demand and price drop. How such outcomes are perceived depends on which stakeholders are involved in the project and are engaged in discussing the outcomes of the research.

As emphasized earlier, the food systems approach is a broad interdisciplinary framework, requiring collaboration of different disciplines. Some project leaders are well aware of the consequences of the research project team composition. As one of them remarked: "Our project mainly shows the technical possibilities that can be improved given the natural conditions in order to produce more but at the same time more sustainably. There is, however, still little social context build around the cases we include and socio-economic analysis underlying the technical options proposed. Integrating socio-economic and technical research remains a major challenge".

Several project leaders pointed to discussions they had internally with project team members about the scope and scale of the project, and the consequences of choices made on these dimensions. For example, a city or regional focus (such as deltas) has the benefit of clear administrative boundaries helping in defining government authorities to be engaged with and facilitating data collection opportunities. The FS LFA in East Africa project leader states that "I have had many discussions in the past with hydrologists of WEnR that wanted to stick to watershed boundaries, which in my opinion was little useful as in many countries water councils do not exist (no policy level to be addressed) and also no socio-economic and agricultural data are collected at this level. "Yet a focus on local or other administrative boundaries within a country has the disadvantage of easily overlooking the influence of and interaction with national and international markets and policies. Same is with the scale of households, sector, commodities or value chains: thinking through the consequences of interventions at different scale levels is feasible, but a big task, also given the limitations in time and budget of each project.

Following on from the last comments on scale, there is a discussion about which stakeholders will be involved in the research. Is a distinction made between large and small farmers, agricultural workers, poor and rich urban consumers? For example, there are countless choices to be made within an actor group, for example between informal and formal agri-food midstream companies, between involved government bodies (which ministries) or NGOs (domestic, foreign, etc.). Any choice in this area is a choice for inclusion and exclusion, and determines the scope of the research results: ultimately, impact pathways not investigated and impacts on stakeholders not included will not be visible. It is therefore important to make very explicit and well-considered choices about the boundaries of our research in terms of scope and scale, in order to indicate how inclusive research results can be interpreted.

6. Concluding remarks

The review of the projects provides a picture that the researchers involved are well aware of the limitations of the scope of their work. Available time and budget are main reasons limiting scope and scale of the analyses. These limitations also determine what is considered as a 'food system' in a research project, and thus the scope of its research results, because what does not belong to the system will never be part of the analyses. Most projects zoom in on certain activities of some (not all) actors in the food system, in combination with a focus on a city or region. These choices also show that these food system analyzes do not pretend to cover a 'complete system', but rather focus on solving specific issues for stakeholders that are involved, or are of most interest to the funder(s) and/or researchers of the study. A higher level of ambition cannot be asked for either: after all, there are no inexhaustible resources in the research program to study 'everything'.

Yet, the above implies choices of what is in the project and what is outside its scope. The Helfgott and Midgley framework of boundary judgement helps to make these choices explicit, preferably at the design phase of the project. Applying this framework will also provoke discussion among researchers, between researchers and clients, and anyway forces all involved in the design of the research to specify the purpose of the project, define the boundaries of the food system analysis explicitly and present assumptions about inclusion and exclusion. Such a listing also makes clear whether there are 'value conflicts', that is, different opinions on who and/or what *should* be in the project.

There is no single answer to the question of where to draw the line of the food system. There is therefore no correct or incorrect definition of a food system; a demarcation is the consequence of choices, often of a practical nature, logically based on a theory (of assumed relationships, or a 'theory of change') and on subjective values of what is considered important. It is important to formulate these demarcation choices as explicitly as possible so that the reader knows on the basis of which principles the scope of the analysis and recommendations that follow from it can be estimated.

In the workshop in June (see section 1) there appeared to be consensus about the need for researchers to enter into a dialogue with funders/customers, but also with fellow researchers about the boundaries of the food system, and to reflect on what value judgments play a role in this. Research cannot do everything, but it is important to clarify on the basis of which choices are made about what does and what is not part of the research. Such a dialogue should be a standard part of the design of each food system analysis.

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Table 5. Project title and name of project leader

Project	**Project lead**
Dhaka FS	Marion Herens
Deltas under pressure Bangladesh	Catharien Terwisscha van Scheltinga/Jan Verhagen
Deltas under pressure (Vietnam)	Catharien Terwisscha van Scheltinga/Jan Verhagen
Nyeri-Kibera fish value chain	Katrine Soma
Food loss and waste interventions	Bob Castelein & Bas Hetterscheid
Improving FS in less-favoured East-Africa – Ethiopia	Huib Hengstdijk
Improving FS in less-favoured East-Africa – Uganda	Huib Hengstdijk
Seaweed as sustainable food source	Dolphi Debrot

Appendix Two illustrations of Food System Conceptualization

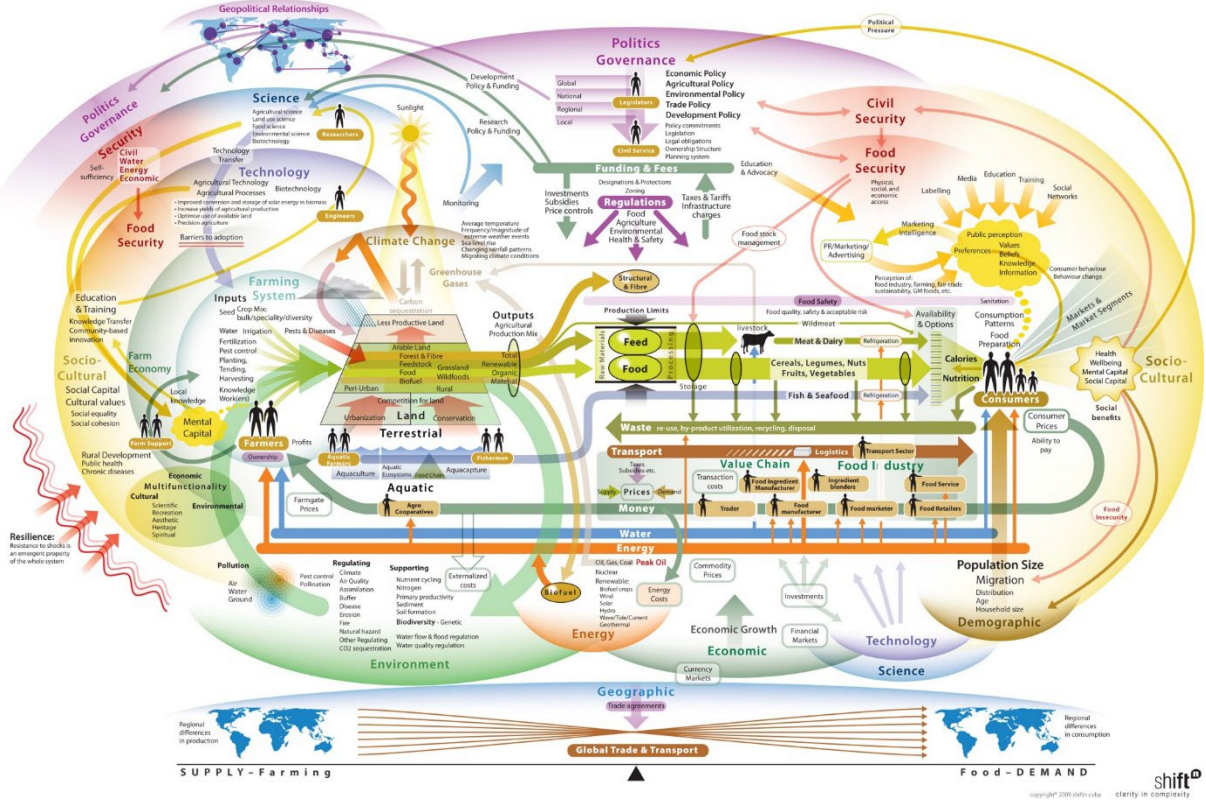

Figure A.1 Food system conceptual framework by SHiftN (retrieved from https::\ShiftN.com)

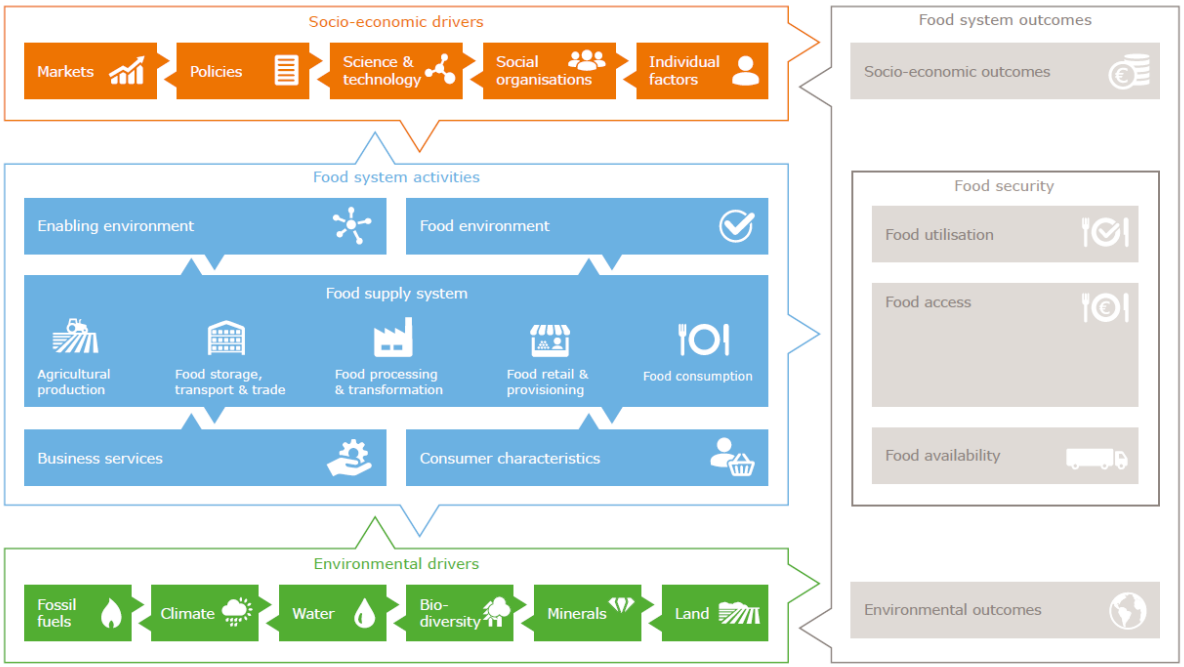

Figure A2. Food system conceptual framework by Van Berkum et al (2018).