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Food Systems Policy and Social-Ecological Resilience:
The role of the European Green Deal for food systems transformation.

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The role of the European Green Deal for food systems transformation.

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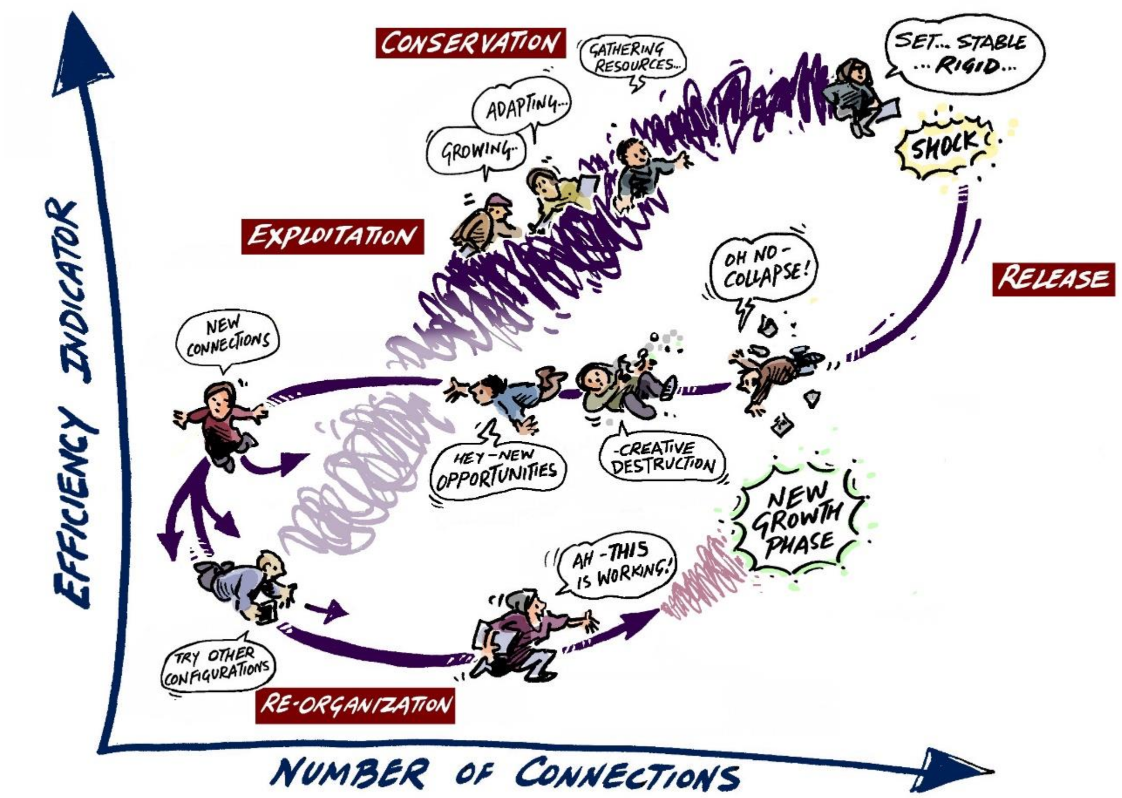

Acknowledgment

The idea of this project grew out of the classes of **Ian Bryceson** and **Ruth Haug**;
I'm grateful to **Ian** for introducing me to the linkages of social and ecological resilience, which continues to present to me a core element of agroecology and its practices.
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Abstract

This master thesis presents a theoretical discussion of the Farm to Fork strategy's aim to transform food systems to become resilient. Over the last 20 years, the international scientific community has established that food systems are threatened by processes of environmental change, exacerbated by modern production and consumption patterns. A growing urgency can be observed in more recent international reports, such as the IPCC special report on climate change and land (2019), the IPBES global assessment report on biodiversity and ecosystem services (2019), or the HLPE report on sustainable agriculture and food systems (2019). The Farm to Fork strategy, published as part of the European Green Deal in May 2020, can be understood as a response to these reports. Using social-ecological resilience as the theoretical lens, this work sets out to assess the potential of the strategy to transform food systems and to make them resilient. Methodologically, systems thinking is used to conceptualize both resilience of social-ecological systems as well as models of food systems. The analysis suggests that the Farm to Fork strategy operates with a narrow and simplified approach to established food systems' problems and focuses on optimization and efficiency; it, therefore. fails to design an actual proposal of transformation and misses an opportunity to build resilience of food systems. On the contrary, it is argued that the Farm to Fork strategy runs risk to further reduce food systems' resilience and to increase vulnerability in the long run.

Key concepts:

Adaptability describes the capacity of actors in a system to adjust to changing variables. This may avoid a shift into a different system's configuration – for better or worse. Adaptability is thus a form of managing systems' resilience.
Adaptive cycles are a metaphorical tool to describe the progression of social-ecological systems through phases of growth, conservation, release and reorganization. With each phase comes a distinct system behaviour and varying degrees of internal connections, flexibility and resilience. Next to the passing though the sequence in this exact order other transitions are possible, even if less common.

Basins of attraction describe all the different stable states of a system which tend to change towards a global attractor i.e. an equilibrium state of the systems. Individual attractors pull or attract individual variable towards them, this an attractor can also be understood as a tendency. In a system with n-variables the basin of attraction is a place located in a n-dimensional coordinate system. Multiple alternative stable states may exist. However, due to variables continuously changing the system remains dynamic and in search for a stable equilibrium state.

> **Multiple basins of attraction** is a phrasing for describing the larger landscapes of various attractors, or tendencies.

Complex adaptive systems are complex systems that are continuously evolving, process-dependent and self-organizing. Complex means here that a system consists of various subsystems, which are hierarchically nested into each other. Complex systems display non-linear dynamics and multiple attractors. They are path-dependent and can re-organize themselves in face of instability and collapse. They are adaptive if a system has an ability to learn and adjust, which is the case in social-ecological systems.

Feedback is or a signal secondary effect as a consequence of a direct effect of one variable onto another. Feedback affects the magnitude of change in that specific effect and can be reinforcing (positive feedback) or weakening (negative feedback). As such feedback helps to maintain stability or to speed up processes of change.

Food Systems Approach (FSA) is an analytical framework to portray and study the complex web of resources, actors, and activities facilitating the production and consumption of food. As a tool, it helps to understand and analyze the relationship between the different system components, and their impact on their geobiophysical, social and economic environments. The approach aims for a holistic mapping of interactions while acknowledging the non-linear nature of systems' behaviours. It therefore lends itself well for the analysis of system behaviour before and in response to (policy) interventions.

Panarchy builds on the concept of adaptive cycles and describes the hierarchical nesting of adaptive cycles at different (spatial and temporal) scales (from small and fast to large and slow cycles). Between the different cycles (scales) effects can travel as revolt (bottom-up) or memory (top-down) and contribute to a system's persistence and improvement over time.

Regimes describes a set of states a system can stay in and hold on to the same structure and function (system configuration). A regime can also be described as having the same identity. Most social-ecological systems can exist in more than one regime. A regime shift therefore describes a rapid reorganization from one system configuration to another. The new regime displays a different set of characteristic structures, functions, and feedbacks.

Resilience has been defined as the capacity to absorb disturbance/ undergo change and remain in the same regime, that is, to uphold the same structure, function, and feedbacks**.**

Social-ecological systems are linked systems of people and nature to reflect on the interrelations between human and environmental systems. They are also described as coupled human-natural systems or human-environment systems. They include ecological, social, and economic systems as integrated and interrelational components.

Sustainability refers to the usage of a resource in a manner that it can persist indefinitely without a significant decline in quantity and quality.

System thinking is a way of thinking about reality. It understands systems to consist of interdependent and interacting components which in their totality produce an emergent quality, i.e. the system's purpose/ function. It focuses on the interactions of the different system's parts (or agents) rather than on the parts themselves. As a methodology, systems thinking provides a language for dealing with systems' complexity and change.

Transformability describes the capacity to create a fundamentally different (new) system when ecological, social, or economic conditions make the existing system untenable.

Thresholds are levels of controlling variables at which feedback to the rest of the system changes.

Variables hold changing values and describe therewith a system's state. Thus, state variables describe variables that constitute the system. Controlling variables are those variables that determine the levels of other variables (e.g. nutrients for plant growth). Fast and slow variables refer to a variable's tendency to change. Ecological variables tend to change slowly while some social variables can change fast (i.e. "fads") and others slowly (i.e. cultures, institutions, etc.).

Abbreviations

AFOLU – Agriculture, forestry and other land use
AoA - Agreement on Agriculture
BFA – Biodiversity for Food and Agriculture
CAS – Complex adaptive systems
CAP – Common Agricultural Policies
CBD – Convention on Biological Diversity
CEAP – Circular Economy Action Plan
CFS – Committee on World Food Security
EGD – European Green Deal
EU – European Union
F2F – Farm to Fork
FAO – UN Food and Agricultural Organization
FFF – Fridays for Future
FSA – Food Systems Approach
GATT – General Agreement on Tariffs and Trade
GHG – Greenhouse gas
GND – Green New Deal
IBRD – International Bank for Reconstruction and Development
IMF – International Monetary Fund
IPBES – Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC – The Intergovernmental Panel on Climate Change
IPM – Integrated Pest Management
ITO – International Trade Organization
NDC – National Determined Contributions (under the Paris Agreement)
OECD – Organisation for Economic Co-operation and Development
OLAF – EU anti-fraud unit
R&I – research and innovations
SAP – Structural Adjustment Programmes
SDG – Sustainable Development Goals
SER – Social-ecological resilience
SES – Social-ecological systems
SME – small- and mid-sized enterprises
SSM – Soft System Methodology
SSP – shared socioeconomic pathways
TFEU – Treaty on the Functioning of the European Union
UN – United Nations
UNEP – United Nations Environment Programme
UNFCCC – United Nations Framework Convention on Climate Change
WB – World Bank
WTO – World Trade Organization
WWF – World Wildlife Fund
XR – Extinction Rebellion

Figures, tables, boxes

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Content

Prelude

The last couple of years have seen unusual attention on climate change and biodiversity loss – both in academia and society. Particularly surprising in 2019 were likely two distinct movements that gained significant media attention: For one, Greta Thunberg's "school strike for climate" which inspired the *Fridays for Future* (FFF) movement of mainly, but not exclusively[1], young pupils around the world. For another, the initially UK-based organization *Extinction Rebellion* (XR[2]), which uses civil disobedience and strategical mass arrests in their demonstrations, attracted attention and growing support around the world. Despite the clear differences in their approach, both movements organized themselves around the understanding that human activities have been stressing and deteriorating natural environments to a degree that if societies do not change their behaviour now, the human population is likely to experience extreme and lasting changes with regard to climate, weather events, natural resources, biodiversity, land use, and habitability.

These movements did yet not develop in isolation but in response to the scientific debate: a general understanding across scientific disciplines exists that climate change will have grave implications for societies and the natural environment alike. Climate change is at this neither a new phenomenon nor is the political debate around it particularly recent. Already in 1992, at the Earth Summit in Rio, were climate change and biodiversity loss of concern and led to the introductions of the *United Nations Framework Convention on Climate Change* (UNFCCC) and the *Convention on Biological Diversity* (CBD) in that same year. By 2018, the year that saw the founding of both FFF and XR, a series of new reports had appeared or foreshadowed their results on the severity of environmental degradation and biodiversity loss due to climate change: after the Intergovernmental Panel on Climate Change's *(IPCC*) special report on *Global Warming* (2018)*,* which appeared in time for the 24th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP24) in December, further influential reports followed in 2019 by, among others, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (2019)[3],

[1] In solidarity with the young generation, groups such as 'Scientists for Future', 'Parents for Future', 'Teachers for Future' etc. have formed offshoots in support of the FFF movement.
[2] XR is the chosen abbreviation by the movement itself.
[3] "Global Assessment Report on Biodiversity and Ecosystem Services 2019".

the UN Committee on World Food Security's High-Level Panel of Experts (2019)[4], the EAT-Lancet report (2019)[5] and the IPCC (2019)[6].

In these reports as well as in research in general a remarkable shift towards the sustainability of agricultural and food systems in changing climates could be observed. Indeed, over the last few years, many of these reports have put agriculture at the heart of their research. This was the case, among others, in the IPCC report on Climate Change and Land (2019), the annual report by the High-Level Panel of Experts on Food Security and Nutrition (HLPE) 2019[7], and the EAT-Lancet report "*Food in the Anthropocene*" (Willett et al. 2019)). The UN Food and Agricultural Organization (FAO) published additionally to its annual report on the state of food security a special report on *The State of the World's Biodiversity for Food and Agriculture* (2019). Common to all these reports was a new urgency for action as well as the analysis of agriculture as not just being negatively affected by climate change but being simultaneously a massive contributor to climate change and biodiversity loss.

In their conclusions, all reports called for a transformation of our food systems.

[4] "Agroecological approaches and other innovations for sustainable agriculture and food systems that enhance food security and nutrition". High-Level panel of experts, Committee on World Food Security, 2019.
[5] "Food in the Anthropocene: The EAT-Lancet Commission on healthy diets from sustainable food systems", Willett et al., 2019.
[6] "Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems", 2019.
[7] "Agroecological approaches and other innovations for sustainable agriculture and food systems that enhance food security and nutrition".

Introduction

With climate change being of growing concern, the need for climate action has increasingly shifted focus toward the OECD[8] countries as the biggest polluters and contributors to changing climates, land degradation, and biodiversity loss. In combination with the financial crises of the last two decades, political ideas of systemic transformation have gained popularity, both politically and in parts of society. As a result, discussions around a so-called Green New Deal have re-surfaced since 2018. In the US, for example, a resolution has been drafted by congress representative Alexandria Ocasio-Cortez and fellow democrats, which has incited significant national debates across the political spectrum. In Europe, the Commission of the European Union (EU) designed meanwhile their own proposal of a green deal, which was presented as a *European Green Deal* (EGD) in December 2019.

In contrast to the American *Green New Deal* the EU's proposal found entrance into the political institutions: tabled in December 2019 by the EU Commission, the EU Parliament voted to support the *European Green Deal* in January 2020. The deal proposes a set of initiatives for the EU to become carbon-neutral by 2050. Among the eight key policy areas the "From Farm to Fork" section is dedicated entirely to making modern agri-food systems "more sustainable and resilient" (EU Commission, 2020e, p. 2).

i. Research question

This aim of creating more sustainable and resilient food systems presents an opportunity to take a closer look at what is proposed. Several questions immediately arise, from what is meant by 'sustainable' and 'resilient' to the nature of initiatives that the EU intends to employ in order to bring about such transformation. This thesis, therefore, sets out to theoretically analyze the Farm to Fork strategy as proposed in the European Green Deal with regard to resilience. The guiding question will be:

What potential does the Farm to Fork strategy of the European Green Deal hold to improve the social-ecological resilience of agri-food systems?

[8] Organization for Economic Co-operation and Development; members are mostly high-income economies with high human development indicators.

The Farm to Fork strategy proposes a transformation of food systems. In the broadest understanding, a transformation means a "physical and/or qualitative [change] in form, structure, or meaning-making" (O'Brien and Sygna, 2013, p. 1). Transformation takes place at different levels (s. below) and is generally a complex process that may come with unexpected consequences (trade-offs) (ibid.). In the field of sustainability, transformation often focuses on development pathways towards reducing emissions – with a particular focus on energy, transport, agriculture - and "purposeful and deep structural changes" (ibid., p. 2). It explicitly includes the role of human agency through socio-cultural, economic, and political institutions as supporting or hindering forces to transformation. According to Sharma (2007) (referred to in O'Brien and Sygna, 2013) three different spheres (figure i.1.) can be distinguished from which change can proceed: 1) the practical sphere of concrete behavioural and/or technical solutions; 2) the political sphere of systemic and structural change that pave the way for practical solutions; and 3) the personal sphere of individual beliefs, values, and worldviews that shape how conditions are viewed and made sense of, thus influencing both former spheres.

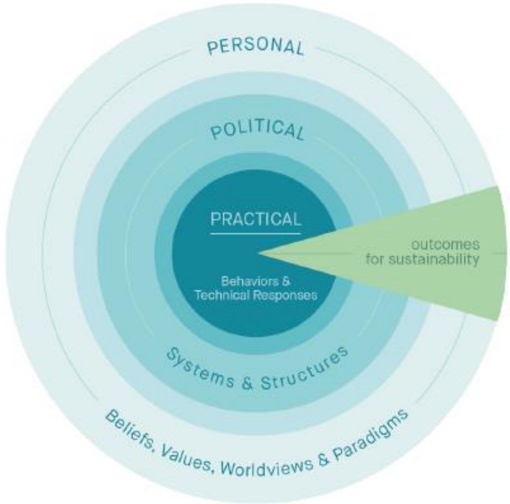


Figure i.1. Three spheres of transformation as printed in O'Brien & Sygna 2013.

With the European Green Deal as the framework of this thesis, this work will be dealing with the political sphere where conditions for behavioural change are created. Politics are "important in the quest for sustainability and enlightened environmental management" (Pritchard and Sanderson, 2002, p.147) and, for the purpose of this thesis, I will follow O'Brien and Sygna's (2013) understanding of the political sphere as the sphere "where both problems and solutions are identified, defined and delimited, and where conflicts of interest must be resolved" (ibid., p. 6).

ii. Thesis structure

In order to assess the potential of the Farm to Fork strategy (hereafter F2F strategy) to increase the resilience of food systems, this paper will begin with presenting a brief review of some core international reports that have argued for a(n urgent) transformation of food systems. In the same chapter, the European Green Deal (EGD) shall be briefly introduced as the EU's political responses to this call. Chapter 2 will engage with the theoretical approach to resilience and develop resilience thinking and social-ecological resilience as the framework with which I shall analyze the proposed F2F strategy. Chapter 3 will clarify how systems thinking has been chosen as the methodological tool to talk about resilience building and food systems, including a brief outline of how food systems can be conceptualized. Chapter 4 will turn to applying the theoretical framework of resilience thinking to modern food systems and assess how the F2F strategy addresses the established understanding of transformation and resilience building. Chapter 5 will finally discuss how, through the lens of resilience thinking, I come to conclude that the F2F strategy holds limited potential to actually transform modern food systems towards resilience and sustainability.

iii. Relevance

The contribution of this thesis is seen in the fact that it tests the EU policy initiative of the F2F strategy towards its stated goal of creating more resilient food systems. The need for reform has long been established, as chapter 1 will show, hence, the policy initiative can be understood as necessary and opportune, if not an overdue action plan. With the rather recent release (May 2020) is has not yet been subject to a larger theoretical debate outside of EU institutions. Various angles of analysing the proposal are possible and this work chooses to investigate the F2F strategy's consideration of and contribution to strengthening social-ecological resilience. Resilient food systems are explicitly mentioned to be the goal of the F2F strategy. I purposefully choose to use social-ecological resilience as my framework of analysis as it seems the appropriate concept for analyzing food systems integrally as social-ecological systems (SES).

This thesis presents a theoretical discussion which will hopefully be supplemented by applied research once the proposal has become enacted as an actual policy. For now, I hope to contribute to a theoretical understanding of the opportunities and limitations seen in the F2F strategy proposal and to stimulate further discussion which can lead to the improvement of this policy proposal.

iv. Positionality

Before diving into the theoretical discussion on social-ecological resilience and the F2F strategy, it is necessary to understand the context of this work and my academic background. This thesis is part of an interdisciplinary master programme in agroecology and brings together ideas from both natural and social sciences. However, I as the author of this thesis, stand unambiguously in the tradition of the social sciences, coming from a background of social anthropology and development studies. This bears important implications for my approach to the topic, the analysis and discussion – both ontologically and epistemologically.

A tension between natural and social science is widespread usually due to diverging epistemologies, and exists, too, in the studies of agriculture and food systems. Their respective focuses traditionally lie with either farming practices, productivity, ecological interactions etc. in the natural sciences, and alternative food systems, supply chain management, knowledge production, social relationships etc. in the social sciences (Wezel et al., 2015). Agroecology as an academic discipline has increasingly emphasized the need for an interdisciplinary and holistic approach, thus demanding for studies to be more integrative (Wezel et al., 2015; Francis et al., 2008). There is the recognition that research on sustainable agri-food systems requires the consideration of both environmental, socio-cultural and economic contexts, which need to be studied inclusively rather than in isolation (Wezel et al., 2015).

This thesis presents a theoretical approach the *European Green Deal,* transformation, and resilience, and is decidedly anchored in the social sciences. However, the subject of analysis relies vehemently on research conducted in the natural sciences. Thus, at the basis of this work lies, therefore, the scientific warnings that have come out of Earth systems-, resilience- and sustainability studies. My work embraces the concept of planetary boundaries and employs the theoretical lens of resilience, which originally derived from the field of ecology and continues to be close to environmental studies - albeit the concept will here be expanded by the notion of the social sphere. My theoretical framework can, hence, be viewed as forging the link between the natural and the social forces for this study.

Epistemologically, this work aims to conceptualize and represent reality systematically through establishing structures and their interactions (*systems*). However, there is an awareness that these conceptualizations rather present hypothetical entities than spontaneous observations in reality; however, these are derived from regularities found in the respective natural or social order and whose effects are observable. Such inclusion of provisional categories serves the purpose of identifying mechanisms at work, which can be subject to change (and transformation). This means that this thesis treats reality to a great extend as external and independent rather than constructed. At the same time, I do hold an understanding of socio-cultural institutions, phenomena and meanings to be continually reviewed and newly accomplished/constructed.

v. Limitations

This thesis is to analyze a proposal for an initiative currently developed by the EU Commission. In effect, this means that the analysis and discussion will rely entirely on a theoretical understanding of both the initiative, agri-food systems and social-ecological resilience. In the absence of any applications in reality, there will be no case study nor any other form of firsthand data collection. Operating with a theoretical design necessarily means that it remains a model of reality rather than a true reflection of reality at a specific time and place. Thus, this thesis does not have a temporal and spatial contextualization nor the observation of factual responses to the suggested activities. At the same time, the abstraction of reality gives possibilities for developing a model-like, systemic understanding of the situation at large (which will be at the heart of this project) and allow for a search of general(ized), rather than place-specific findings. However, there is, of course, the risk to miss out on important connections, and this requires the flexibility and willingness of any researcher to remain open to continuously adjust their understanding of the system. It is presumed that case studies at a later point in time will provide the necessary feedback for the conceptualizations of this project.

Chapter 1: Problematical situation (Materials)

This chapter introduces in section A the background to the call for food system transformation. More importantly, it also introduces the basic information upon which in chapter 4 the understanding of food systems' problems and drivers is built. It does so by reviewing a selection of core international reports that have been published in the last 15 years. It also visualizes the notion of a growing urgency to act. Section B will introduce the European Green Deal as a recent response to the call for food systems transformation.

A. Review: A social-ecological crisis in the making

Over the last 50 years, the recognition of an ecological impact of modern agri-food systems has been growing (Clapp, 2016). The industrial agricultural model has increasingly been associated with the unfolding ecological crisis - with numerous studies evidencing its disruptive impact on the environment, biodiversity, and global climates since the 1970s. It seems, therefore, that the development of modern food systems has come at a cost, and while initial concerns focussed on the threats climate change and (socio-economic) vulnerabilities pose to food systems (e.g. Rosenzweig and Perry, 1994; Fischer et al., 1996; Perry et al., 1999; Nelson et al., 2009), the last two decades, in particular, have progressively also studied the impact of industrial agriculture and modern supply chains as important contributors to environmental and socio-economic crises. [→ for a brief overview of how modern food systems have been shaped by social and economic forces since industrialization refer to appendix 1].

The following will review some of the most prominent reports on the state of agriculture and food production since the *Millennium Ecosystem Assessment* report 2005[9].

i. After the Millennium Ecosystem Assessment report, the next major report to be published was the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) report of 2008. Financially sponsored by the United Nations (UN) and the World Bank, this comprehensive report, "call[ed] into question the idea that this universal principle of technological progress in a free-market economy is the ideal concept for sustainable food production and agriculture" (Zukunftsstiftung Landwirtschaft, 2016, p. 21). Bringing together 400 experts and 110 governments, the report aimed for assessing the agricultural knowledge, science, and technology with regard to facilitating social and environmental

[9] The Millennium Ecosystem Assessment was the first major scientific assessment of the ecosystems and the impact humans have on them. Key messages were that the human impact on nature since the second half of the 20th century has been greater than in any other comparable time period before. Growing demand for food, water, timber, fuel, and other resources had contributed to human well-being and economic gain but also contributed significantly to ecological degradation and loss of ecosystem services to an extent that may be irreversible (Millennium Ecosystem Assessment 2005).

sustainability (IAASTD, 2009a). By doing this, the report responded “to the widespread realization that despite significant scientific and technological achievements in our ability to increase agricultural productivity, we have been less attentive to some of the unintended social and environmental consequences of our achievements.” (IAASTD, 2009a, p. 3). Among their key findings were that a) a focus on productivity had negative consequences on the environment, b) demographic and income projection indicated a shift in consumption patterns and a growing food demand, c)intensive export-oriented agriculture had next to some benefits also adverse consequences on soil and water management as well as on exploitative labour conditions, and d) negative impacts, whether socio-economically or ecologically, tend to affect the poor more often and more intensively (IAASTD, 2009b). It suggested that investments and institutional arrangements, including public policies, are crucial for the adjustment to change. It proposed to strengthen agricultural knowledge and research, technological innovation, and the inclusion of multiple voices and perspectives. In this regard, the report contended that “[t]he ability and willingness of different actors, including those in the state, civil society and private sector, to address fundamental questions of relationships among production, social and environmental systems is affected by contentious political and economic stances” (IAASTD, 2009a, p. 4). Finally, it concluded that an acknowledgment of current challenges and a long-term commitment from decision-makers is necessary to meet the challenges of food and livelihood security under increasingly constrained environmental conditions.

ii. Just one year later, in 2009, some of the IAASTD observations found additional support in the publication of “A safe operating space for humanity” by Rockström et al. (2009b). Understanding that “human actions have become the main driver of global environmental change”, this article was concerned with proposing a framework for identifying planetary boundaries, which “define the safe operating space for humanity with respect to the Earth system and are associated with the planet’s bio-physical subsystems or processes” (ibid., p. 472). The framework identified nine key variables – climate change, rate of biodiversity loss, interference with the nitrogen and phosphorus cycles, stratospheric ozone depletion, ocean acidification, global freshwater use, change in land use, atmospheric aerosol loading, chemical pollution –, the “crossing of which may trigger non-linear changes in the functioning of the Earth System, thereby challenging social-ecological resilience at regional to global scales” (Rockström et al., 2009a). They suggested, “three of the Earth-system processes — climate change, rate of biodiversity loss and interference with the nitrogen cycle — have already transgressed their boundaries” (ibid., p.473). Modern agriculture figured here in particular in form of pollution. Apart from the high dependence on fossil fuels, the large-scale application of synthetic fertilizers had distorted natural nitrogen- and phosphorus-flows leading to polluted environments and additional greenhouse gases in the atmosphere – all of which threaten the resilience of diverse ecosystems[10].

iii. In 2015, Steffen et al. published a revised and updated framework of the planetary boundaries concept (figure 1.1.). Several of the boundaries were now two-tiered (regional and global level) to "[reflect] the importance of cross-scale interactions and the regional-level heterogeneity of the processes that underpin the boundaries" (Steffen et al., 2015, p. 1259855-1). Climate change and biosphere integrity were identified as core planetary boundaries "based on their fundamental importance for the [Earth System]" (ibid., p. 736). The authors understood these two fields as "highly integrated, emergent system level phenomena that are connected to all of the other [planetary boundaries]" (ibid., p. 1259855-8). These two fields provide an overarching system in which the other boundaries operate. At the same time, these other boundaries regulated the former two categories via their operations (ibid.). Even though neither agriculture nor food systems were explicitly mentioned, they can yet be directly related to land-system change (e.g. for agriculture) and changes in biogeochemical flows (e.g. loss of carbon

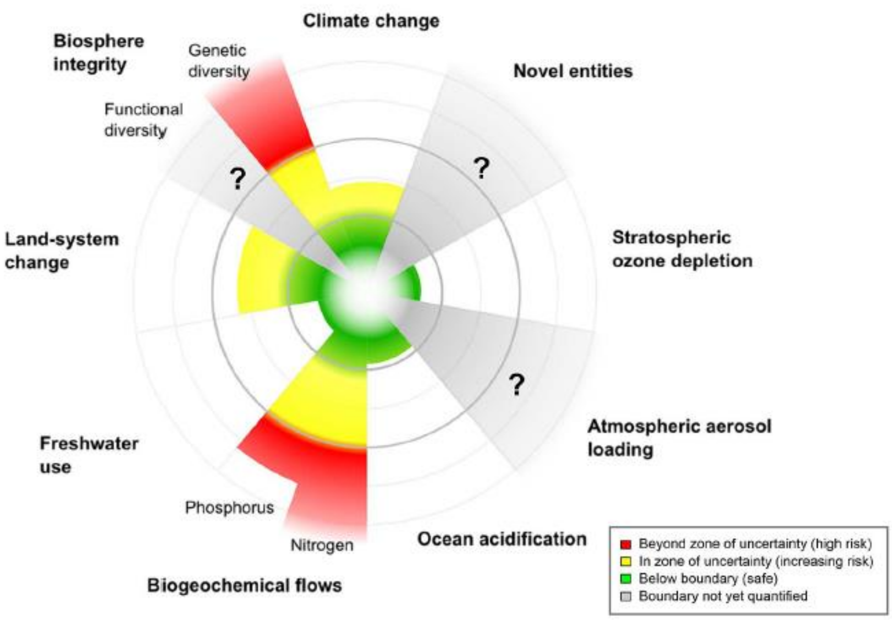


Fig. 1.1. Planetary Boundaries framework as printed in Steffen et al.,2015.

[10] Here needs to be noted that the planetary boundaries framework has important limitations: originating from Earth system sciences the framework uses a systemic approach to physical processes. In order to do so, it tends to generalize heterogenic, highly complex systems. It focuses on the physical environment and does not take into account the human dimension, except for the fact that people do interact with the physical environment. The framework presents a tool to assess the core statuses in relation to their identified boundaries (safe operating spaces) beyond which it is uncertain how the ecological environment will behave (assuming, however, disastrous consequences for human life). The framework does neither suggest how societies should develop nor how to protect safe operating spaces (Steffen et al., 2015); these are decisions to be made in the political arena.

sinks, disrupted nitrogen-, phosphorus cycles) - two boundaries that are in fact in an uncertain state and a high-risk area, respectively.

iv. An application of the planetary boundaries framework to food systems can be found in Meier 2017 and Springmann et al. 2018. Meier (2017) found that agriculture/food production does significantly attribute to biodiversity loss, disrupted biogeochemical flows, and land-system change. According to this study, the application of nitrogen was particularly worrisome and needed immediate curbing. The study did yet not assess the impact of food processing, trade, and consumption, due to a lack of data (ibid.). Springmann et al., on the other hand, developed a projection for the impact of agricultural production in 2050 based on the 2010- data on GHG emissions, cropland, used freshwater resources, and nitrogen and phosphorus application. The prediction was contextualized by estimates on socioeconomic developments (i.e. population growth, income growth etc.). Based on these, they predicted “the environmental pressure of the food system to increase by 50-92% for each indicator in the absence of technological change and other mitigation measures” (ibid., p. 520). They concluded that for the food system to stay within the planetary boundaries required significant dietary changes, reduction in food waste, and improvements in technology and management for water efficiency, reduced nitrogen and phosphorus application, and recycling.

Ten years after the first discussion of planetary boundaries, numerous international reports have further confirmed the dangerous state of the environment due to intensified human activity since industrialization. Most recently, in 2019 and 2020, several international reports explicitly named modern agri-food systems as both threatened by and contributing to a climate and biodiversity crisis.

v. The most widely discussed report in 2019 has probably been the IPCC special report on *Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems* (2019). The report presented an unprecedented comprehensive analysis of the climate-land system and emphasized the immense pressure people are putting on land – directly and indirectly. One decisive role therein does play agri-food systems. A growing population and changes in per capita consumption of food, feed, fibre, timber and energy have increased the demand for land and freshwater use (IPCC A1.3.). An estimated 70 percent of global freshwater usage fall to the share of agriculture alone (A1.3) The expansion of agriculture and forestry “have contributed to increasing net greenhouse gas (GHG) emissions (*very high confidence*), loss of natural ecosystems (e.g. forests, savannahs, natural grasslands and wetlands) and declining biodiversity (*high confidence*)" (IPCC A1.3.). While climate change has already negatively affected the production of certain food items (both crops and livestock), increasing risks of regional food insecurities (A2.8), agriculture and other food systems' activities are contributing to a further worsening. The IPCC report estimated that currently 23 percent of anthropogenic greenhouse gas emissions derive from agriculture, forestry and other land use (AFOLU). The whole food system, including agricultural production, land-use change, and off-farm activities is estimated to make up 21-37 percent of anthropogenic emissions (A3.6). Additionally, land-use change affects temperatures and precipitation, contributing to the intensity and duration of extreme weather events (A4.2). Further climatic changes will exacerbate already existing conditions and pose additional "risks to livelihoods, biodiversity, human and ecosystem health, infrastructure and food systems" (A5) in the future. The report finally estimated food supply instabilities to be high at around 1.5˚C and very high at 2˚C increase in average global temperatures (A5.3). Nutritional values may go down with higher atmospheric CO_2 levels, while processes of further desertification will reduce agricultural productivity as well as modify and reduce biodiversity (A5.4).

The report contextualized these developments with the socio-economic conditions. In what they have called *shared socioeconomic pathways* (SSP) (p.13ff.) the report engaged in projections on the degree of climate change depending on the socio-economic development trends, i.e. population growth, income, inequality, resource-intensive production, material-intensive consumption, lifestyle, and technological change. By doing so, the report emphasized the direct relationship between socio-economic and ecological developments. In opposing two projections, SSP1 (*population peak and decline with ~7 billion in 2100, high income, reduced inequality, effective land-use regulation, less resource-intensive consumption, free trade and environmentally-friendly lifestyles and technologies*) and SSP3 (*high population with ~13 billion in 2100, low income, continued inequalities, material-intensive consumption and production, trade barriers, slow technological advancements*) the report stresses, in particular, the negative implications SSP3 would have while SSP1 is assessed as both feasible ("low challenges to mitigation and low challenges to adaptation (i.e. high adaptive capacity)"(p. 14)) and desirable.

vi. A second report that gained much attention in 2019 was the global assessment report on biodiversity and ecosystem services of the IPBES. Its central message was that biodiversity is declining at unprecedented rates (IPBES, 2019b). IPBES chair Sir Robert Watson declared, that

> "the health of ecosystems on which we and all other species depend is deteriorating more rapidly than ever. We are eroding the very foundations of our economies, livelihoods, food security, health and quality of life worldwide" (IPBES, 2019a).

In the same line proclaimed Professor Settele of the Helmholtz-Centre that

> "[e]cosystems, species, wild populations, local varieties and breeds of domesticated plants and animals are shrinking, deteriorating or vanishing. The essential, interconnected web of life on Earth is getting smaller and increasingly frayed. […] This loss is a direct result of human activity and constitutes a direct threat to human well-being in all regions of the world" (IPBES, 2019a).

Among the drivers as well as affected areas did fall agriculture. Not only have species been lost – causing, among others, agroecosystems to be less resilient -, but also has agriculture directly influenced biodiversity loss via land-use change and pollution (IPBES, 2019b). More explicitly than the IPCC report has the IPBES report linked biodiversity protection with socio-economic developments (e.g. production and consumption patterns). They, too, have called for "transformative change", by which they mean "a fundamental, system wide reorganization across technological, economic and social factors, including paradigms, goals and values" (IPBES, 2019a).

vii. With the worrying degree of biodiversity loss, the FAO launched its first special report on biodiversity for food and agriculture (BFA) in 2019. It presented an assessment based on information provided from 91 countries and 27 international reports with inputs and reviews from a total of 175 authors. In line with the before-mentioned reports, this assessment, too, emphasized that biodiversity is essential to food and agriculture: not only is biodiversity an important resource for higher food production, but it also increases the resilience of food systems against shocks and stresses. Additional value derives from the fact that it also reduces the need for external, often costly and/or harmful inputs, thus reducing negative impacts on the natural environment as well as on farmers' livelihoods. However, evidence suggests that at both ecosystem-, species-, and genetic-levels the diversity is in decline. The country reports indicated that among the threatened species were many with high value also to agriculture, such as pollinators, natural enemies of pests, soil organisms, and wild food species. Among the drivers of biodiversity loss, the assessment understood to be global climate, demographic, and economic changes. More immediate drivers were land-use changes, pollution, intensive use of external inputs, overharvesting and a proliferation of invasive species. It had been reported that, in particular, demographic changes, increasing urbanization, markets, trade and consumer preferences directly affected food systems, often with negative consequences on the BFA. A widespread transition towards intensive production patterns with a reduced number of species, breeds, and varieties, remained among the major drivers of BFA and ecosystem services loss.

Finally, the report suggested that the enabling framework for sustainable use and conservation of BFA were insufficient, "urgently need to be established or strengthened" (FAO, 2019, p. Xl). While many countries had legal, policy, and institutional frameworks in place constraints continued to exist in the development and implementation of effective policy tools. Among the reasons were a lack of awareness by policymakers and other stakeholders, a general knowledge gap with regard to policy impacts, a lack of understanding broader system interactions (i.e. between different sectors, ecological and socio-economic components), as well the existence of divergent interests held by different actors. The report called for integrated ways of managing genetic resources, species, and ecosystems – in conservation, research, policies, and application. It suggested that a cooperation across disciplines and sectors could help overcome knowledge gaps, ensure improved collaboration and effective actions by relevant authorities. While frameworks for individual sectors did exist and often spanned international borders cross-sectoral cooperation and multi-stakeholder activities remained inadequate.

viii. A fourth international report in 2019, raised the question of how to feed a population of 10 billion while staying within Rockström et al.'s (2009a) planetary boundaries. The report *Food, Planet, Health* by the EAT-Lancet Commission (2019) focused both on the environmental urgency to change the way how food is produced as well as the need for a growing population, which has a right to healthy diets. The report also addressed the triple burden of malnutrition – that is food insecurity/hunger, malnutrition, and overconsumption/obesity. Based on the evidence that "food production [was] among the largest drivers of global environmental change by contributing to climate change, biodiversity loss, freshwater use, interference with the global nitrogen and phosphorus cycles, and land-system change" (Willett et al., 2019, p. 447), the EAT-Lancet commission called for a "Great Food Transformation" (ibid., p. 448). As food production "depends on continued functioning of biophysical systems and processes to regulate and maintain a stable Earth system" (ibid., p.447), they suggested a so-called *reference diet*, which is to present a win-win situation as it is healthy while sustainably produced. However, to achieve such a win-win situation it needs "substantial change in the structure and function of global food systems" (ibid., p. 476), both in production and consumption. Their proposals were i) to commit to shifting towards healthy diets (as laid out in the report), ii) reorient agricultural priorities towards quality (healthy foods) rather than quantity, iii) sustainably intensify production, iv) strong, coordinated governance of land and oceans, and v) to at least halve food loss and waste. They suggested an urgency to begin such a transformation and proposed strong political governance, i.e. the institutionalization of strategies in international bodies such as the UN (ibid., p. 483f.)

ix. In light of the COVID-19 pandemic and rising food insecurity, the most recent report by the High-Level Panel of Experts (HLPE) on Food Security and Nutrition, called for radically transforming food systems in order to achieve the UN Sustainable Development Goal 2[11] (SDG 2) by 2030 (HLPE, 2020). The report argued that the challenges that had existed already before COVID-19 were now exacerbated and made actions even more urgent. The report stressed further that current trends – expanding malnutrition, fragile livelihoods for the poor, climate change, resource degradation, food loss, and waste, disrupted food and agricultural markets, reduced public investment in agriculture, inequality, and demographic changes – weakened food systems' resilience and thus required substantial reform. Their proposal was therefore to strengthen and consolidate conceptual thinking around food security and nutrition, and to implement critical policy shifts which would enable conditions that uphold all dimensions of food security[12] (ibid., p. 8).

x. Finally, in September 2020, the WWF Living Planet report (WWF, 2020), too, opened with a need for "a deep cultural and systemic shift" (p. 3). The report stressed again the unprecedented extent of current biodiversity loss and linked it directly to the socio-economic changes of the last 50 years, in particular "an explosion in global trade, consumption and human population growth, as well as an enormous move towards urbanisation" (ibid., p. 4). These trends in human development relied on an overuse of resources and incited natural destruction and degradation. At the heart of the report was the emphasis that human life and health depend on ecologically healthy systems. Biodiversity was crucial for food and energy production, fresh water, as well as

[11] SDG 2: "End hunger, achieve food security and improved nutrition and promote sustainable agriculture" (UN, 2015).
[12] The four dimensions of food security refer to availability, access, stability, and utilization. For details see f.ex. FAO 2008: http://www.fao.org/3/al936e/al936e00.pdf (17.11.2020).

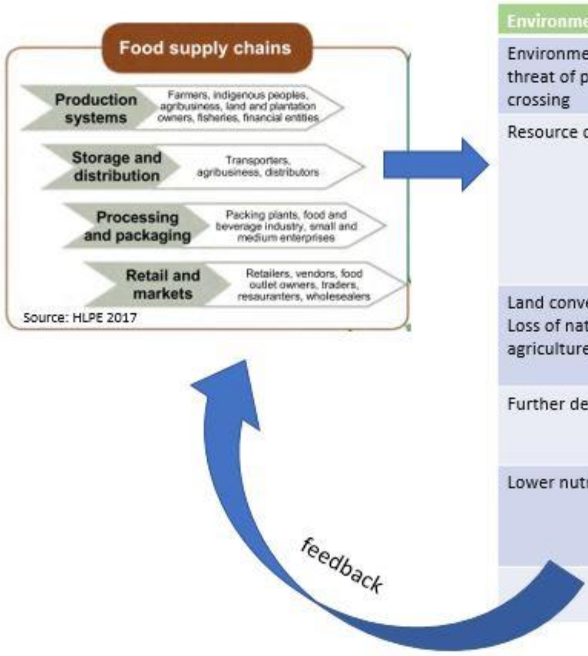
medicines; it helped regulate climates, pollution, the impact of floods and storms as well as pollination services. Yet, throughout the last 50 years has the ecological footprint of the world's population (as a total) consistently exceeded the sustainably available resources. As a consequence, a stark decline in population abundance in mammals, birds, amphibians, reptiles, and fish was recorded – an average 68 percent between 1970 and 2016[13]. With regard to ecological systems' composition (or biodiversity intactness) the average index is 79 percent - while the lower safe planetary boundary is suggested to lie at 90 percent. Also with regard to habitat availability, the index indicated "a strong and general downward trend" (ibid., p. 12) due to human land-use changes and increasingly also climate change. Food systems figured also in this report as a major force behind the progressive loss in species due to the role it played in climate change, land conversion, depletion of freshwater resources, and pollution of aquatic and terrestrial ecosystems; at the same time this reduced biodiversity threatened food production and food security. In a related report, the WWF together with the UN Environment Programme (UNEP), EAT and Climate Focus, put forward that improved food systems could indeed significantly contribute to global emission reduction goals. In *Enhancing Nationally Determined Contributions (NDCs) for Food Systems* (WWF Germany, 2020) the claim was made that food systems' contributions to overall GHG emissions – which account for up to 37 percent - were largely neglected in the National Determined Contributions (NDCs) under the Paris Agreement[14]. The report argues that if the food systems continued their current trajectory, they would not be compatible with the 1,5 ˚C degree target. A continuation of the current model would additionally lead to the transgression of multiple planetary boundaries until 2050. The report did recognize that some broad agricultural emission targets did exist in most NDCs, but found that food loss and -waste, improved production methods as well as the potential of changing diets had not been considered at all. In particular, the stages after food production were neglected in most NDCs. The report, therefore, urged governments to commit to food systems transformation and laid out 16 measurements identified as mitigation opportunities, among others supporting nature-based solutions, agroecological approaches, diversifying the food system, halving food waste and loss and adopting healthy and sustainable diets.

[A] 20 811 populations and 4 392 species were studied.

[14] The Paris Agreement is an agreement under the United Nations Framework Convention on Climate Change (UNFCCC), which negotiated as a long-term temperature goal to keep average global temperature increases under 2˚C (3.6˚F) in relation to pre-industrial levels. Recognizing the risk associated to higher average temperatures it was further agreed on to pursue efforts to limit increases to 1.5˚C (2.7˚F).

Despite all of these reports primarily focussing on the environmental impact of human activities, the more recent reports explicitly also referred to the socio-economic context that facilitated and/or exacerbated ecological degradation. Indeed are these spheres tightly interwoven and interdependent and require to be studied together This is to say that the negative outcomes of modern food systems are growing in all core subsystems, i.e. the ecological, social, and economic spheres. [The socio-economic context is discussed in appendix 1].

Figure 1.2. shows an overview of negative outcomes as indicated in the reports reviewed here. Outcomes means thereby resulting from processes; many of the outcomes are simultaneously also drivers, which need to be captured as feedback structures (cf. chapter 2).



Environment	Society	Economy
Environmental change + threat of planetary boundary crossing	Persistent food and nutrition insecurity in the world	Econ. deprivation of small-scale farmers/ food producers, and farm workers
Resource degradation	Malnourishment, deficiencies and overconsumption resulting in "diseases of civilization" i.e. diabetes II, obesity, hypertension, cardiovascular diseases etc./ public health	Powershift and concentration (corporatization) along the supply chain
Land conversion; Loss of natural ecosystems (for agriculture)	Food safety risks (contamination, diseases, fraud, etc.) / public health	Volatile food prices
Further desertification	High amounts of food loss and waste	Disrupted food and agricultural markets
Lower nutritional values	Security risks to livelihoods, infrastructures and food systems due to environmental change	Deregulation, financialization of agricultural markets
	Social unrest (i.e. Arab Spring)	Reduced investments in agri-food sectors

Fig. 1. 2. Overview of modern food systems' problematical outcomes

B. The European Green Deal – a proposal for transformation

In light of growing scientific evidence on global ecological degradation, discussions around a so-called green new deal re-ignited in the political arenas of both North America and Europe throughout 2019. [→ for an overview of the developments of green-deal ideas refer to appendix 2].

When in December 2019 the EU Commission president presented the first vision of *the European Green Deal* (EGD) it was introduced as a unique opportunity and "a new growth strategy that aims to transform the EU into a fair and prosperous society" (EU Commission, 2019, p. 2). Recognizing the threats to societies that emanate from climate change and environmental degradation, the deal is to initiate a transformation of the EU economy towards "a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases by 2050, economic growth is decoupled from resource use, [and] no person and no place is left behind" (EU Commission, 2020b). Simultaneously, the EGD will be an integral part to the EU's strategy of implementing the UN 2030 Agenda and the Sustainable Development Goals (EU Commission 2019, p. 3).

The Commission trusts in the collective ability of the EU to transform the economy and societies, and to be at the forefront of the international endeavour for sustainable economic growth. Thus, the deal sets out "to protect, conserve and enhance the EU's natural capital" as well as to protect EU citizens' health and well-being (ibid., p. 19) with core transformative policies regarding the following eight areas (in bold are the respective titles used on the website (EU Commission, 2020b):

- Increasing the EU's climate ambition for 2030 and 2050 (climate action)
- Supplying clean, affordable and secure energy (clean energy)
- Mobilising industry for a clean and circular economy (sustainable industry)
- Building and renovating in an energy and resource-efficient way (building and renovation)
- Accelerating the shift to sustainable and smart mobility (sustainable mobility)
- From 'Farm to Fork' strategy: designing a fair, healthy and environmentally friendly food system (From Farm to Fork)
- Preserving and restoring ecosystems and biodiversity (biodiversity)
- A zero-pollution ambition for a toxic-free environment (eliminating pollution)

As part of these areas, the Commission will prepare a. o. i) a European Climate Law, ii) a biodiversity strategy 2030, iii) Farm to Fork strategy, iv) a carbon border tax, v) a circular economy action plan, vi) a Just Transition Fund, vii) a European Green Deal Investment Plan, viii) EU strategies for energy system integration and hydrogen, and ix) a European Industrial Strategy.

Box 1

The significance of the New Deal for the Green Deal

The idea of a Green New Deal (GND) stands in direct reference to the US' New Deal of 1933-39 and has to be understood as a suggestion of what a GND is to be: an ambitious and comprehensive response to an emergency.

The original New Deal was a response to the Great Depression, initiated and implemented by President Franklin D. Roosevelt. With a comprehensive set of reforms, programmes, and policies, which together formed the New Deal, Roosevelt was to addressed high unemployment, wide-spread poverty, high food prices and a deflated economy. The deal consisted of the three pillars: relief, recovery and reform. The New Deal set out to reform the monetary systems, which Roosevelt understood to have caused the depression. It implemented a set of programmes to provide relief to the people, in particular by providing work (public work programmes) and several major social security schemes, of which few exist until today. Finally, the deal was to help the economy recover, mainly by boosting the different industries, including agriculture, via stimulus funds and strengthened labour unions.

Coinciding with the Great Depression was a period of severe drought and dust storms, which commonly got to be known as the phenomenon *Dust Bowl*. Roosevelt generally saw great importance in rural and farming America for the larger good of the nation. He therefore initiated these numerous programmes to help with settlement, electrification, infrastructure, reforestation, and modernization of farms. Further, did he enact the Agricultural Adjustment Act (1933) to restore fair prices and secure incomes for farmers while at the same time protecting consumers' interests, too (Berkin, 1997, p. 627ff.)

When today there is talk about a new deal it is often in allusion to Roosevelt's holistic approach to the crisis as well as the large investment in work, social security, and modernization. Similar to the New Deal being a response to a great emergency, so is the talk about a GND to be understood as a response to, initially, the financial crisis of 2007/08 but more recently to the growing climate and biodiversity crises. This means that the demand for a GND is a demand for urgent action and a demand to reform the current dominant socio-economic system, which seems to be failing both society and the environment. It is a demand for a holistic and comprehensive response to the various crises of environmental, economic and social nature, which also overlap and reinforce each other.

Thesis Focus: The Farm to Fork Strategy

The Farm to Fork Strategy is considered to be "at the heart" (EU Commission, 2020e, p. 2) of the EGD[15] and is further central to achieving the SDGs. It sets out to "addresses comprehensively the challenges of sustainable food systems and recognises the inextricable links between healthy people, healthy societies and a healthy planet" (ibid.)[16]. It understands that a need for actions arises from "[recurrent] droughts, floods, forest fires and new pests", which are "constant reminder[s] that our food system[s] (…) must become more sustainable and resilient" (ibid.). It describes food

[15] Incidentally, the Common Agricultural Policy (CAP) is also one of the biggest EU programmes; in 2018, out of €162.11 billion EU budget, €58.82 billion alone were spent on farmers' support (European Commission n.a.).

[16] Sustainable agriculture is described - rather than defined - by the EU as being concerned with balancing environmental, social and economic objectives (cf." Sustainable agriculture in the CAP". European Commission website: https://ec.europa.eu/info/food-farming-fisheries/sustainability/sustainable-cap_en, 20.10.2020).

systems to be "under threat" and therefore have to "become more sustainable and resilient" (ibid.). As aspects that contribute to the unsustainability of food systems, the Commission notices that

- agriculture, manufacturing, processing, retailing, packaging and transportation of food significantly contribute to EU GHG emissions as well as air, soil and water pollution with "a profound impact on biodiversity" (ibid., p. 3);
- food systems are among the "key drivers of climate change and environmental degradation" and urgently need to reduce their dependencies on pesticides antimicrobials, and excess fertilisation (ibid., p. 3);
- despite their central role in the food system, primary producers "still lag behind in terms of income"; however, "ensuring a sustainable livelihood (…) is essential for the success of the recovery [from the Covid-19 pandemic] and the transition" (ibid., p. 2).
- European diets "are not in line with national dietary recommendations[17]" and "[contribute] to a high prevalence of diet-related diseases" (2020d, 3); at the same time around "20% of the food produced is wasted" (ibid., p. 3).

The Commission emphasizes the need for "a robust and resilient food system" (ibid., p. 2). With reference to the COVID-19 pandemic, the commission emphasizes being aware of the fragility of food systems and the need to ensure access and sufficient supply to affordable food in all circumstances. The need for action is thus interpreted as a need for sustainable food systems[18]. The commission also notices that Europeans increasingly value food sustainability and "pay increasing attention to environmental, health, social and ethical issues" (ibid.). The EU Commission understands the need for action further as an opportunity "to improve lifestyles, health, and the environment" (ibid.) as well as for "improving the incomes of primary producers and reinforcing EU's competitiveness" (ibid., p. 4). Finally, it understands that sustainable food systems "will be essential to achieve the climate and environmental objective of the Green Deal" (ibid.).

The goals of the F2F strategy are therefore presented as the following:

- a reduction in the environmental and climate footprint of EU food systems,
- a strengthening of food systems' resilience,
- a guarantee of food and nutrition security, and
- spearheading a global transition towards competitive sustainability from farm to fork (ibid).

[17] No further information or reference was available in the document.

[18] No definition is provided. However, according to the science advice for policy by European academics (SAPEA), a sustainable food system "provides and promotes safe, nutritious and healthy food of low environmental impact for all current and future EU citizens in a manner that itself also protects and restores the natural environment and its ecosystem services, is robust and resilient, economically dynamic, just and fair, and socially acceptable and inclusive. It does so without compromising the availability of nutritious and healthy food for people living outside the EU, nor impairing their natural environment" (SAPEA, 2020, p. 68).

To achieve these goals, it will be necessary to build on existing legislation as well as on new policy initiatives. The main part of the document presents six focus areas outlining the activities planned or aspired to do in order to achieve the transition. This part consists of the actual strategy and shall be briefly summarized here.

1. Ensuring sustainable food production

The transition, which the EU envisions, will be supported by technical and financial assistance on the one side and by new policy initiatives and legislative proposals, on the other. A legislative proposal of *a framework for a sustainable food system* will be drafted by 2023 to encourage policy coherence at EU and national levels. Responsibilities of the different actors shall be addressed and targeted incentives for sustainable practices given, while certification and labeling will communicate the sustainability performance of food products. Crucial will be for all actors along the supply chains to participate. For farmers, this will mean changing their methods to include nature-based solutions (integrated pest management (IPM), agroecological approaches, etc.) and technological solutions (optimization of use of inputs, like pesticides, fertilizers etc.). Additionally, methods that remove CO_2 from the atmosphere shall be rewarded; farmers shall be encouraged to invest in renewable energy, such as biogas and solar energy, as well as consider biofertilizers and other bio-chemicals in their production. Their efforts will be complemented by new green business initiatives, as promoted under the Climate Pact, and the Circular Economy Action Plan (CEAP). As far as the use of pesticides and fertilizers is concerned the EGD plans to

- reduce by 50% the use and risk of chemical pesticides by 2030.
- reduce by 50% the use of more hazardous pesticides by 2030.
- reduce nutrient losses [especially nitrogen and phosphorus] by at least 50%
- reduce fertilizer use by at least 20% by 2030 (EU Commission, 2020c).

Further is there a need to reduce by 50% the sales of antimicrobials for farmed animals and in aquaculture by 2030 in order to reduce antimicrobial resistance. Innovative food additives and alternative feed materials shall help to reduce the environmental impact of animal production. All this shall be supported by an integrated nutrient management action plan, which the Commission will develop. Generally, animal welfare and plant health will have a high priority in finding more sustainable responses to diseases and pests and shall receive support through innovative approaches in biotechnology and new bio-based products; the potential of new genomic techniques, too, is under consideration. Further, shall measures be taken to register seed varieties, improving the access to “a range of quality seeds” and “traditional and locally-adapted varieties” (EU Commission, 2020e, p. 8).

Finally, the EU shall boost the development of organic farming areas and achieve 25% of total farmland under organic farming by 2030 as well as significantly increase organic aquacultures. This transition needs to be anchored in the Common Agriculture Policies (CAP). The EU understands the boost in organic agriculture and aquaculture also as an economic opportunity, which will help achieve decent incomes for farmers and their families. Direct payments shall continue to target family farmers over companies and new eco-schemes will offer new channels of funding supporting sustainable practices such as precision farming, agro-ecology, carbon farming, and agro-forestry. Similarly, the Commission will take steps to support more sustainable fishing and strengthen fisheries management and revise the fishery control systems. For farmed fish and seafood new sustainable guidelines shall be developed and the algae industry receive more financial attention as an important new alternative.

2. Ensuring food security

Threats to the supply chain can emanate from social, economic, ecological and/or health crises and may in severe cases put food security and livelihoods at risk. Food security herein is constituted when a “sufficient and varied supply of safe, nutritious, affordable and sustainable food to all people at all times [can be ensured]” (ibid., p. 11). Biodiversity loss and climate change are among the imminent and lasting threats and need to be closely monitored, together with the competitiveness of farmers and other food operators. The EU Commission notices that the various actors in food systems are differently affected in cases of crisis while challenges can occur in form of disrupted logistics, labour shortages, loss of certain markets, changing consumption patterns etc. The strategy, therefore, sets out to increase the sustainability of food producers and to protect critical staff by ensuring the European Pillar of Social Rights. Mitigating the socio-economic consequences of crises, ensure social protection, health care, safety, and good working- and housing conditions are vital for strong, sustainable food systems. The Commission will further work on a common response to food systems crises and “develop a contingency plan for ensuring food supply and food security to be put in place in times of crisis” (ibid.). To do so, the Commission will draw on former experiences (“lessons learned”) and assess the resilience of food systems.

3. Stimulating sustainable food processing, wholesale, retail, hospitality and food services practices

The Commission recognizes the negative impact the EU food and drink industry has on the environment as well as on the health of citizens. To promote healthier and more sustainable choices, and to ensure the availability and affordability of these, the Commission will develop an EU code of conduct for responsible business and marketing practice. The corporate governance framework will be improved and require the industry "to integrate sustainability into corporate strategies" (ibid., p. 12). The Commission intends to take action to stimulate diet shifts towards healthier food and the reformulation of products via new nutrient profiles. Further, will the Commission promote sustainable and socially responsible production methods and circular business. Packaging, in particular, plays a key role and the Commission will revise legislation on food contact materials and possibilities of limiting/substituting single-use packaging. It is also in the interest of the Commission to reduce dependence on long-haul transportation and marketing standards and geographic indications shall help reinforce the uptake of more sustainable products.

4. Promoting sustainable food consumption and facilitating the shift to healthy, sustainable diets

The Commission identifies current consumption patterns as unsustainable, both for the environment and for public health. It will, therefore, propose "mandatory front-of-package nutrition labelling" (ibid., p. 13) and explore additional ways of communicating nutritional, climate, environmental, and social aspects of food products. Additionally, the Commission will determine mandatory minimum criteria for the procurement of sustainable food in institutional catering to improve both availability and price. Finally, tax incentives are contemplated to help drive the transition and to encourage the consumption of sustainable, healthy products over others. It shall also aim to ensure that prices reflect real prices in terms of resource usage, emissions, and other environmental externalities.

5. Reducing food loss and waste

The Commission ascribes food waste a key role in achieving sustainability in food systems. It brings savings, can feed into redistribution and reutilization, and can help recover nutrients. This is ultimately also linked to ambitions in the fields of feed production, food safety, biodiversity, bioeconomy, waste management and renewable energy. In line with the SDGs, the Commission commits to halving per capita food waste at retail and consumer level by 2030. It will propose a baseline and binding targets by 2023 when updated data from all member states are collected.

6. Combating food fraud along the food supply chain

The final area concerns food fraud, which is deceitful to the customer and undermines the safety and sustainability of food systems. The Commission will therefore regard a zero-tolerance policy and examine possibilities of tighter coordination with the EU's Anti-Fraud Office (OLAF).

The third section of the document introduces a two-tracked approach to enabling the transition. As a first track, there is a designated focus on *research, innovation, technology and investments* on the one side and *advisory services, data and knowledge-sharing, and skills* on the other. The Commission sees research and innovation (R&I) as important drivers of change as they help identify barriers and develop new (technological) solutions. It will propose to spend EUR 10 billion under the research scheme *Horizon Europe*. To help innovation and uptake of R&I the schemes shall be complemented by strengthening the European Innovation Partnership's *Agricultural Productivity and Sustainability*-programme as well as by investments through the *European Regional Development Fund*. Further investment opportunities shall be provided through the *InvestEU Fund* for investments into the agri-food sector, and there shall be a framework to facilitate and mobilize more sustainable investment also in the financial sector. Part of the first track is also to improve Europe's broadband connection and to connect all farmers and rural areas to fast internet connections, which will help the uptake of modern technology, improve business, and also add to life quality through more possibilities in the area healthcare, e-government, and entertainment.

The second track is concerned with the advisory and the provision of information. The Commission wants to promote a new *Agricultural Knowledge and Innovation Systems* (AKIS), it will convert its *Farm Accountancy Data Network* into the *Farm Sustainability Data Network* and collect data on sustainability indicators, including F2F- and biodiversity strategy targets. To increase competitiveness, data on land use, production, environmental impact, and others will be collected under the agriculture data space. All of these programmes are to provide tailored advisory services, considering regional, national and sectoral contexts. Programmes such as *Copernicus* and *European Marine Observation and Data Network* (EMODnet) will facilitate and secure investment in fishery and aquaculture (ibid., p. 16). Finally, the Commission will commit to providing tailored solutions also to small and mid-sized enterprises (SME) along the food chain, disseminating guidance on best practices and update its Skill Agenda, to ensure access to suitably skilled labour.

The final part of the F2F strategy discusses the commitment to act as a role model and to promote a global transition to more sustainable food systems. The EU shall form *Green Alliances* to help other countries to transform, it will consider its trade policies and "seek to ensure that there is an ambitious sustainability chapter in all EU bilateral trade agreements" (ibid., p. 17). The EU will push for setting new standards and help produce agri-food products with high safety and sustainability requirements. For compliance, the EU will promote this in international standard-setting bodies and multilateral fora, will integrate all these ambitions into their international cooperation, and it will consider import tolerances for substances no longer approved by the EU, in order to set cut-off criteria in line with World Trade Organization's (WTO) rules and obligations. These standards shall further be made transparent to customers via new schemes, such as the EU sustainable food labelling framework, and strict enforcement of rules on misleading information.

In the larger scheme of the European Green Deal, the F2F strategy will have to be close to and coherent with other sections of the deal, which are, in particular, the biodiversity strategy 2030, the circular economy action plan, and the zero-pollution ambition. The Commission will further collect data regularly and thus monitor the transition toward sustainable food systems and their operation within planetary boundaries.

Box 2: The CAP alignment with the European Green Deal

In an analysis of links between the CAP and the EGD, the Commission identified the CAP as "important instrument in managing the transition to sustainable food production systems and strengthen the efforts of European farmers to contribute to the climate objectives of the EU and to protect the environment" (EU Commission 2020). Nine objectives guide the CAP reform proposal:

- to ensure a fair income to farmers;
- to increase competitiveness;
- to rebalance the power in the food chain;
- climate change action;
- environmental care;
- to preserve landscapes and biodiversity;
- to support generational renewal;
- vibrant rural areas;
- to protect food and health quality. (European Commission website 2021)

The Commison further found that these nine objectives of the CAP reform proposal were in line with the EGD's goal of food systems transformation with regard to the follwing aspects:

- Increased contribution of EU agriculture to climate change mitigation and adaptation;
- Improved management of natural resources used by agriculture, such as water, soil and air;
- Reinforced protection of biodiversity and ecosystem services within agrarian and forest systems;
- Effective sustainability of food systems in accordance with societal concerns regarding food and health on e.g. animal welfare, use of pesticides and antimicrobial resistance;
- Ensuring a fair economic return and improving the position of farmers in the food supply chain (EU Commission 2020).

The CAP is important for the F2F strategy as it is for the success of the EGD in general. It is, however, not the same. With the focus on the F2F strategy, the CAP objectives illustrate the EU's approach and commitment, most importantly yet the future CAP is significantly involved in designing national targets and provide the relevant funding via their various support schemes.

Chapter 2: Resilience thinking for social-ecological systems

This chapter introduces Resilience Thinking and social-ecological resilience as the theoretical concepts with which I will approach the F2F strategy and its stated aim for transforming food systems towards resilience and sustainability. It provides a brief paragraph on the development of resilience as a concept in various scientific disciplines. It introduces key heuristic tools and concepts to identify and build resilience in systems, and highlights how resilience is essential to sustainability. Finally, seven attributes of resilience building are presented, which will be used in the assessment of the proposed actions in the F2F strategy.

Over centuries, humanity has successfully modified the biosphere it is surrounded by. This made possible a rapidly growing world population, steeply increasing economic activities, and an over-production of food to an extent that food prices and global hunger were in decline (Walker and Salt, 2006). At the beginning of the 21st century, however, there are concerns over the costs of these developments. Global climate change and resource degradation created new challenges to humanity, and indicate that the present use of the biosphere is not sustainable (i.e. the capacity of ecosystems, landscapes, and communities to provide essential goods and services for humanity's well-being are diminishing (ibid.)). This unsustainability of current trends has been recognized at the Earth Summit in 1992, making *sustainability* a buzzword for decades to come. While the literal meaning of *sustainability* is subject-less and describes "the quality of being able to continue over a period of time" (Cambridge Dictionary, 2020), the research interest of sustainability studies often refers to Gro Brundtland's report "Our common future" (World Commission on Environment and Development, 1987). The latter aimed at combining development questions of poorer nations with concerns for the natural environment; it recognized the need for resources in development and argued for the need to balance economic and ecological necessities. This is relevant for both present and future generations adding a sense of inter- and intragenerational justice to the concept. Today, sustainability is often – however not exclusively – used synonymously with sustainable development and understood as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (ibid., p. 41). Over the last couple of decades, sustainable development has become one of the core focus points, both in large parts of academia as well as the public discourse. One of the most prominent reflections can possibly be found in the *UN Millennium Declaration* (2000) and the *agenda of sustainable development goals* of 2015.

Since the early 2000s, another concept has entered the sustainability discourse and has gained popularity in scientific and policy debates since then: resilience (Brown 2013a; Folke 2016).

2.1. Resilience as key to sustainability

Resilience thinking is a "lens of inquiry" into social-environmental relations (Folke, 2016, p.1) and viewed by some as a subset of sustainability studies (ibid.)[19]. Sustainability is hereby primarily understood as a harmonious coexistence of the biosphere and human societies; secondarily, it focuses on "[maintaining and creating] conditions, under which humans and nature can exist in productive harmony, that permits fulfilling the social, economic, and other [ecological] requirements of present and future generations (…)" (U.S. Government, 1969, Sec.101 (a)). Consequently, sustainability is based on the recognition of three interacting and interdependent domains, which are ecology, economy, and society, as well as the necessary limitations to and of them (United Nations, 1987, chapter 2). The recognition of human actions as interacting between the social, economic, and environmental spheres, allows to view sustainable development as social-ecological processes and sustainability as emerging property of social-ecological systems. Hence, to ensure sustainability, there needs to be a balance between human needs and environmental resources. As a result, sustainability is concerned with maintaining social-ecological systems for the good of human societies without compromising the environment – neither today nor in the future.

The idea of sustainable development continues to shape many academic debates as well as public policymaking. More recently, the discourse around sustainability has been complemented by the concept of resilience. With sustainability focusing on the continuous well-functioning of social-ecological systems, resilience is concerned with aspects of change and crisis and the possibility of far-reaching systemic change (*regime shift*). A sustainable social-ecological system thus deals with balancing demand and (negative) impact; a resilient social-ecological system focuses on avoiding or recovering from unwelcomed disruptions ("surprises") in order to continue providing its goods and services. A system's capacity to recover after disturbance is therewith key to sustainability (Walker and Salt, 2006). Noteworthy is that sustainable development descends from the social sciences and was concerned with the challenges facing humanity; resilience, in contrast, originates from the natural sciences and originally focused on the capacities of ecosystems.

Ecological resilience and the "new ecologies"

Over the last two decades, the central role of resilience for sustainable development has been advanced within various sub-fields of sustainability science (i.e., Brand and Jax, 2007; Brand, 2009; Walker and Salt, 2006). A core contribution to the development of resilience as a concept across

[19] An argumentation for keeping resilience and sustainability as separate approaches can be found in Redman (2014).

various disciplines was Holling's definition of ecological resilience. Accompanied were these developments by the emergent 'new ecologies' in the social sciences (e.g. ecological anthropology, political ecology, environmental and ecological economics), which formed an important foundation for today's interdisciplinary sustainability sciences (Scoones, 1999).

In 1973, C.S. Holling introduced in his seminal article "Resilience and Stability of Ecological Systems" a resilience concept to ecology, which understood dynamics of change and ecosystems' capacity to persist in face of change and disturbance (Folke, 2016). He hypothesized that ecosystems hold multiple stability domains rather than one, challenging the assumption that ecological systems behave linearly and are equilibrium-oriented. Until then, resilience usually referred to the time and quality of a system to return to equilibrium after a disturbance. Also known as *engineering resilience* (Holling, 1996), this resilience view is concerned with ecosystems' ability of "maintaining efficiency of function, constancy of the system, and a predictable world near a single steady state" (Folke, 2006, p. 256). Resilience in this understanding is about resisting change and to conserve the system as it is (ibid.). This view has long shaped environmental and natural resource management, aiming for optimal exploitation of resources.

In Holling's hypothesis, however, ecological resilience describes the "capacity of ecosystems with alternative attractors to persist in the original state subject to perturbations" (Folke et al., 2010, n.s.). Critiquing the single-equilibrium view, Holling proposed a theory of multiple basins of attraction (Figure 2.1.). This meant that rather than perceiving ecosystems as oriented towards one global attractor [20] (which would resemble an equilibrium-orientation), Holling understood ecosystems to operate in a landscape with various attractors.

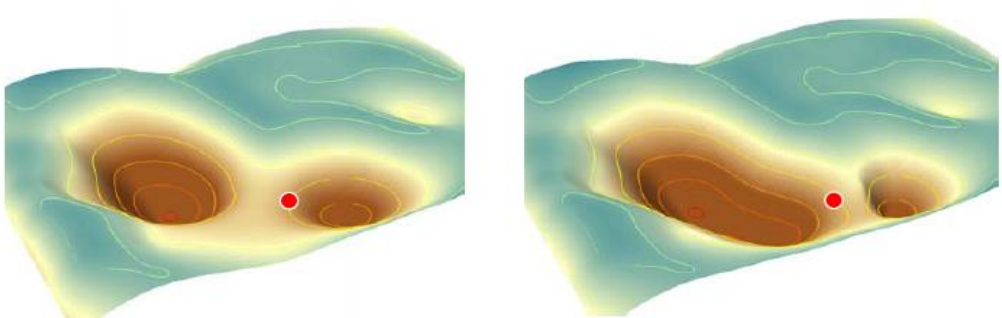


Fig. 2.1. Stability landscape with two basins of attraction as examples of possible regime shifts in changing landscapes (Walker et al., 2004 in Walker & Salt, 2006, p. 54f).

[20] An attractor is a place of stability within a dynamic field of changes and developments. A basin of attraction is defined by all the stable states of the system and tends to change towards an attractor (Walker and Salt, 2006).

This model depicts a system in relation to specific thresholds. Every system consists of important variables, “state variables” that describe the system. A simplified farm system could f. ex. consist of grass, trees, livestock, and the people employed, thus be four-dimensional. The system can then be depicted as several basins in a four-dimensional landscape (cf. Walker and Salt, 2006, p.54f). The ball therein depicts the current state of the system, which is the combination of the particular amount for each state variable. Exposed to changes (for example the loss of one species) an ecosystem (indicated as the ball/dot in figure 2.1.) may be attracted to a different basin in their process of reorganization. The landscape of multiple basins, therefore, depicts tendencies of dynamics that exist in complex adaptive systems.

Within a basin, a system holds essentially the same structure, function, and feedbacks. The ball (the system) in this landscaped is always moving in search of the equilibrium state within its basin. However, with changing external conditions, the shape of a basin changes accordingly. The ball is therefore always in movement. Once it steps over the edge of its current basin into a new basin the feedbacks that push-and-pull the ball change and, as a consequence, the system is pushed into a different structure and function. This is the process of crossing a threshold into a new basin of attraction (*regime shift*). From a perspective of resilience two relations are important: for one, a system’s relation to the threshold(s); for another, the size of the basin. The smaller a basin the easier it becomes for a system to cross into a different basin. The distance to a threshold thus defines ecological resilience[21] as resilience is concerned with a system’s capacity to absorb disturbance while maintaining the same structure and function. Ecological resilience is about retaining the ability to persist rather than to “bounce back”.

Holling’s theoretical framework of ecological resilience is based on the perception of ecological systems as complex adaptive systems (CAS). *Complex* systems are systems consisting of subsystems, which are hierarchically nested into each other. They display non-linear dynamics and multiple attractors. They are path-dependent and can re-organize themselves in face of instability and collapse (Berkes et al., 2003) (s. *adaptive cycle* below). *Adaptability,* on the other hand, indicates a system’s ability to learn and adjust. Complex adaptive systems are thus continuously evolving, process-dependent, and self-organizing. CAS have emerging behaviour; however, this behaviour is not predictable by understanding individual system components. Additionally, changes in different components can have both minor and major impacts, at times resulting in an entire reconfiguration

[21] Engineering resilience, in contrast, is not interested in thresholds but the equilibrium point of a basin.

of the system (Walker and Salt, 2006). The study of CAS, therefore, deals with explaining systems' complex structures and patterns of interactions between system properties, as well as a CAS's ability to reorganize after disruption (Folke, 2006).

Following this, in complex ecological systems disturbances and other dynamics of change that act upon the system can push individual state variables[22] - which define the system- beyond a crucial threshold, potentially causing it to "flip" into a qualitatively different state (*regime shift*). Such a transition can be sudden but can equally be the result of gradual (slow) change towards a different attractor (Folke, 2006). With his proposal of multiple basins of attraction, Holling's hypothesis acknowledged this perpetual presence of uncertainty and possibilities of discontinuity. Individual thresholds are yet not easily predictable[23] and transition towards a new stability domain, whether gradual or abrupt, can be costly and irreversible (Berkes et al., 2003). This possibility of (sharp) shifts between basins of attraction had Holling formulate a new understanding of resilience as being concerned with the amount of disturbance an ecosystem can absorb without having to change fundamentally its structural and functional characteristics, which are its identity (Berkes et al., 2003; Walker and Salt, 2006).

Resilience thinking is not just concerned with the likelihood of a system to (not) cross a threshold into an alternate state. Thresholds, if identified, also help to manage for resilience. However, research in both the natural and social sciences suggests that systems – social and ecological alike – proceed through recurring cycles of renewal (Walker and Salt, 2006). In the strive for managing or transforming an ecological and/or social system, it is necessary to understand the different cyclic phases a system passes through, as some phases are better suited for effective change than others. This notion of cyclical change has been metaphorically captured in the adaptive cycle of renewal (Holling, 1986; Holling and Gunderson, 2002).

[22] Variables indicate changing values. Within a natural system, components can show varying values, f. ex. in a forest a specific tree species can exist in high or low numbers, pests can affect trees in varying degrees, the soil may show mineral fluctuations etc.
[23] For example, the loss of pollinators affects the propagation of many agricultural and wild species. If propagation of some species cannot take place other species that do not depend on pollinators will eventually fill their space. Thus, the ecosystem adapts to the changing situation. It is yet difficult to identify at what exact degree of pollinator loss (i.e. the threshold) the system, i.e. a wildflower field, will change into an entirely new system, that no longer upholds the same functions as the former system did, i.e. into a field of shrubs or grassland for example.

a. The adaptive cycle

The adaptive cycle (figure. 2.2.) is a heuristic model based on Holling's observations of ecosystems. He argued that there was a regular cycle of exploitation + conservation (*foreloop*) and collapse + reorganization (*backloop*), of which the first two phases of the foreloop tend to be significantly slower in comparison to the backloop (Berkes et al., 2003).

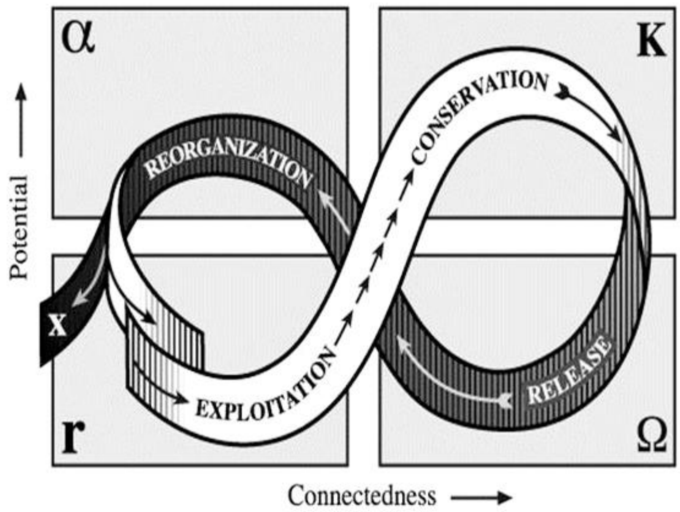


Fig. 2.2. Adaptive cycle of renewal as printed in Holling & Gunderson, 2002, p.34.

This four-phased adaptive cycle of renewal consists of the four stages (1) exploitation (r-phase), (2) conservation (k-phase), (3) release (Ω-phase), and (4) reorganization (α-phase).

The r-phase is characterized by rapid growth. In this phase, species (people, organizations) exploit available resources and opportunities for maximum growth. In the following k-phase the system moves into a conservation stage. This means, the accumulation of resources and increasing interconnectedness slowly leads to a fairly stable system. While in the r-phase opportunists had a competitive edge as they adapt well to variability and uncertainty, specialists, who use established and mutually reinforcing relationships, are generally superior in this later phase (Walker and Salt, 2006). Specialists additionally tend to be more efficient in their use of resources and operate across larger scales and longer periods. However, with specialization and high interconnection, the system becomes increasingly rigid and regulated. As connectedness increases does growth slow down as resources are increasingly locked up. High efficiency but declining flexibility make the system vulnerable to shocks and disturbance. Such a rigid system desires release and reorganization for improvement. A transition from the k- to Ω- phase can therefore happen quickly. The higher the rigidity of the k-phase the smaller a shock can be to break apart the entire system. In the Ω- phase the system becomes undone, releasing all resources and breaking apart all established connections and structures. This phase is usually brief and chaotic, can be destructive but can also carry a creative element: the dismantling of relations facilitates re-organization and renewal of the system (for better or worse). Finally, the α-phase is characterized by reorganization and novelty. It is in this phase that innovation and experimentation are common. This can mean the invasion of novel species an/or a new combination of actors and/or new possibilities. While no basin of attraction exists in the Ω -phase (there is no stable state), the α-phase sets the foundation for the new system identity, i.e. the new attractors for the following r-phase. This cycle is yet not absolute and exists with variations: sometimes a rapid growth phase can transition directly into release, or a conservation phase might move back to growth; only a transition from the backloop directly to a conservation phase is not possible (Walker and Salt, 2006). Noteworthy at this point is that a regime shift (the overstepping of thresholds) usually happens after release and in the phase of reorganization.

Traditionally, and in ecology explicitly, attention was almost exclusively paid to the *foreloop*, that is the two phases of exploitation and conservation. By including the *backloop* (release and reorganization) the adaptive cycle emphasizes the idea that disruption or collapse is in fact part of development (Folke, 2006). The cycle captures, thus, that both stabilities and instabilities "organize the behaviors", and that "periods of gradual change and periods of rapid transitions coexist and complement one another" (ibid., p.258). Holling later found that cyclical change is pervasive also in social systems and has often been embedded in the traditions of different cultures and religions (Berkes et al., 2003). Examples of such cycles can be found, for example, in the four different seasons[24], the boom-and-bust cycles found in the economy or the ascent, crisis and reorganization of cultures/societies. The adaptive renewal cycle therewith also establishes that development, too, is not necessarily linear but in fact often circular.

This model of an adaptive cycle allows for the conceptualization of the commonalities of cyclical change[25] in and of ecological and social systems. It does however lack the different spatial and temporal scales. This fact has spawned a second model: the panarchy.

b. The panarchy

The conceptual model of the panarchy (figure 2.3) was developed by Holling and Gunderson (2002) to include the above-mentioned cross-scale interactions. The model is to describe the dynamic relations in CAS across temporal and spatial scales. A system progresses through adaptive cycles at

[24] In the northern hemisphere, spring is marked by an exploitation of nutrients, and plants and trees start to grow and blossom; in summer when they reach their full potential nutrients are accumulated slower and become sequestered ("conservation"); in autumn then when flowers and leaves begin to wither those bonded nutrients get to be released again, so that in winter finally the reorganization and renewal of the cycle allows for the plants and trees to start anew.

[25] The cycle as a model is naturally not able to reflect unique and divergent responses.

various scales simultaneously. These cycles are, however, connected and inform each other. In other words, whatever happens on the local scale informs, or is affected by, developments on the regional and national scale (and vice versa)[26]. Equally, do past events affect present and future events. This means, key processes at one scale of the system are linked, informed, or governed by processes on higher and lower scales of the system (Walker and Salt, 2006). Focussing on one particular adaptive cycle means to ignore the other scales in which it is embedded or built upon.

The concept of the panarchy, therefore, consists of several adaptive renewal cycles, which are hierarchically nested into each other from the smaller, faster to the larger, slower cycles. However, hierarchical does here not imply any power relation from top to bottom or vice versa; information is indeed exchanged in both directions (Folke, 2006; Holling, 2001).

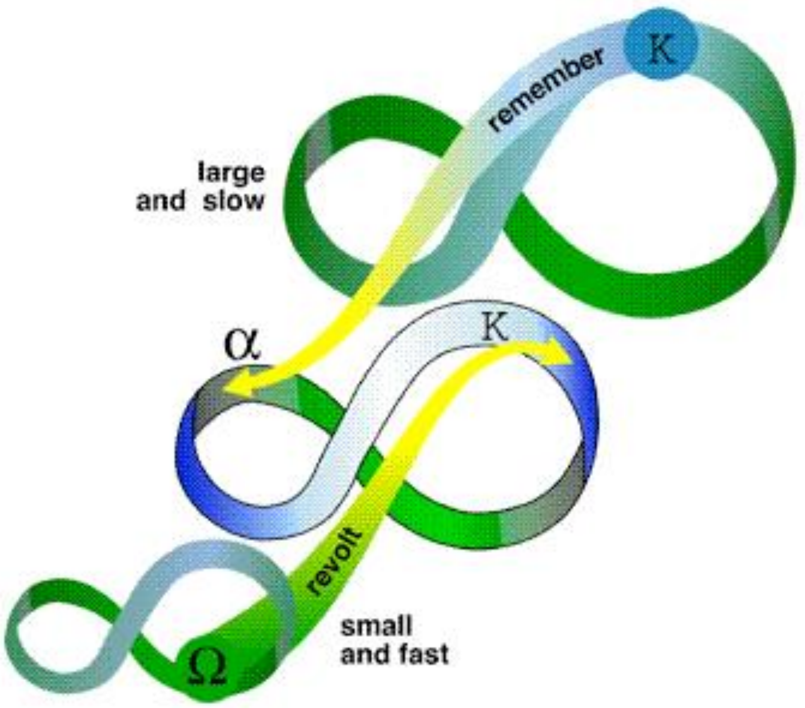


Fig 2.3. Linked adapted cycles: The panarchy (as printed in Holling & Gunderson 2002, p. 75).

The different cycles communicate with each other, and while there are numerous connections possible, the panarchy captures two significant ones: ‘remember’ and ‘revolt’.
Revolt means hereby that smaller, faster cycles are often responsible for testing and experimenting (‘renewal’). Experimental changes, if successful, may affect the larger slower cycles over time. Hence, the smaller faster cycles tend to be responsible for variability and novelty. For example, a beneficial genetic mutation may spread from the individual to the group and eventually to the entire

[26] An individual tree is connected to its patch and the larger forest; a team member is connected to its team and the larger office, etc.

population. Similarly, a local public demonstration may create greater opposition and eventually affect national policy. Remember, on the other hand, relates to the information stored in larger, slower cycles that smaller faster cycles can access when needed, for example after a disruption. So can, for example, a forest draw upon seed banks and surviving species in the process of renewal after a fire. Similarly, can traditions and history preserve relevant knowledge for a society in face of chaos. The memory stored in these larger, slower cycles may also overwrite novelty if the revolt was not successful; novelty may therefore not necessarily persist.

CAS do not simply recover but reorganize themselves – usually – into a similar but not the same system. This means that CAS continuously develop (Folke, 2006). Within the panarchy, each level operates at its own pace; it is in their interplay that invention and conservation come into being, allowing for “a dynamic balance between change and memory, and between disturbance and diversity” (Berkes et al., 2003, p. 19). In other words, the panarchy depicts both variability and stability in a system over time. It illustrates the importance of memory, at the same time as it explains how experimentation and novelty can occur and influence a system’s configurations. The dynamic interplay across scales, which the panarchy theory suggests, indicates that resilience in complex systems is not about resisting change but about the re-organization and adjustments “to (..) retain essentially the same function, structure, identity and feedbacks” (Folke 2006, p. 259). Folke (2006) further stresses that resilience is not just about persistence but equally about the opportunities disturbances create for renewal and evolution of systems’ properties. The continuous development holds an important adaptive quality, which helps sustain the overall functions a system holds. Thus, both persistence and adaptive development stipulate resilience. However, both qualities can also be detrimental if they withhold the system from transitioning to a more desirable state (Gunderson and Holling, 2002). This indicates importantly that resilience is not a normative concept but rather describes a system’s quality; resilience can exist in desirable and undesirable system configurations. What defines a desirable state is not always easily identified and different actors may indeed identify different desirable states.

2.2. From ecological to social-ecological resilience

During the 1990s, the realization that many of the problems observed were more complex than could be understood and managed by individual disciplines, renewed the interest in resilience studies (Berkes et al., 2003). For long, a divide between the social and natural sciences existed where the natural sciences excluded humans entirely and social science ignored the natural environment[27]. Since the 1970s however more integrative works had appeared with the rise of subfields such as political ecology, environmental ethics, and ecological economics (the “new ecologies”) (Berkes et al., 2003; Scoones, 1999).

Traditionally, social sciences were concerned with human agency and their capabilities to respond to environmental conditions; they often viewed human activity as an external rather than an internal driver of ecosystems’ dynamics. What distinguishes human systems is that people behave intentionally and with a certain amount of foresight; they communicate more elaborately, including creative expressions (i.e. of the arts) and ideas; additionally have they developed complex technologies in the pursuit to understand and work their environments (Holling, 2001). Human activities are yet more than barely an impact on the ecosystem; the separation of the social and the ecological spheres does not reflect the intricate interplay between the two and ignores the processes that shape both the environmental landscapes and the human engagement with them.

In 1998, Berkes and Folke proposed that the boundaries around social and natural systems are “artificial and arbitrary” (p. 4) and that there is a need to study their interdependence. The authors pushed forward the understanding of humans-in-nature and thus the concept of social-ecological systems (SES) (Berkes and Folke, 1998; Folke, 2016). Both ecosystems and human systems “are (..) complex systems in their own right” (Scheffer et al., 2002, p. 210) but in practice, many of their dynamics are intertwined. SES, therefore, depict “complex, integrated systems where human activities and environmental processes are inter-dependent, co-evolving, and linked through various feedback loops” (Renaud, 2016, p. 926). As an approach, it emphasizes that socio-economic structures are embedded into the biosphere across all spatial (local to global) and temporal (from past to future) scales. As such, they recognize that human agency shapes the emergent structures, including ecosystems (Folke, 2016, p. 10f). SES have become core units in the discussion of resilience and sustainability and do increasingly so also for vulnerability and risk assessments (Renaud, 2016). After all, in face of unsustainable developments in human-nature interaction, it is necessary to understand both ecosystem properties and the socio-economic drivers that inform humanity’s engagement with nature.

[27] With some exception such as ecological anthropology and cultural geography.

Resilience thinking for social-ecological systems consequently builds on this understanding of complex linkages between the social and the natural systems and the feedback loops between them. Adaptability and transformability become central characteristics. The former refers to the ability to learn and adjust its processes to changing conditions. The latter refers to the capacity to transform into an entirely new system in case of nonviability. Resilience as a quality of SES is therefore about "cultivating the capacity to sustain development in face of change, incremental and abrupt, expected and surprising, in relation to diverse pathways and thresholds and tipping points between them" (Folke, 2016, p. 27).

Important to remember here is the hypothesis that any social-ecological system, too, is surrounded by a number of different "domains of attraction", and therefore, various configurations (or "regimes") are indeed possible. Consequently, a SES's behaviour after disturbance is uncertain: it could be attracted to the original state, but it could also be brought over a threshold towards a different, possibly even contrasting basin of attraction (Folke et al., 2010, n.s.). With the inclusion of human activity, the study of resilience and complex adaptive social-ecological systems adds crucial questions of governance, institutions, and power relationships, and needs to consider aspects of culture, religion, and other worldviews. Finally, three system's properties are important to be examined: "the amount of change a system can undergo and retain the same structure and functions; the degree to which it can re-organize; the degree to which a system can build capacity to learn and to adapt" (Brown, 2013b, p. 108).

2.3 Resilience thinking as a framework

Resilience thinking is about understanding the dynamics of a changing world. Viewing social-ecological systems as a whole, rather than in two separate systems, is to acknowledge their interdependence as well as the high degree of behavioural unpredictability deriving from it. Resilience thinking suggests a systems approach to human-natural organizations, which operate within a landscape of attractors and across spatial and temporal scales. It is this landscape that defines the system's identity. A great number of variables drive a social-ecological system but usually a small number of key controlling variables – and ideally their threshold – can be identified within the system of interest. The metaphor of the adaptive cycle captures moreover the dynamics of everchanging social-ecological systems, usually along the lines of growth, conservation, release, and reorganization (but other transitions are possible). The backloop has been identified as the phase of greatest change and innovation. Resilience is thus found in a system's distance to its thresholds, and its capacity to absorb disturbance and/or to reorganize itself without leaving the current basin (Walker and Salt, 2006).

The critical processes for resilience are located both in the backloop of the adaptive cycle, where *release* and *reorganization* take place, as well as in the connection between the scales; the processes of *remembering* and *revolting* support here a system's persistence and evolution respectively (Holling, 2001). These four processes are essential to self-organization, adaptation, and keeping the system in a certain stability domain or development path; they are thus responsible for continuation and development with opportunity and innovation.

The difficulty lies yet in understanding both the challenges to and the critical linkages within a SES. As a quality, resilience is difficult to measure as some indicators for SES are difficult to identify; there is also a risk to view a system too narrowly. Rather, to detect loss of resilience and the possibility of an advancing critical transition (regime shift) "warning signs" in the system's activities and development paths need to be established (Folke, 2016, p. 17). An example of such an approach can be found in Rockström et al.'s (2009a) planetary boundary framework, which proposed a space of save operations in opposition to a zone of uncertainty. In the latter, the point and fashion of a system's transformation into a new stability domain with presumably less favorable conditions for human life is uncertain but likely (Folke, 2016, p. 17).

The analysis of social-ecological systems requires not only an understanding of how ecosystems are organized and behave but also an understanding of how people and institutions engage with them. As people are a core factor in SES, social mechanisms and institutions hold indeed an important function: they influence, incentivize, and restrict behavioural patterns; they define in large parts how people engage with changes in social-ecological systems. It is relevant to understand how communities relate and interact with their environment, how they respond to change, and what capacities they have to adapt and/or adjust to changing situations. Unsustainable development is not necessarily a willful act by the people involved; sometimes people do not have or perceive a choice, other times it may be a lack of knowledge, understanding, and/or the application of failing models of how social-ecological systems work (Walker and Salt, 2006). An awareness of these possibilities is necessity in SES studies.

A lot of the sustainability focus of the last decades has yet focused on optimization and efficiency; the aims proposed are often to use resources more efficiently and/or improve the technology involved – from collections of recyclables and energy-saving light bulbs to fuel-efficient engines and alternative energy sources and resources etc. However, optimization and efficiency focus on maximizing production, to get more out of less. These narratives often hold ideas of an optimal sustainable system state or an optimal development path for a sustainable system, if changing conditions are acknowledged (Walker and Salt, 2006). Usually, this lacks the consideration of higher and lower scales as well as the integration of natural adaptive cycles of renewal. The idea to optimize individual system components ignores yet the complex dynamics that exist between the various components and across scales. Moreover, to strive for optimization and efficiency can induce a drive for specialization and thus contribute to a loss of flexibility. Sustainability understood this way may consequentially rather increase vulnerability to shocks and disturbance (Walker and Salt, 2006). The key to sustainability is yet to acknowledge the roles change and resilience play in social-ecological systems.

To maintain resilient SES an analysis of social-ecological interrelations, feedbacks, resources, and adaptive capacity becomes necessary (Berkes et al., 2003). It requires further analysis of who or what decides about the nature of interrelation, and in whose interest or with what motivation do they take place. Managing for resilience thus becomes a political task, which requires some form of governance. The latter can be formally institutionalized, anchored in national laws and regulations, but it can also be expressed as norms and values in interactions. A capacity to manage for resilience can be found in individual actors, social networks as well as institutions (Lebel et al., 2006). These should moreover be accountable, just, deliberate (i.e. open to discussion and reflection), multilayered and participatory if they are to represent “good governance” (ibid.).

Several principles for building resilient social-ecological systems have been proposed: Berkes et al. (2003), for example, introduced an overview for how to build resilience and adaptive capacity in SES, suggested the four subcategories i) learning to live with change, ii) nurturing diversity for reorganization and renewal, iii) combining different types of knowledge for learning, and iv) creating opportunity for self-organization (cf. p. 355ff.)

Walker and Salt (2006) suggested nine core values that would shape a “resilient world” (p. 145); they emphasize yet that these present “visions of what a resilient world might look like” (ibid.) while a deeper and better understanding of resilience in the world has still to be gained.
More recently, Biggs et al. (2015) built upon these and proposed seven principles for enhancing the resilience of ecosystem services (table 2.1.). Both *values* and *principles* can be read as proposals “to develop governance systems that make it possible to relate to environmental assets in a fashion

that secures their capacity to support societal development for a long time into the future" (Folke 2006, p. 253).

Salt and Walker 2006	Biggs et al. 2015
V1 Diversity	P1 maintain diversity and redundancy;
V2 Ecological variability	P2 manage connectivity;
V3 Modularity	P3 manage slow variables and feedbacks;
V4 Acknowledging slow variables	P4 foster complex adaptive systems thinking
V5 Tight feedbacks	P5 encourage learning and experimentation;
V6 Social capital	P6 broaden participation;
V7 Innovation	P7 promote polycentric governance
V8 Overlap in governance	
V9 Ecosystem services	

Table 2.1. **V**alues and **p**rinciples of building resilience

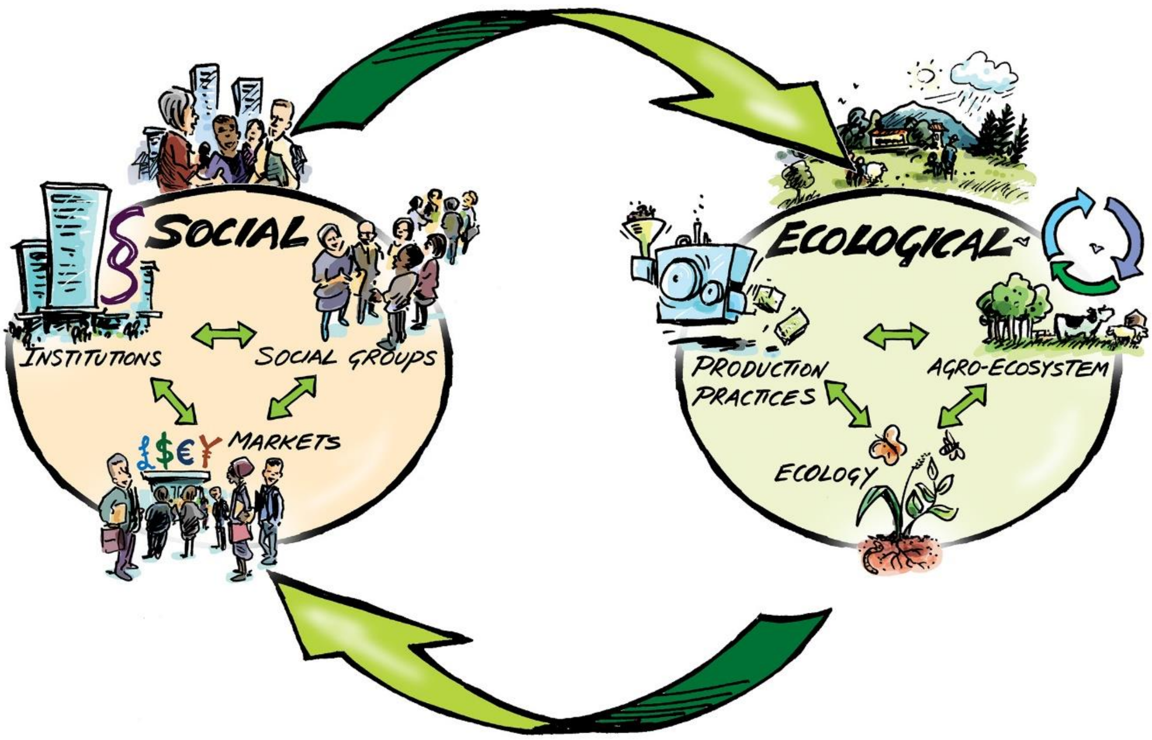
There is a growing literature concerned with what supports and builds *resilience* and some attributes may be more relevant for some situations/systems than others. There remains a critical dependence on the context. For the analysis of the F2F strategy, which at this point is only a proposal and cannot be evaluated for actual impact, the following seven attributes as recently summarized by Walker (2020) shall be used in the assessment of proposed actions:

- **Response diversity**: refers to the need to have different actors upholding the same or similar functions as well as having actors that cover a variety of different functions, in order for a system to be able to respond and reorganize in case of crisis.
- **Exposure to disturbances**: refers to the four phases of the adaptive cycle and the need to pass through crises in order for systems to develop and adjust to changes. Keeping a system in a stable (conservation) phase will reduce its resilience and make the system increasingly vulnerable to shocks.
- **Being modular**: refers to the degree of connectivity among system components. Both an over- and under-connected system is less resilient. The former is vulnerable to a quick spread of failure or diseases, the latter may be inefficient and ineffective, respond too slowly as it suffers from unnecessary redundancies, lack of information and learning abilities, etc.
- **Being able to respond quickly to shocks and changes**: relates to the before, and is concerned with barriers that prevent a system to respond, i.e. due to obstruction of information flows or the suppression of response etc.
- **Being ready to transform**: refers to the need to transform if a system is no longer purposive, practical, or viable in its current configuration or if it is in an undesirable state (deliberate transformation).
- **Thinking, planning, and managing across scales**: refers to the complexity of social, ecological, and social-ecological systems which operate across different temporal and spatial

scales. Managing systems only at the perceived problem level, ignores the impact and unwanted consequences such interventions can cause on other scales.

- **Guiding not steering**: refers to the uncertainty in development that complex adaptive systems generally display. To be resilient, systems need to remain open to uncertainty and surprises; a rigid design for a particular purpose is likely to reduce resilience in the long term.

With these seven attributes in mind, this thesis shall discuss the potential of the proposed F2F strategy to enhance *resilience*. However, before this can be done it is necessary to establish systems thinking as core methodology.



Chapter 3: Methodology

This chapter lays out the approach to the research question and the analysis. It focuses on systems thinking for food systems as the core unit of analysis. It stresses systems thinking as the common language of resilience and food systems studies.

This work is built on two pillars: the observation of a growing number of reports pointing to the problematical state of global food systems on the one side, and the recent publication of the European Green Deal and pivotally its Farm to Fork strategy, on the other. This is complemented by *resilience* as sustainability's succeeding concept in the sustainable development discourse. Chapter one thus reviewed a set of prominent international reports that engaged with the status of modern agriculture and food systems. They have been chosen based on their highly ranked institutional context and/or for the influential impact they exerted in the discussion of planetary boundaries and modern food systems. The review of reports does not claim to be exhaustive but allows to represent the growing international consensus on the problems experienced in globalized modern food systems.

In response to these problems, the recently published Farm to Fork strategy (May 2020) as part of the policy initiative of the European Green Deal was introduced. This initiative suggests a food system transformation to increase resilience (also influenced by the outbreak of COVID-19). This presents relevant reasons to explore what *resilience* of food systems is (or can be) as well to investigate the meaning and nature of transformation (vis-à-vis other forms of change). With the great impact that a policy initiative conceived by the EU will have there is a need to deliberatively engage with the proposal and develop a deeper understanding of what it is that is envisioned. This includes an understanding of the worldview, values, assumptions, and interests upon which the F2F strategy builds.

The analysis and discussion of the potential that the proposed actions hold (to contribute to a transformation of food systems towards greater social-ecological resilience) methodologically build on systems thinking. As both food systems studies and resilience research/resilience thinking traditionally employ systems thinking as a means to speak about the world, it provides an already established common language with which to conduct this research.

[Readers unfamiliar with systems thinking will find a brief introduction under appendix 3.]

This chapter is concerned with the application of systems thinking to food systems. The following introduces the food systems approach as well as how food systems are conceptualized. Before moving on to the analysis, the remainder of this chapter will introduce different models of food system conceptualizations, to reflect on the epistemological complexity that exists in the literature on food systems in general.

3.1 Systems thinking for food systems

Systems thinking has influenced much of the recent agricultural and food studies as a means to study structures and interactions rather than individual components (Chase and Grubinger, 2014). In the late 1990s, when interest in the interactions between global environmental change and food production/food security grew, food systems as an approach offered a possibility to accommodate the complexity of issues involved[28] (Ingram, 2011).

As a conceptual framework, the food systems approach (FSA) portrays the complex web of all resources, actors, and activities facilitating the production and consumption of food. It further allows representing the two-way interactions between the many activities as well as their outcomes, the latter including environmental parameters (ibid.). As a tool, such a framework helps to understand and analyze the relationship between the different system components, i.e. the various actors and processes from production through to consumption as well as their impact on their geobiophysical, social and economic environments. It focuses attention on "the things done" and thus invites an analysis of "the things to do differently" in face of environmental and/or socio-economic stresses (ibid., p.420).

Box 3

Systems characteristics

A system...

- Consists of **interrelated parts** that interact with each other towards a greater purpose;
- Has **boundaries** that separate system from its environment;
- Has an **environment** which is not part of the system but may influence it and which may be influenced by the system;
- (possibly) contains **subsystems** that contribute to the overall purpose Subsystems stand in **defined and specific relationships** to each other; a change in their relationships results in changes in the system at large
- Shows **emerging properties**, meaning that the specific interplay of parts of the system results in characteristics or behaviours no individual part holds;
- Has **purpose**;
- Has ways of **communication** (feedback loops) internally and externally with its environment;
- Has a mechanism of **control** that allows them to respond to changes in the environment.

(cf. Armson, 2011; Checkland, 1999)

[28] The concept was not new at this time and was recognized particularly among sociologists (Ingram, 2011). However, monodisciplinary perspectives and/ or specific problems continued to be the norm in most research.

Systems thinking provides here a means for organizing, thinking, and talking about food systems. Focussing on interrelations and interactions, an FSA aims to see food systems in their totality rather than compartmentally, as has often been done in the past. Its value derives from the fact that the focus on connections helps to "identify, analyze and assess the impact and feedback of the systems [sic] different actors, activities and outcomes (…)" (Future of Food, s.a.). This means it is concerned with the interplay of components assuming that if one variable gets changed it possibly affects all other variables and their interactions (Combs et al., s. a..; FAO, 2018; IPES, 2015). Therefore, the better the interrelations are understood the more can an FSA help to identify possibilities for interventions.

As a concept, food systems encompass all processes that relate to the production and utilization of food. It describes the complex webs of different actors that account for growing, harvesting, storing, transporting, processing, packaging, marketing, selling, consuming, and disposing of foodstuff. As such, food systems are composed of several subsystems (i.e. farming, marketing, waste management etc.), and interact with other systems (i.e. trading, energy supply, public health etc.). Food systems further accommodate a flow (inputs and outputs) of resources (from biogeochemical substances to labour, time, and money), and finally, the specific environments, in which activities take place. These are, for one, the biophysical environments of particular places, which decide over the kind of produce, success and quality of production; and, for another, the socio-economic, cultural, political and technological conditions, which significantly shape and determine ways of doing and practicing farming, trading, and consuming food. These different environments can also be understood as drivers as they facilitate (or hinder) and define the food systems processes via feedback loops.

The purpose of food systems is usually portrayed as providing sufficient, healthy foods (food and nutrition security). However, at a closer look, there are various additional expectations, such as that food systems generally are also supposed to provide income, employment, and (to some actors) profits; more recently they are also explicitly expected to contribute to general public health, healthy living environments, and sustainable land management. Finally, they are increasingly demanded to be environmentally friendly and stress[29] resilient. In order to fulfill all or some of these expectations, institutional and regulatory frameworks exist to govern processes towards these aims.

[29] Stress can be both of natural and of socio-economic qualities, like a drought for the former, or an economic crisis for the latter.

Many of these frameworks are yet not explicitly designed for and directed at food systems but rather sectoral or cross-sectoral (e.g. employment, curbing pollution, following trade agreements, etc.), hence often operating at a broader higher scale. Therefore, so far policies rather affect food systems than being explicitly designed for them. The F2F strategy can thus establish a new policy example to food systems in general.

The conceptualization of food systems represents the interrelation of human activity and nature. Food systems thus have to be understood as coupled natural-human systems. The use of land for food production is traditionally among the most immediate interactions communities have with nature. As a framework, coupled natural-human systems recognize the wide variety of internal processes, i.e. the nutrient cycle on the natural side, the politics, and economics on the human side. As a coupled system, the natural present the conditions for food production while the human-side shapes the form of engagement and management of the former (Vanek and Zimmerer, 2018). As coupled systems, feedback flows between the two subsystems determining food systems as evolving systems.

As a consequence, human practices have a direct impact on the natural system, which in turn will respond and adjust over time. Challenges such as climate change, soil degradation, desertification, pollution etc. constitute changes with to a significant degree occurred in response to human activity. The food systems approach aims for a holistic mapping of interactions while acknowledging the non-linear nature of systems' behaviours. It, therefore, lends itself well for the analysis of system behaviour before and in response to (policy) interventions.

3.2. Limits to systems thinking

Systems thinking has contributed to structuring research of relationships and interactions in the field of agri-food studies. It contributed to a move away from studying the individual stakeholders and/or subsystems within the agri-food systems. Instead, it suggested to focus on the interconnectedness of ecological environments with food production, farmers' life quality, consumers' health, animal welfare, supply chain management, trade etc. However, as Bland and Bell (2007) have pointed out, there are also significant limitations to systems thinking. In their article "A holon approach to agroecology" they argue that while systems thinking has allowed to conceptualize the more complex interactions in agriculture, it also invites to develop an "*over-connected understanding* of the world" (p. 281, emphasis in original). There is, they say, a problem with defining both the boundaries drawn around a system (*where does a system start and end*?) as well as the narrative to be told about the system (representation is done within one (the researcher's) worldview). In other words, boundaries and representation of a system are affected by the systems thinker's personal experiences and interests. In this, they agree with Checkland and colleagues who reasoned that "systems thinking always in part reflects the priorities of the systems thinker", thus inevitably is shaped by human institutions, by ideologies, politics, and powers (Bland and Bell, 2007, p. 281). This means, epistemologically the system is - subjectively - limited by the researcher, while ontologically its representation and interpretation are partial and contestable.

The idea that systems thinking facilitates more holistic research in that it is anti-reductionist is equally challengeable: the methodology has the study of relations and interactions at heart and demands to see every part in relation to the other; at the same time, any representation of reality in system models is very likely a reduction of what is. This is partly due to the already mentioned limitations within the person of the researcher themselves. Partly this is also due to the fact that the complexity is too vast and not everything is understood in each and every detail.

Despite these limitations, this paper utilizes systems thinking for the discussion of policy interventions. Value is seen in it both as a tool to capture the interrelatedness of entities and the language it offers to commonly discuss and debate them. The fact that some reduction or simplification occurs in the representation is important to reflect on as, naturally, it could lead to some significant relations being missed. Simultaneously it may also be due to this simplification that a researcher is able to manage a complexity, which otherwise might be overwhelming. With this in mind, it seems advisable to aim for the greatest complexity possible as well as to continuously retain the flexibility to negotiate and adjust a system throughout the process. Systems thinking is thus employed here as a means to inquire about relations and interactions within agri-food systems and to discuss possibilities of transformations as proposed by the EGD.

3.3. Conceptualization of food systems (models)

With the many different spheres and stakeholders, food systems can be studied through the lenses of various disciplines (economics, public policies, public health, agriculture, social anthropology, environmental studies, marketing etc.). Accordingly, the conceptualization of food systems can vary and be biased towards a guiding interest (i.e. environmental protection, economic sustainability, public health etc.). It is likely for any depiction of food systems to be incomplete; they are therefore never more than a tool for the analysis of interactions and relationships between the various actors and their outcomes in terms of social, economic, cultural, and environmental impacts (van Berkum et al., 2018, p. 8). This includes observing different qualities of processes as well as feedback loops between stakeholders and/or the environment.

Various models of food systems exist. Conceptualizations vary usually in their focus and may portray more or fewer interactions between system components and their environments. A detailed model, which attempts to capture food systems in their full complexity may be all-encompassing but simultaneously also overwhelming and unintelligible (cf. for example figure. 3.1.). Such a holistic portrayal of food systems is hence of little practical use for an analysis. It needs to be broken down into broader units of processes.

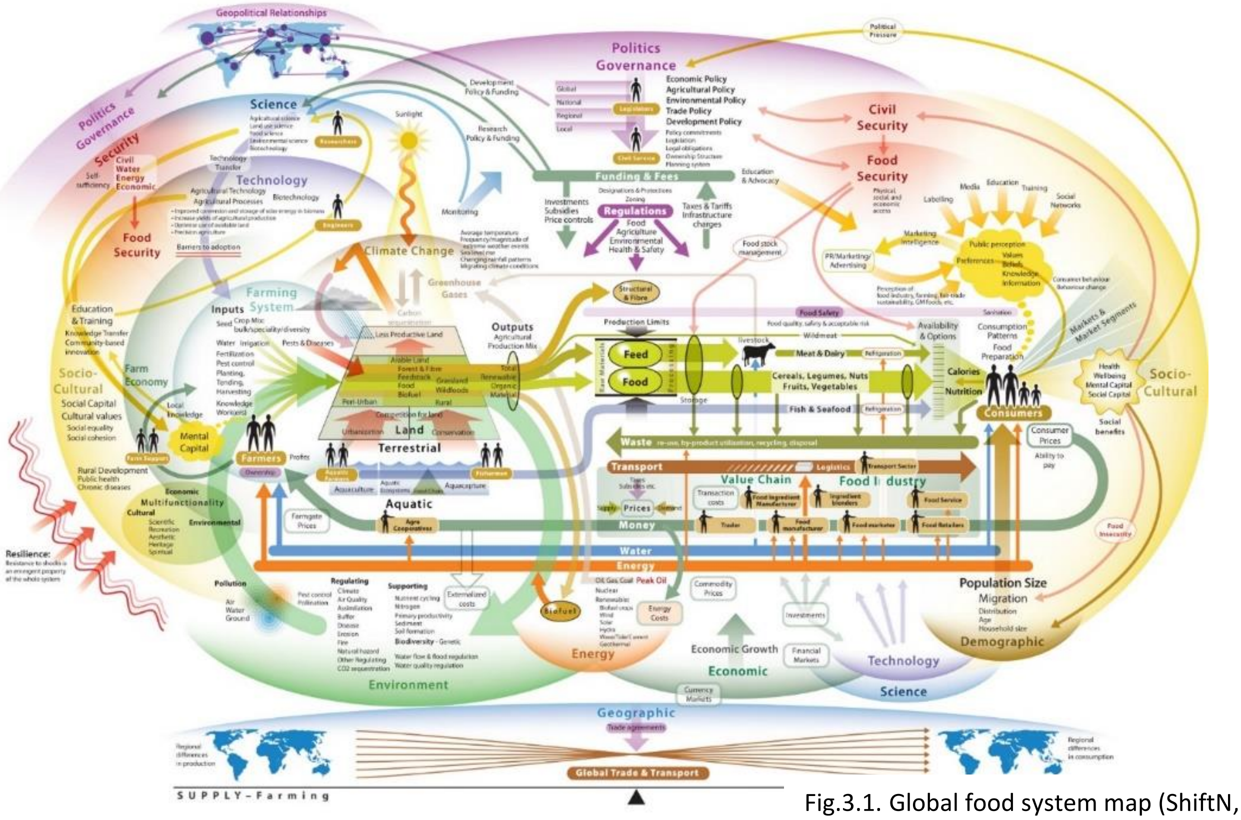


Fig.3.1. Global food system map (ShiftN, 2016)

Alternatively, food systems can be presented in their basic elements. In figure 3.2., for example, the different processes that go into producing and consuming food have been spatially divided into the three units, farmers (to the left), consumers (to the right), and food industry (in the middle). Interactions happen between, but also around them, with immediate interactions and processes that impact activities in varying degrees. The closer to the units the more immediate is their impact and outcome(s) to the unit in question. Worth noticing is herein also the mentioning of values, knowledge, and preference on the side of the consumer. These are factors that vary significantly with people having different cultural traditions, socially formed preferences, different understandings, and information. These are also factors, which usually are difficult to measure as they are subjective, may overlap, and hence are not necessarily unambiguously identifiable. While this representation indicates food security as an immediate outcome, it seems yet to suggest that production leads to availability; the role of physical and /or economic access to food in food security as well as the quality of food for nutrition security do not find reflection.

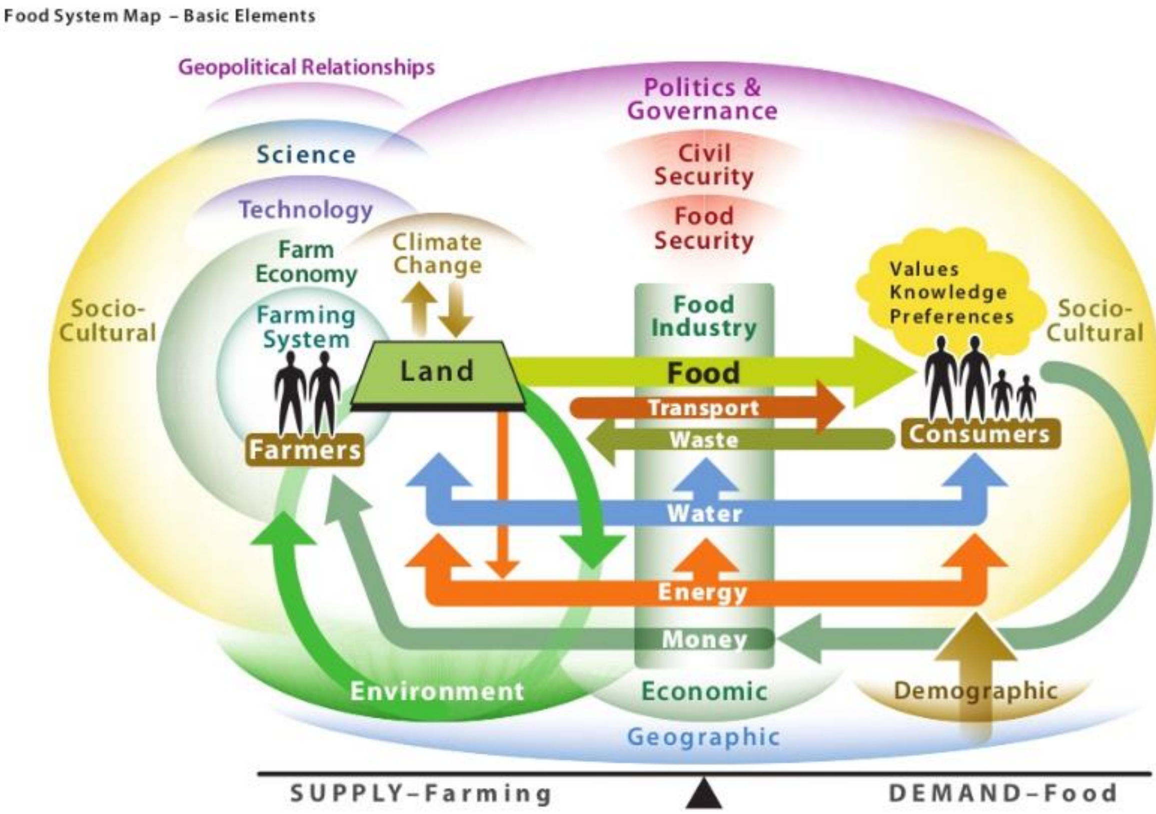


Fig.3.2. Basic Elements of a food system (ShiftN, 2016)

The more comprehensive but simplified food system map of figure 3.3, on the other hand, focuses rather on reflecting the fact that any food system consists of different spheres of interaction, that is, farming, environmental, social, economic, and political. Distinguishing these subsystems of a food system allows to include the representation of more actors, interactions, and processes that make up a food system. This model is an example of a simplified yet holistic food system representation as it incorporates decidedly the different spheres as subsystems. It is more detailed, distinguishes more system processes, and includes various spatial scales. At the same time, it remains comprehensible and manageable.

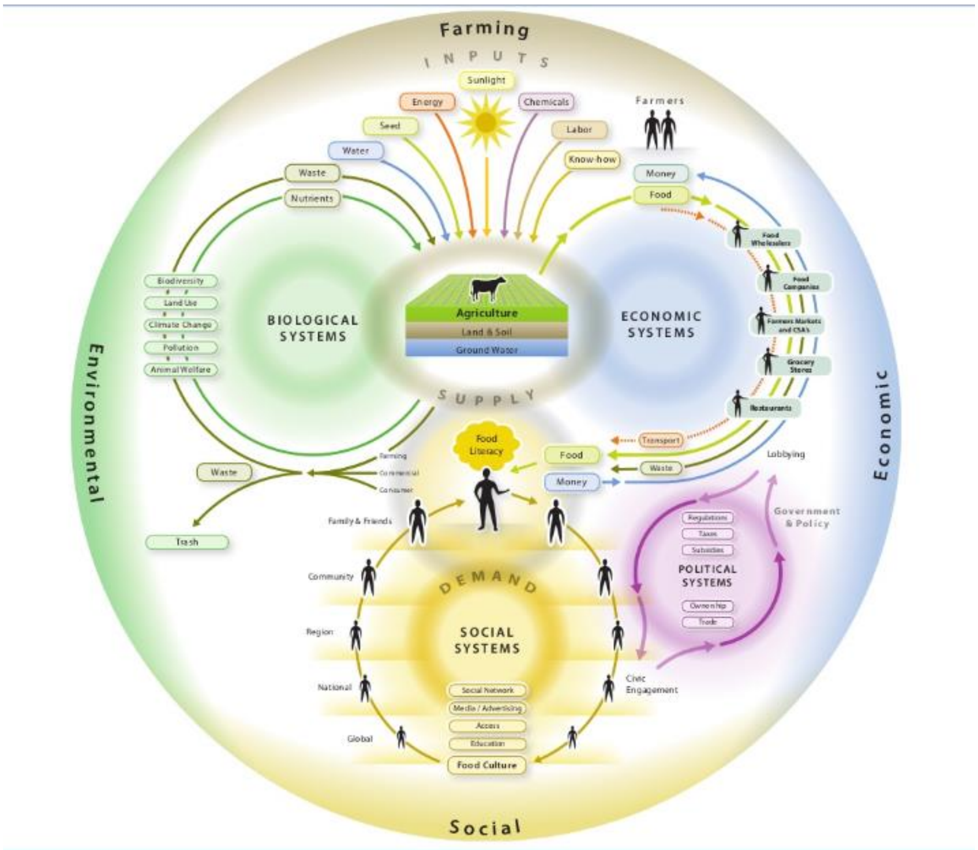


Fig. 3.3. A simplified holistic food system map (ShiftN, 2016).

Not reflected in any of these figures is the fact that food systems vary in scale – both spatially and in size. Food systems can be local, regional, transnational, and global, which indicates the distance food travels from production to consumption. Size, on the other hand, indicates the complexity of actors involved, from direct marketing at farm-level (few actors) to the full supply chain of transportation, processing, packaging, distribution, and retail (many actors).

These models focus on capturing the diversity of actors and their many interactions. It is to show the complexity of the coupled social-ecological system that food systems are. Such a representation does justice to the requirements of a holistic approach and needs to be remembered in what follows. Depending on the field of studies, other conceptualization of food systems can be found. Often food system conceptualizations are then oriented towards a specific impact or purpose.

Two influential models shall be presented here, which in particular in the context of sustainability research have become frequently used and appropriated.

a. Polly Eriksen's model of food systems and their drivers (2008)

In the field of global environmental change, it is Polly Eriksen's (2008) model of food system drivers that has found a broad application (figure. 3.4.). It incorporates a focus on drivers of global environmental change, rather than ecological drivers in general. In that sense it specifically aims to capture the dynamics of change, even if limited to the natural component of the system.

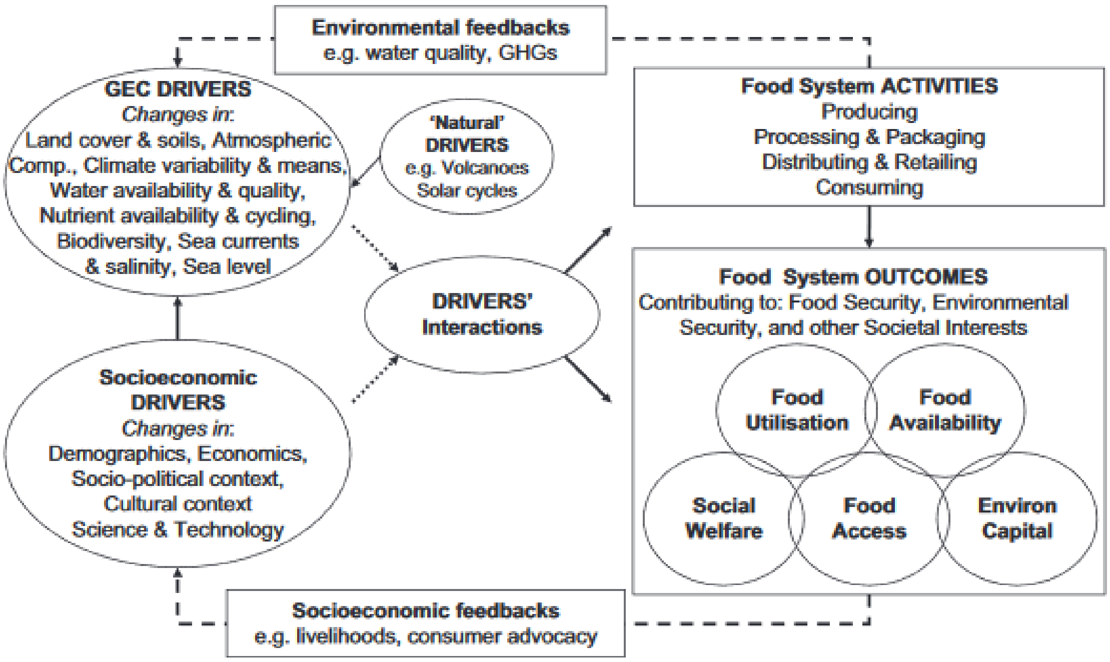


Figure 3.4. Food systems and their drivers as printed in Polly Eriksen (2008).

a. HLPE's conceptual framework of food systems for diet and nutrition (2017)

As a second influential model (figure 3.5.) needs to be mentioned the one designed by HLPE. It represents the key components or fields of activities that are relevant to food and nutrition security. As a product of an international political institution, it incorporates the human rights framework (the human right to food) and its four pillars of availability, access, utilization, and stability, as well as, additionally, the aspects of participation and sustainability. This framework gets particular employed in the political context of (global) food and nutrition (in)security, sustainability development (i.e. SDGs), and other fields relating to the broader global political economy of food and diets.

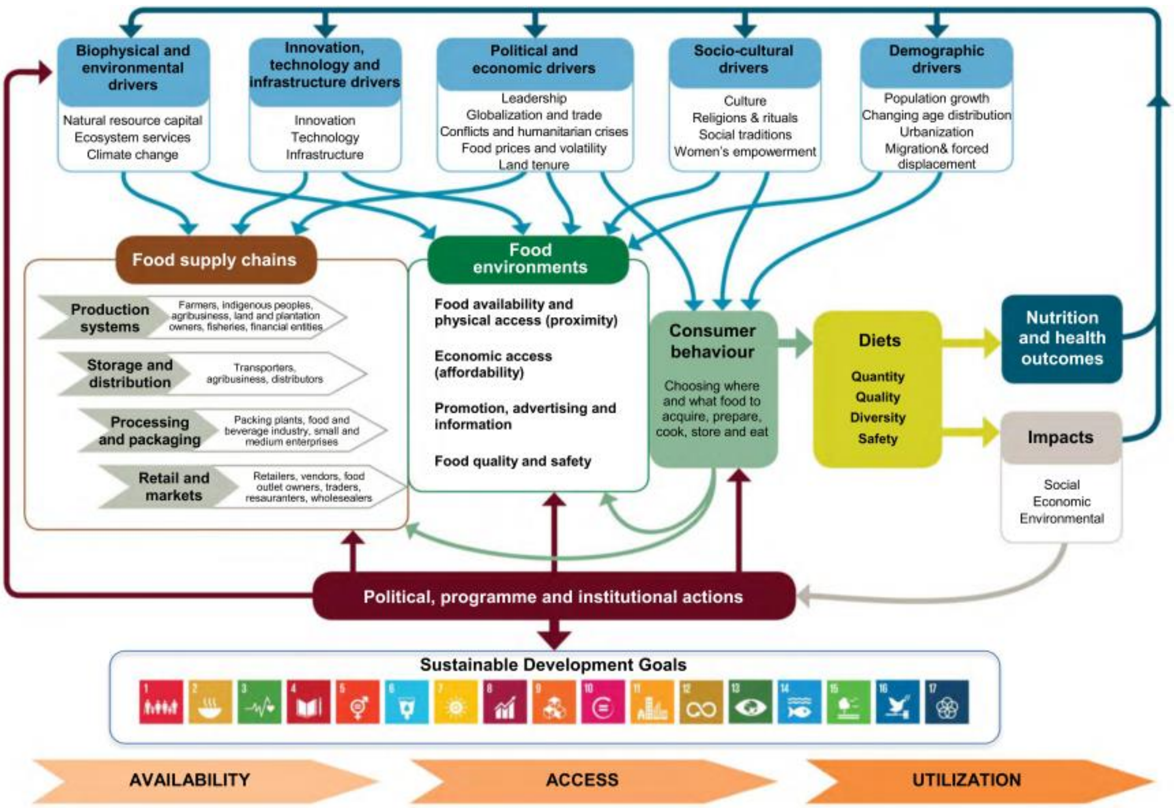


Figure 3.5. Conceptual framework of food systems for diets and nutrition as printed by HLPE (2017)

Both these later models focus on the goal of food and nutrition security. However, while Eriksen (2008) highlights both the environmental and socio-economic feedbacks that exist between the food system activities and outcome- and system drivers, the HLPE (2017) framework presents more detailed the different drivers that exist as well includes the component of political, programme and institutional actions, which inform both various system drivers, food supply chains, food environments and people (consumers).

These different conceptualizations present examples of ways to think about food systems. They all exist in their own rights but noteworthy set out with different emphases and/or intentions.

In the following, the simplified holistic food system map shall be employed as the conceptualization that aims to present the multiplicity of interrelations with a complex food system. The two frameworks from Eriksen (2008) and HLPE (2017) are valuable for their emphasis on systems' drivers, impact and the crucial role feedback holds for change, adaptation, and transformation, and will therefore be referenced with regard to these.

Chapter 4: Making sense of food systems' resilience as part of the Farm to Fork (F2F) strategy

In this chapter, I conceptualize modern food systems in terms of resilience thinking. I first establish where to locate and how to talk about resilience with regard to food systems. I then move on to evaluate the F2F strategy with regard to its addressal of current systems' drivers, and its contribution to transformation and resilience building.

4.1. Operationalization of resilience thinking for food systems

Chapter 2 introduced resilience thinking as a framework, which builds on a) identifying a system's landscape of basins (drivers, thresholds), b) the processing through stages of the adaptive cycle, and c) the idea of a panarchy, which represents cross scale-interactions, adaptive cycles at different scales. As a first step, I shall operationalize this framework to locate resilience within food systems. This will allow for assessing the proposed actions of the F2F strategy towards their potential to transform food systems and to increase their resilience.

a. Food systems operate in a landscape of basins

Food systems are social-ecological systems and therewith complex adaptive systems that consist of different interacting components. This social-ecological system is in a continuous dynamic process of change and adjustment as change in one unit can lead to change in another. This means food systems experience a continuous process of change and adjustment. Importantly, food systems as complex adaptive systems are self-organizing and adjust in response to feedback that flows between the different components (also called *adaptation*).

In chapter 2, the image of a ball in a basin of multiple attractors was used to visualize the dynamics of a system within a landscape of different basins (i.e. different configurations). A system's location within a basin is defined by its specific set of state variables. Of interest are therefore the different drivers that influence and change these variables; they force the system to respond and adjust. The core drivers of food systems were part of the review in chapter 1A. Table 4.1. presents a summary of core food systems' drivers as stated in the reports of chapter 1.

Environmental drivers	Social drivers	Economic drivers
Climate change/ GHG emissions Biodiversity loss Interference in nitrogen and phosphorus cycles Stratospheric ozone depletion Global freshwater depletion Atmospheric aerosol loading Chemical pollution Land system change Loss of natural ecosystems Unsustainable resource usage Intensive use of external inputs Overharvesting Limited species variety used in agriculture Proliferation of invasive species	Population growth Growing food demand Shifting diets Technological progress Growing demand for land Urbanization Changing production and consumption patterns Global trade patterns Intensive export-oriented production Growing energy demand Social inequality	Changing financial markets for food and agricultural investments Free-market economy Global trade patterns and free trade agreements Powershift and concentration (corporatization) Low returns Low wages Financial insecurity for food producers

Table 4.1. Overview of core food systems' drivers

The continuous processes of change and adjustment can push a system closer to critical thresholds and even lead to a regime shift (a new configuration). A food system's resilience is therefore defined by the distance between its state variables and their critical thresholds. In response to social and ecological variation, these distances vary over time and affect thus the general resilience of food systems.

The identification of critical thresholds is yet difficult. In the presentation of the problematical situation, the planetary boundaries framework presented several critical thresholds that are applicable also to food systems (climate change, biodiversity loss, interference in nitrogen and phosphorus cycles, freshwater usage, land-use change, chemical pollution, ocean acidification, stratospheric ozone depletion, atmospheric aerosol loading). It was suggested that food systems are not just negatively affected in their operations if certain variables change further towards their thresholds; but also are food systems themselves contributing to moving closer to these thresholds. The framework of planetary boundaries has been influential and shown useful for the study of environmental change due to human activity. As that, the framework can inform on food systems' contributions to environmental change; it can yet not identify threshold(s) for food systems as a whole.

The field of environmental research is, indeed, closest to suggesting critical thresholds with studies indicating irreversible systemic change for individual systems components (e.g. on nitrogen and phosphor usage, the lack of pollinators etc.). For the socio-economic components of food systems have thresholds so far been difficult to establish (particularly due to the unpredictability of human behaviour). In these realms, it is rather about crisis and collapse of existing connections that force the system to reorganize and adjust. These typically come in the aftermaths of natural disasters, economic-, health- or political crises.

As a result of this, the landscape of food systems is not readily and distinctively identifiable. While advances in understanding the ecological thresholds suggest boundaries, the same is not possible to establish for the social-economic system components. However, it is possible to acknowledge important system drivers that work on core food systems' variables and shape the current and future systems' configurations. A long-term, historical appreciation of diverse dynamics (cf.4.1.c) has contributed here to an understanding of which dynamic (driver) affects state variables and with what impact (direction of change). The problems that result from modern food systems make it necessary to understand not just how these individual drivers affect the system but also how they correlate and possibly reinforce or hinder each other. If transformation is the goal, it can only be achieved by changing drivers.

b. Food systems operate in adaptive cycles

As a second important concept in resilience thinking was introduced the adaptive cycle. We learnt that ecological and social systems process through phases of growth, conservation, release (crisis), and reorganization. As social-ecological systems, food systems can be expected to pass through these phases of the adaptive cycles, too. Operating on different spatial and temporal scales, food systems embrace and are affected by a number of different adaptive cycles (operating in sub- and superordinated systems). These cycles bring about change from the smallest to the largest units, while memory is shared from the slower higher cycles to the faster lower ones. This means, food systems accommodate multiple processes of change and innovation from across the spectrum of its ecological, economic, and social systems' components. These processes may, however, take a long time until they bring about systemic change on the level of food systems. It is generally suggested that ecological variables tend to change slowly (*slow variables*) while social variables can be fast (e.g. trends) or slow (e.g. culture). The slow variables tend yet to determine the overall dynamics (Walker and Salt, 2006).

Figure 4.1. symbolically captures the presence of adaptive cycles across food systems. components.

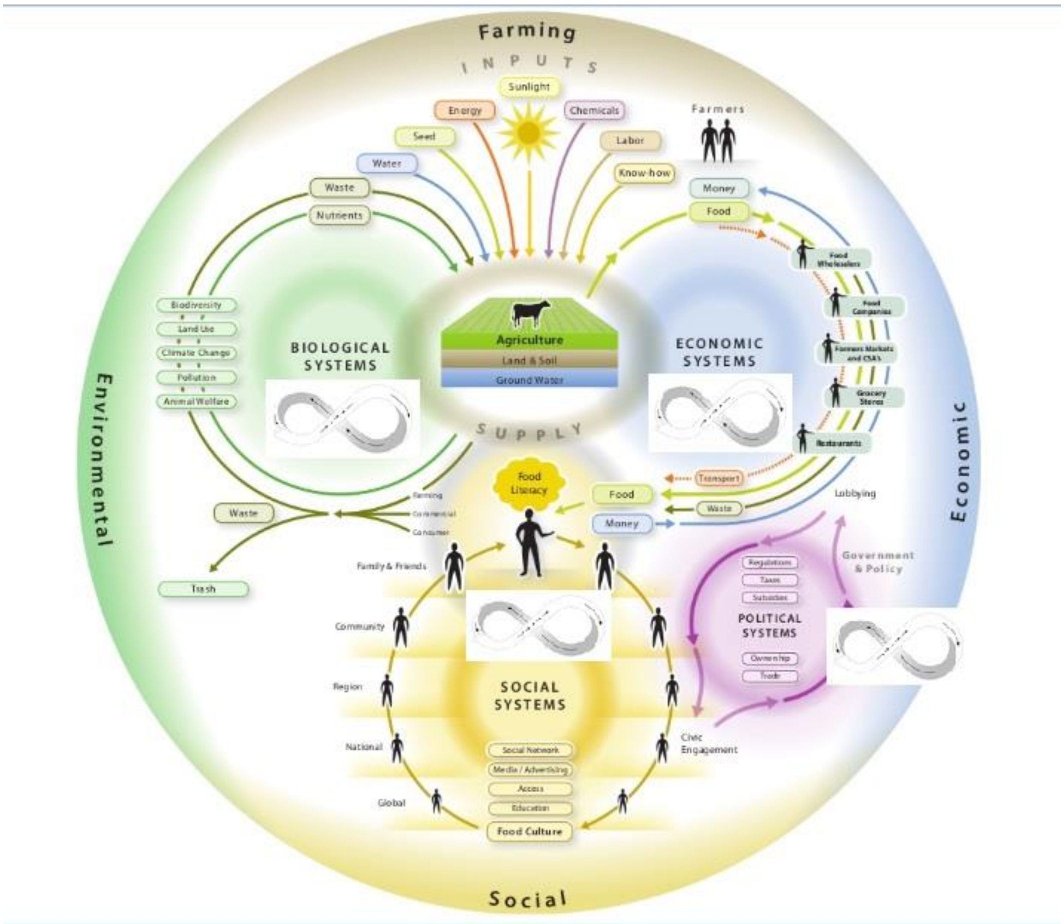


Fig. 4.1 Food system model with adaptive cycles (ShiftN, 2016; adaptive cycles added).

c. Food systems regimes can be captured in a panarchy

Transformational changes have changed and shaped global food systems since the onset of colonialization and industrialization. The idea of food regimes, as proposed by McMichael (2009) (cf. appendix 1) allows for a conceptualization of food systems' developments in term of a panarchy. Figure 4.2. attempts to present a (simplified) version of this panarchy.

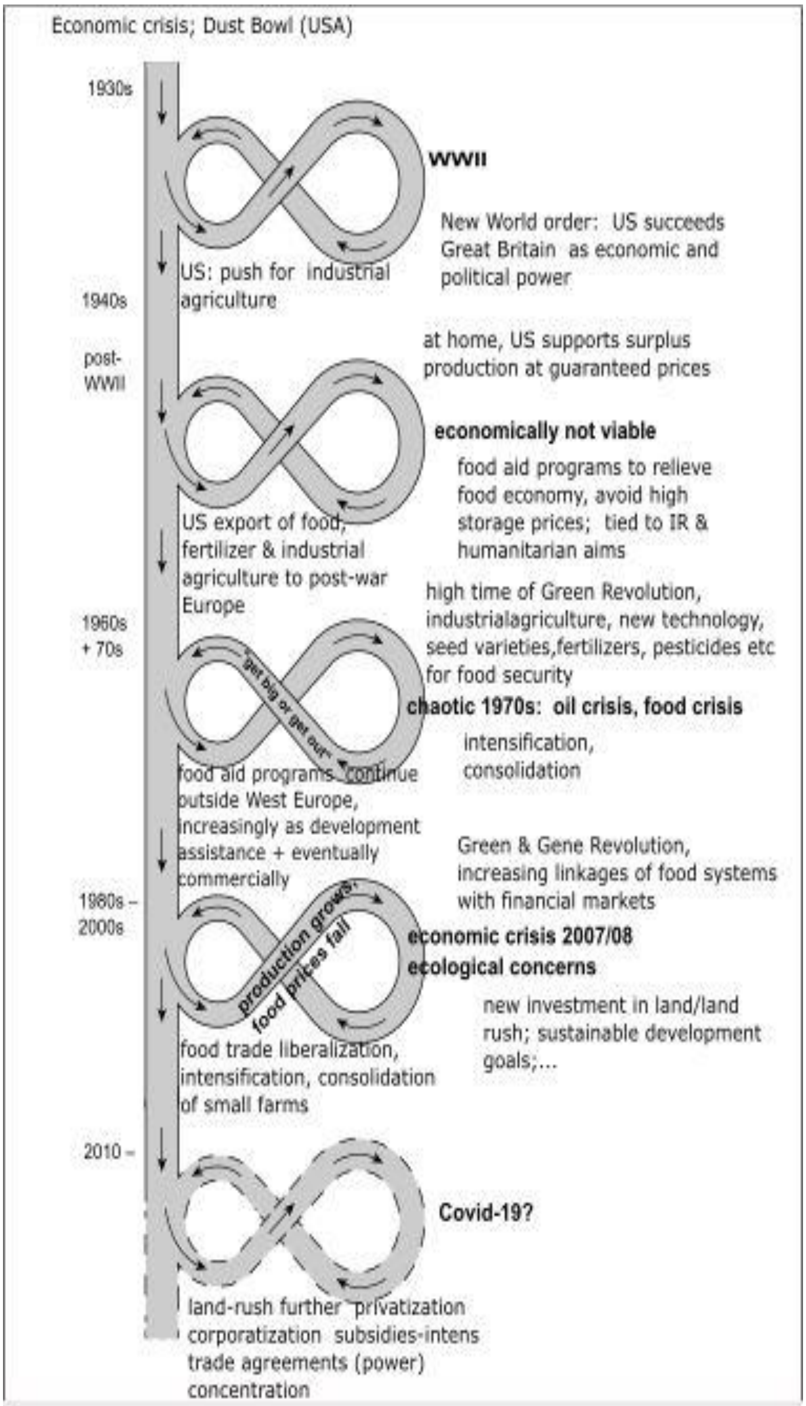


Fig.4.2. Proposed panarchy of modern food system development

The panarchy as a representation of the social-ecological system describes how food systems have continuously re-invented themselves in relation to (political) interventions and crises. It is useful to study the historical development towards the events that have shaped it, to understand the linkages across scales as well as to identify possible, critical thresholds.

This means, to acknowledge the history of the system helps to understand general systems dynamics; it presents a starting point for identifying adaptive cycles and their linkages across scales. As a model of reality, the panarchy visualizes that change is both continuous and crucial for further development. Further, it visualizes the decisive role that crises have played in the overall formation of today's modern food systems.

As a contextualization of how the system's drivers impact food systems' developments, it provides important insights into processes of adaptation and transformation; these can be relevant also for the management of food systems.

It is yet important to remember that the panarchy captures the dynamics neutrally as processes. It is the human state, activity, and purpose that defines whether change is negatively or positively connotated.

4.2. The Farm to Fork strategy's transformation proposal

In its 19 pages, the Farm to Fork strategy lays out a wealth of activities to develop and/or to improve in the coming years. As a reminder from chapter 1, the strategy consists of the following six focus areas for the activities. These were:

1. Ensuring sustainable food production
2. Ensuring food security
3. Stimulating sustainable food processing, wholesale, retail, hospitality and food services practices
4. Promoting sustainable food consumption and facilitating the shift to healthy, sustainable diets
5. Reducing food loss and waste
6. Combating food fraud along the food supply chain

Within these six areas over 20 actions are suggested (table 4.2.), which shall be summarized and grouped here with regard to the relevant subsystem of intervention. This is to localize the place of intervention whilst being aware that their impacts go beyond these and will affect the larger SES as a whole.

BIOLOGICAL SYSTEM	SOCIAL SYSTEM	ECONOMICAL SYSTEM
Promoting organic farming **At least 25% of EU farmland to be under organic farming by 2030 Support sustainable aquaculture.** *Support sustainable practices (nature-based, technological, digital, space-based)* *Eco-schemes: boost precision agriculture, agro-ecology (including organic farming), carbon farming, agro-forestry, etc.*	**Guaranteed decent income**	**Bio-based economy**[30]
Reduce overall use and risk of chemical pesticides and more hazardous pesticides by 50% in 2030. *revision of the Sustainable Use Directive (SUD) to reduce the use and dependency on synthetic chemicals pesticides;* *reduction in use of pesticides by the implementation of Integrated Pest Management (IPM); make a new legislative proposal to enhance the implementation of Integrated Pest Management (IPM).* *revision of the pesticides statistics regulation to overcome data gaps and reinforce evidence-based policy making;*	**Better efficiency and effectiveness of direct payments under CAP**	**Promote circular business models**[31]
Reduce nutrient loss (especially of nitrogen and phosphorus) by 50% in 2030 while ensuring that there is no deterioration in soil	**Protect critical staff (agri-food workers) better in reference to the European Pillar of Social Rights**	**Geographical indication and sustainable criteria labelling as marketing standard**

[30] Bio-based economy is tightly linked to the biotechnology industry and refers to an economy that uses renewable biological resources from land and sea to produce food and non-food products such as textiles and energy (cf. European Union, 2012).

[31] Circular business models refer to an economic system that aims at keeping products and materials in use for longer. Circularity therefore involves sharing, re-using, recycling, and refurbishing, including the use of waste as regenerative resource, if possible (i.e. energy production).

fertility; Reduce use of fertilisers by at least 20% in 2030. *Encourage precision fertilisation.* *Recycling of organic waste for organic fertilisers* *manage better nitrogen and phosphorus application.* *Develop integrated nutrient management action plan*		
Reduction in environmental and climate footprint *Renewable energy (biogas, solar panels and other energy efficiency solutions)* *promote the EU carbon farming initiative under the Climate Pact, promote new green business.*	**Improve agricultural rules/legislative initiatives to strengthen position of farmers, their cooperatives and producer organisations in food supply chains and to capture a fair share of the added value of sustainable production**	**Short supply chains**
Reinforce vigilance on plant imports; *adopt new measures to protect plants better from emerging pests and diseases, reinforce vigilance on plant imports and develop new innovative techniques incl. plant protection products containing biological active substances*	**Revise fishery control system for fairness**	**Tax system should aim for price differences to reflect their real costs in terms of use of resources, pollution, GHG emissions and other environmental externalities.**
increase alternative feed materials (insects, algae, and by-products from the bio-economy (e.g. fish waste), foster EU-grown plant proteins (reduce dependency on imports of unsustainably produced feed), and feed additives. *revision of the feed additives regulation to reduce environmental impact of livestock farming*	**Initiatives to stimulate reformulation of processed food, including the setting of maximum levels for certain nutrients; initiatives to facilitate the shift to healthier diets.** *Facilitate nutrient profiles to restrict promotion of food high in sugars, fat, and salt.* *mandatory front-of-pack nutrition labelling to enable consumers to make health- conscious food choices* *improve channels to spread relevant information (health)*	**Revision of EU marketing standards/EU code of conduct for responsible businesses and marketing practices for healthy, sustainable food options** *provide for the uptake and supply of sustainable agricultural products;* *reinforce the role of sustainability criteria taking into account the impacts on food loss and waste*
Reduce EU sales of antimicrobials for farmed animals and aquaculture	**Revise food contact materials legislation to improve safety and public health.**	**Seek commitment from food companies to:** **Reformulate food products for health and sustainability, reduce environmental footprint and energy consumption.** **Ensure food prices campaigns do not distort consumers' perception of the value of food.** **Reduce packaging.**
Revise animal welfare legislation *Evaluation and revision of the EU legislation on animal welfare, including on animal transport and slaughter of animal.* *Consideration of options for animal welfare labelling.*	**Revamp agricultural crisis reserve; Conceive a common response mechanism for ensuring food supply and food security in crisis**	**facilitate better registration of seed varieties and ensure easier market access to traditional and locally adapted varieties (incl. organic and new innovative techniques)**
improving advisory services *to enable farmers to become sustainable;*	**Improve corporate governance framework including a requirement for the industry to integrate sustainability into their strategies**. *Legislative initiative on re-use to substitute single-use packaging* *Create a voluntary sustainable labelling framework with a sustainable food logo that would integrate the nutritional, environmental, climate and social*	**Facilitate market access for innovative feed additives, alternative feed materials (insects, algae, etc.)** **that help reduce the carbon footprint, pollution as well as methane emission.**

	dimensions of foodstuffs (on nutrition, climate, environment, social aspects)	
	Tax incentives to encourage consumers to choose sustainable and healthy options.	**clarifying the scope of competition rules** *in the TFEU for collective initiatives that promote sustainability in food supply chain*
	Halve food waste by 2030; Proposal for EU-level targets for food waste reduction. *set a baseline and propose legally binding targets to reduce food waste; a revision of EU rules on date marking*	
	Scale up fight against food fraud along the agri-food chain. *adopt zero tolerance policy, strengthen cooperation, control and investigation*	.
	Setting mandatory minimum criteria for sustainable food procurement in institutional catering. *to promote healthy and sustainable diets, including organic products, in schools and public institutions*	

Table 4.2. Overview of F2F strategy activities

The text of the F2F strategy employs the term *resilience/resilient* without providing a definition. In chapter 2, I used the definition of resilience as the capacity of a system to persist in its original state (identity) in face of perturbations. This does include change but, importantly, without crossing a threshold to a different identity (*regime shift*); resilience is characterized by the distance between state variables and their thresholds.

With regard to transformation, the F2F strategy employs both the term of *transformation* and *transition* of food systems. Variations of *transform (-ation, -ational, -ative, -ing) appear three times and refer to agricultural and aquacultural production methods (1x), "greening" and digitalizing farms (1x) and, finally, to the food system as a whole (1x). If *transition*[32] is added to the search, the emphasis becomes more apparent: There are 29 mentions which refer to sustainable food systems (15x), sustainable practices (5x), and sustainability in general (1x); climate and ecology are referred to once each, while economic opportunity and a just transition find mentioning twice each. The remaining two refer to sustainable livelihoods for primary producers and financing the transition.

This matters with regard to resilience as it holds a desire for adaptation rather than transformation if the system's state allows it. In contrast to transformation, which involves a regime shift,

[32] Transformation and transition are of course not mutually exclusive terms but have become used almost interchangeably, especially in political and scientific discourses (Hölscher et al., 2018, p. 1).

adaptation is concerned with managing the systems in ways that help keep it in a (desirable) state and thus away or towards the relevant thresholds. With this being said, the F2F document refers also to *adaptation (adapt, adaption, adapting): a total of six times of which half of them are in direct relation to climate change, one to locally adapted seed varieties, one to diverse challenges to food systems, and one to marketing and advertising strategies. With this observation, it is yet unambiguous that the F2F strategy stresses the plan of a transformation towards sustainable food systems - ecologically, socially, and economically. The EU has tasked itself with governing transformative change rather than managing food systems for adaptation, that is, to stay in the current configuration.

After this has been established, the F2F strategy can now be tested with regard to its contribution to i. transform food systems and to ii. building their resilience. Since thresholds are often too difficult to identify and food systems too complex to be measured in precise units (Cabell and Oelofse, 2012), the focus needs to be on analyzing the strategy's engagement with systems' drivers; these drivers matter as they have been identified to influence systems' variables in undesirable directions (if we think of the image of the system as a ball in a basin of attraction, drivers inform us on how this ball is moving.).

4.3. Evaluation

With the help of the heuristic tools of the landscape of basins, the adaptive cycle and the panarchy, critical information has been provided on key actors and drivers as well as on points of structural change (crises) and undesirable (problematical) dynamics. It is now possible to relate the proposed actions to these models and to assess if these hold the potential to reshape modern food systems (due to its size, the overview of actions, and the assessment of drivers and problems addressed by them, can be found in appendix 4).

4.3.a. Addressing systems' drivers

An analysis of the proposed interventions shows that the F2F strategy addresses numerous drivers that are currently defining the food systems' basins of attraction (cf. appendix 4). Adhering to the functional division of ecological, social, and economic subsystems' components, specific emphases can be detected for the respective places of intervention (acknowledging their impact on the SES as a whole). These indicate that the F2F strategy is:

(1.) particularly concerned with curbing unsustainable resource usage, intensive use of external inputs, GHG emissions, chemical pollution, atmospheric aerosol loading, and the interference in nitrogen and phosphorus cycles. It further acknowledges the growing energy demand, including for the production of food, and the threat that invasive species hold for ecosystems functioning. The F2F strategy pushes for changes in production patterns, that is, towards those identified as more sustainable (= reduced impact of the before-mentioned drivers).

(2.) As a second focal point, the F2F strategy focuses on shifting diets and consumption patterns (in quality terms) that have a negative impact on public health as well as on the environment. It shows concern over the chemical pollution via packaging materials which can pose additional public health threats and can negatively affect the natural environment via their production and disposal. It is apparent that the strategy understands the link between production and consumption patterns as key areas in need of change (transformation); a transition here is identified as crucial for achieving better health of both people and the natural environment.

(3.) The F2F strategy acknowledges the need for empowered producers that earn their fair share. The change towards sustainable food systems is dependent on producers and agricultural workers; their financial insecurity due to low wages and returns can hinder the envisaged transformation. The proposed economic support for more sustainable production is associated with incentivizing compliance by producers/businesses and a free-market logic that will choose in favour of these products.

Central to the strategy's ambitions are advances in technology; it relies on these with regard to their potential to increase efficiency in production (farming in particular), and energy generation and saving.

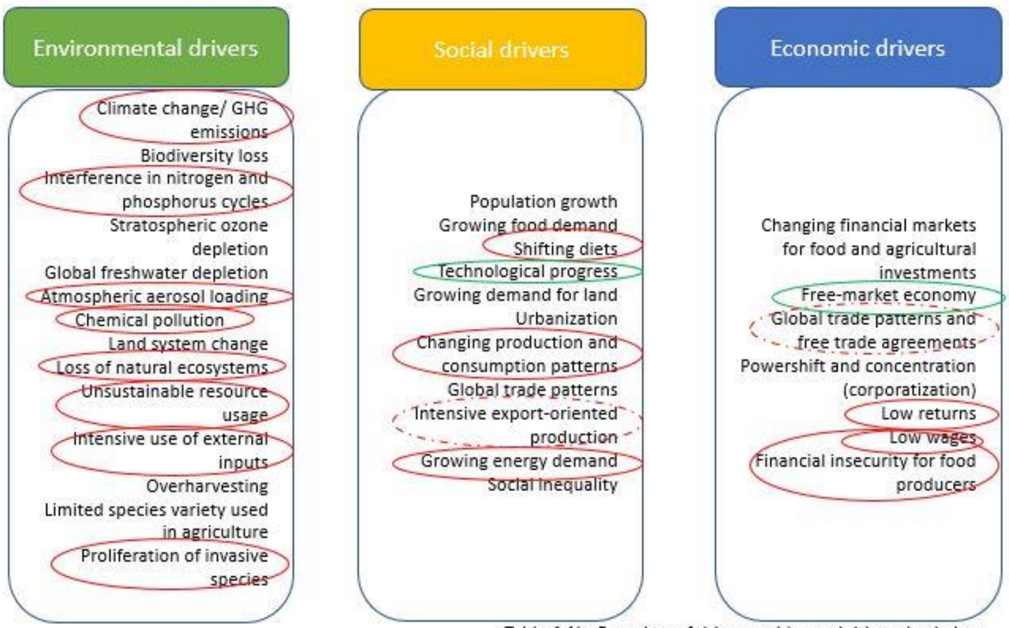


Table 4.1b. Overview of drivers, addressed drivers in circles; green circles indicate a reinforcing use of drivers; hyphened circles represent a partial addressal.

Table 4.1b provides an overview of the lists of drivers as identified before; the drivers found addressed are circled red.

On the problem level, the F2F strategy can therefore be said to respond to the observation of environmental change and its effects on food production (i.e. seed quality); malnourishment, deficiencies, and overconsumption resulting in "diseases of civilization" i.e. diabetes II, obesity, hypertension, cardiovascular diseases etc., food safety risks and food loss and waste; and finally it addresses the economic deprivation of small-scale farmers/food producers and farmworkers.

Environment	Society	Economy
Environmental change + threat of planetary boundary crossing (cf. Rockström 2009)	Persistent food and nutrition insecurity in the world	Econ. deprivation of small-scale farmers/ food producers, and farm workers
Resource degradation	Malnourishment, deficiencies and overconsumption resulting in "diseases of civilization" i.e. diabetes II, obesity, hypertension, cardiovascular diseases etc./ public health	Powershift and concentration (corporatization) along the supply chain
Land conversion Loss of natural ecosystems (for agriculture)	Food safety risks (contamination, diseases, fraud, etc.); public health	Volatile food prices
Further desertification	High amounts of food loss and waste	Disrupted food and agricultural markets
Lower nutritional values	Security risks to livelihoods, infrastructures and food systems due to environmental change	Deregulation, financialization of agricultural markets
	Social unrest (i.e. Arab Spring a.o.)	Reduced investments in agri-food sectors

Fig. 4.3. Overview problematical outcomes addressed

4.3.b. Drivers and problems unaddressed

In a second step, these interventions need to be viewed with regard to the drivers and problematical outcomes the F2F strategy does not address. It is in juxtaposition that an appreciation of the strategy's own understanding of resilience and a transformation towards resilient food systems can be achieved.

Looking back at the tables of food systems drivers and problematical outcomes (figures 4.2. and 4.3), it shows that core themes of food systems' challenges do not actually get addressed in the F2F strategy. While mentioned in the European Green Deal, the core aspects of growing food demand due to population growth as well as a growing demand for land - including for increasing urban areas -, do not get specifically addressed. Biodiversity loss finds mentioning as a consequence of GHG emissions and pollution, it is associated with modern industrial agriculture but finds no specific addressal in form of a strategy to diversify agricultural production or the agroecological environment. It needs to be noted, however, that under the *Biodiversity strategy 2030* support for organic agricultural and biodiversity-rich landscapes, as well as the reduction of (harmful) pesticides is featured as core strategies to halting and reversing biodiversity loss (EU Commission, 2020a).

Land system change, stratospheric ozone depletion, global freshwater depletion, overharvesting, and the reduced number of species variety in agricultural production find no mentioning in the strategy.

Equally, the F2F strategy does not mention social inequality as a critical factor in food and nutrition security, unhealthy diets, and public health concerns. Neither does it engage much with the political economy of modern food systems, which has been identified as a major driving force of modern food systems and human engagement (exploitation) of natural environments. In particular, the aspect of changing financial markets for food and agricultural investments, increasing privatization, financialization, and corporatization, as well the power shift and concentration, which accompany these trends, are neither mentioned nor addressed.

On the problem level, this leaves visibly a greater number of problematical outcomes of modern food systems unaddressed: The strategy does not address the widespread processes of land conversion/land-use change and associated loss of natural ecosystems (often for agriculture) and their contribution to further desertification. It does not consider climate change's impact on food to be lower in nutritional values, and it does not take into account how these processes affect the persistent food and nutrition insecurity in the world. Security risks to livelihoods, infrastructures, and food systems due to environmental change linger in the background rather than actually being addressed. There is a plan to revamp the emergency reserve and there is concern for climate-adaptable seeds; beyond this, there is, however, no reference to security risks. Concerning the political economy, there is hardly any change envisaged, the only exceptions are the consideration of fairer income streams for small- and medium-scale producers as well as to aspire for sustainable food production to lead new market-competitions, within the EU as well as in the long-term internationally. This means yet that the growing power shift and corporatization, volatile food prices, disrupted food and agricultural markets, reduced investments, and the deregulation, financialization of agri-food markets are in no way subject to any of the F2F strategy's considerations.

It needs to be noted that the strategy does mention world food insecurity in section 4 on promoting the global transition. Here the focus is on how the EU should use existing trade policies and international development cooperation to make sustainable food production a global standard; they shall also "boost cooperation to improve nutrition and to alleviate food insecurity by strengthening resilience of food systems and reducing food waste" (EU Commission, 2020e, p. 18). This section remains yet unsubstantiated with any concrete plans; I have therefore not considered this among the actions planned as part of the strategy.

Finally, I recognize that the EU understands the EGD as a means to, among others, increase and rejuvenate investment streams into agri-food businesses. In that sense, the F2F strategy can be considered to address the problem of reduced investments. However, I have not considered this an action as part of the strategy but, rather I understand this as an anticipated - or hoped for - consequence of the EGD initiative.

4.3.c. Addressing transformation

Transformation describes a new development pathway into a different system's configuration. Hence, transformational change "involves a change in the nature of the stability landscape, introducing new state variables and losing others" (Folke et al., 2010, p. 24). In the context of environmental change, deliberative transformation has been introduced as a concept for describing intentional, or directional change (O'Brien, 2012; Chapin et al., 2009), which is "carried out with the intention of achieving a particular goal" (O'Brien, 2012, p. 670). Deliberative transformation is initiated and requires interventions that affect state variables and feedback loops, to reinforce desirable interactions over undesirable ones.

This means, in order to achieve a transformation of food systems, the F2F strategy needs to initiate a new system's identity; it needs to qualitatively change state variables towards the desired (or preferred) new system's configuration. The F2F strategy does not introduce its vision of a future food system in detail; its "goals are to reduce the environmental and climate footprint of the EU food system and strengthen its resilience, ensure food security in the face of climate change and biodiversity loss and lead a global transition towards competitive sustainability" (EU Commission, 2020e, p. 4). The EU, hence, aims for food systems to be with "a neutral or positive environmental impact", providing "access to sufficient, nutritious, sustainable food" and "[preserving] affordability of food while generating fairer economic returns". These involve activities of preserving and restoring land, water, and other resources food systems depend on; mitigating and adapting to climate change; protecting land, water, soil, air, plant and animal health and welfare; reverse biodiversity loss; ensuring food and nutrition security, and public health; and the goal to make the most sustainable also the most affordable food (ibid.).

The question is here consequently whether the proposed actions suggest to change state variables to a degree that the current systems will be set on a new development path. Or do these actions rather suggest change within the current configuration? Both options (transformation and adaptation) can achieve above-mentioned goals, even if at different costs. In contrast to an adaptation, a transformation means yet that state variables and feedback loops need to be managed in ways that the current undesired configuration becomes weakened (this involves possibly the destruction of resilience), thresholds are passed, and new feedback loops are established and managed to uphold the resilience of the newly configurated system (Biggs et al., 2015).

With the identification of all critical thresholds being difficult for SES, an assessment of how far the proposed actions will be able to achieve transformative change remains intricate. This will be a task for future research projects once the F2F strategy has been operationalized. However, we do know that meaningful transformative change depends on fundamental changes to practices, values, and governance (IPCC, 2018). Read towards these later qualities, the F2F strategy and the analysis of drivers addressed (table 4.1b) suggest the following:

<u>Practices</u>

The proposed strategy distinctively addresses critical practices and aims at changing these. This applies particularly to agricultural production and the unsustainable usage of resources, GHG emissions, and chemical pollution. Further behavioural changes are envisaged with regard to the interference in nitrogen and phosphorus cycles and the growing energy demand of agri-food systems. As a second core area, the strategy refers to consumption patterns and dietary shifts. It proposes several actions to incentivize healthier and more sustainable food consumption[33].

Regarding the economic drivers, the strategy decides to reinforce existing free-market principles, and emphasizes competitiveness and innovation as crucial drivers of change.

<u>Values</u>

[33] Consumption in this context focuses on quality, not on quantities of food consumed.

At the heart of the F2F strategy lies a value shift towards sustainability, that is, the sustainability of food and production systems. It stresses the urgent need for more environmentally-friendly food systems, which provide healthy nutritious foods for generally better public health. It appeals to the principles of the European Pillar of Social Rights and stresses the importance of empowerment of all food system actors to earn a decent income and to produce under fair conditions. This explicitly includes all food sector workers.

Economically, the F2F strategy relies on current market dynamics and competitiveness; it understands the shift to sustainable food production as an economic opportunity in itself.

Governance

The F2F strategy in its very nature is a product of governance and employs political tools in its aspiration for change. It proposes new laws and frameworks in order to bring about the desired transformation. It focuses thereby on the established systems and institutions and contains no ventures towards any new actor-institutional networks.

4.3.d. Addressing resilience building

In a last step, the F2F strategy needs to be read for its qualities to support resilience building. In chapter 2, Walker (2020) was summarized with seven attributes, which are understood to promote general resilience. I will use these here as a means to establish a basic orientation over the strategy's contribution to foster such processes via its interventions. Other principles, values, and attributes of resilience building exist; these largely share the same core conceptions and distinguish themselves in individual details and depths.

- **Response diversity**: The F2F strategy is concerned about biodiversity loss and acts on the need to have more seed varieties in agriculture. Apart from this, however, diversity is not a subject. Important diversities in producers, products, traders, governance, and other institutions, which can substitute or complete each other in times of crisis, are not thought of.

- **Exposure to disturbances**: This attribute may pose the greatest challenge to policy-makers, as it includes the consideration of necessary crisis. A policy is usually expected to provide stability. While the strategy provides for an improved crisis response mechanism across the EU it does not integrate cyclical thinking around the different stages of the adaptive cycle. Whether natural, economic, or social crises, none are in any form considered as a possibility. Rather, the strategy presents measures exclusively to avoid crisis.

- **Being modular**: The connectivity between components of food systems across spatial or temporal scales is considered with regard to a sense of under-connection between EU members and institutions. There is a desire for greater alignment across the countries and sectors as well as a stated need for better cooperation of institutions in charge of protecting food systems from fraud and other threats to its security. The focus is thereby on greater efficiency and reliability. The possibility of over-connections and negative side-effects remain immaterial. The connectivity in and between individual subsystems/sectors is not subject to the strategy.

- **Being able to respond quickly to shocks and changes**: the strategy does not consider the barriers to food systems' response mechanisms - whether administrative nor ecologically. The only preparedness the strategy tasks itself with is with regard to the consequences of climate change. This is however seemingly limited to provide for climate-smart agriculture, particularly the provision of seeds that can sustain climatic changes. Additionally, the crisis reserve is to be revamped. A consideration of continuous changes and the possibility of other unexpected events are not discussed.

- **Being ready to transform**: The strategy considers itself to initiate transformative processes. The incorporation of mechanisms that allow room for food systems' self-organization and transformation beyond this policy proposal, i.e. a degree of flexibility in responding and adjusting to crises, is not thought of.

- **Thinking, planning, and managing across scales**: apart from the obvious need to think, plan and manage trans- and internationally for all EU member states there is little further consideration of food systems operating across spatial scales. Different temporal scales are not acknowledged. Problems are addressed at the problem level.

- **Guiding to steering**: the strategy does not display an understanding of food systems behaving as complex adaptive systems. Uncertainty and surprises are not planned for; in contrast, the strategy is to give off a sense of control in face of potential crises.

With the F2F strategy only being a proposal at this point in time, the final formulation is yet to happen. Considering the food system development (panarchy) and the theoretical understanding of what constitutes and supports resilience, the proposal as it stands now suggests, however, that both the quality of transformational change and of social-ecological resilience building remain rather limited. This assessment shall be discussed and reasoned for in the following chapter.

Chapter 5: Discussion

This final chapter will engage with the assessment made in chapter 4, where my conclusion is that both the transformative change as well as the building of social-ecological resilience of the F2F strategy are limited. Here I argue for the barriers I identify as relevant for a true transformation of food systems towards (social-ecological) resilience and sustainability.

5.1. What potential does the Farm to Fork strategy of the European Green Deal hold to improve the social-ecological resilience of agri-food systems?

a. Transformability vs adaptability

While there is agreement on *transformation* to imply *change*, diverse articulations of what transformation consists of exist across the various disciplines (Few et al., 2017; O'Brien and Sygna, 2013). In this work, I follow the perspective of social sciences and understand transformation in the context of food systems as a process that needs to acknowledge the diversity of actors, politics, and power relations. *Transformatio*n thus means fundamental changes in practices, values, and governance systems (O'Brien and Sygna, 2013). Distinguished needs to be further *transformation* (here understood to comprise of a new system's configuration) from *adaptation*; the latter refers to processes of adjusting the current system in order to uphold the same system's identity. Only across different scales may transformation facilitate adaptation (at a higher scale of the panarchy).

With this understanding of transformation, the F2F strategy does not present a proposal for fundamental change. Instead, it holds an understanding of transformation as a technical-managerial approach; one that relies on (technological) innovation, alternative technologies, and practices. The F2F strategy ranks foremost technological and innovative advances, the digitalization of food systems, and greater efficiency in order to reduce emissions, pollution, food waste, and other negative impacts. Socially, it wants to incentivize more sustainable consumption patterns, which is a valid measure to take, but simultaneously admits that this is in response to already changing values among European citizens[34]; the value shift has thus begun prior to and external from the F2F strategy. Economically, the strategy as well as the EGD as a whole build on the current principles of free-market dynamics and competitiveness as a motor of economic growth, which is believed to support the "green" and sustainable choices under these initiatives.

Viewed against the historical developments of food systems (cf. appendix 1), this approach suggests to perpetuate the same growth paradigm that has shaped the food systems over the last couple of decades. Since WWII, the political economy has shaped food systems into their current configuration predominantly by a continuous discourse of growth, efficiency, and free-market economies. The F2F strategy shows no intention to change this. Instead, it actively relies on exactly this market logic and understands the F2F strategy to be an economic opportunity for new businesses and markets, "[offering] economic gains" and "to boost the economy" (EU Commission, 2020e, p. 2). In view of the reports from chapter 1, this means that the critical assessments of socio-economic factors, that spur, among others, material- and energy-intensive consumption patterns and distort food prices and markets, the strategy subjects itself to technological and innovative fixes and self-regulation. There is no qualitative move away from the narrative of intensification, growth, and economic profitability.

Other important drivers, which I identified in chapter 4, find no consideration at all in the proposal: Developments of a growing demand for land, also due to population growth and processes of urbanization remain unaddressed. Biodiversity loss is a visible motivation for change, but there is little support of significant diversification in production; the value of traditional seed varieties finds mentioning but the focus lies on new, climate-resistant varieties, including genetically modified ones; there is no mentioning of livestock or other species. Social inequality, which holds some responsibility in currently shifting diets towards cheaper, less healthy, processed foodstuffs, is not addressed. Instead, there is a push towards affordable sustainable food, and the aim of sustainable food being the cheaper food items. There is no information on any concrete measure, a timeline, or on what affordability means in actual terms. It seems to suggest intensified *sustainable* food production on a large scale for prices to sink; there is no referral to incomes, jobs, social equality etc. Finally, the investment structures that have been identified to have played a crucial role in the development of global food prices and significantly affected food insecurity in the world, also find no addressal. On the contrary, the F2F strategy understands investment dynamics to work in favour

[34] "People pay increasing attention to environmental, health, social and ethical issues and they seek value in food more than ever before." (EU commission, 2020e, p. 2).

of the European Green Deal, expecting financial streams to flow into the deal due to its future vision of a sustainable and resilient food system.

As a result, I understand the F2F strategy to be less about transformation than it is about regulation. The proposed interventions are directed at managing and adapting key state variables to acceptable values in order to avoid crossing critical thresholds and to maintain the current system. Whether it is about resource usage, application of fertilizers and pesticides, international trade patterns, shifting diets or current production, consumption, and investment structures, the F2F strategy does not aim to transform these; it sets out to manage these for advantageous outcomes, i.e. reduced emissions and pollution, healthier diets, and more production, consumption, and investment in (what is termed) sustainable food. In other words, with regard to values, governance, and dominant practices, the F2F strategy supports business as usual – with a degree of adjustment to reduce negative impacts and to stay away from crossing critical thresholds.

This trend towards optimization is yet little surprising: it has long shaped the development of food systems with a focus on efficiency and maximizing production while controlling negative impacts. The underlying assumption therein is one of an optimal state, "which will deliver maximum sustained benefit" (Walker and Salt, 2006, p.6). Terms such as *maximum* or *optimal sustainable yields* signify this approach. Optimization also tends to focus on quantifiable and marketable values and to ignore other values with no immediate quantifiable and economic value (Walker and Salt 2006), hence depreciating and neglecting qualities such as ecosystem services, human well-being, and the like. A central characteristic of the optimization approach is further the assumption of gradual and linear system behaviours, i.e. cause-and-effect dynamics, which ignores different temporal and spatial scales and defies cyclical developments of growth-destruction and renewal. As a consequence, the strive for optimization tends to lock-in systems in their conservation phase (*k*-phase).

As a reminder, in the *k*-phase of the adaptive cycle, the system appears more efficient as it reduces redundancies, strengthens specialization, and exerts increasing control over processes. At the same time, there is neither capital accumulation nor room for novelty and experimentation. Overall flexibility is increasingly reduced as processes become standardized and constrained; the system becomes vulnerable to shocks. The longer the system stays locked-in to this k-phase the higher the cost of release. Yet, release (or crisis) is synonymous with chaos, insecurity, and loss of capital.

Managing food systems with the philosophy of optimization, as I suggest the F2F strategy proposes, is therefore dangerous. It means that while in the near future it may look like an improved system, there is no meaningful change taking place for the long-term. On the contrary, the systems' resilience will be reduced and make food systems more vulnerable to ecological, economic, and social shocks.

b. Building resilient and sustainable food systems

The F2F strategy states that "[t]he COVID-19 pandemic has underlined the importance of a robust and resilient food system (…)" and further that "our food system is under threat and must become more sustainable and resilient" (EU Commission, 2020e, p. 2). In absence of a definition provided by the EU of how they understand *resilience*, it is the *robust and resilient* that insinuates what Walker (2020) describes as "a common misinterpretation of resilience" (p. 11): Robustness generally appeals to the quality of withstanding and resisting disturbances and change. *Resilience* in such a context is consequently taken to be a system's ability to resist or 'bounce back' to equilibrium after a perturbation - rather than the capacity to cope, adjust and change to keep the same functions and identity (Walker, 2020; Walker and Salt, 2006). This suggests that the EU Commission worked with an understanding of *resilience* which in chapter 2 I described as *engineering resilience*, i.e. *resilience* as the quality of resistance or rapid recovery of systems' structures and functions after a disturbance.

This interpretation of resilience has important implications: it emphasizes the desire to keep the system in its current configuration and, rather than preparing it to respond to and absorb possible future shocks, it focuses on stabilizing the system for it to be resistant to these shocks and to be able to stay the same. This is in line with the managerial approach and the strive for optimization as discussed under 5.a. It also underlines once more that the F2F strategy is less about transformation than it is about adaptation.

The F2F strategy ends up proposing problem-level interventions to hold the system in its current configuration. The actions outlined address emissions, pollution, unsustainable resource usage etc. in order to not cross planetary boundaries; it shows concern over shifting diets and unhealthy food consumption to relieve public health concerns, which are eventually also economic concerns. These are fair proposals and important actions to be taken in their own rights. However, I argue that the F2F strategy's goal of transforming food systems towards greater sustainability and resilience cannot be met with the current proposal – if social-ecological resilience is meant. On the contrary, in not acknowledging the broader systemic problems that arise from current food systems in the interplay of various processes that characterize the modern food systems lies the risks to reduce resilience even more and to increase food systems' vulnerability in the long run.

The problem of the F2F strategy lies not just in the understanding of resilience as resistance but also in its narrow view of how to increase food systems' resilience: it focuses on specific threats. Instead of a holistic systems-view, the F2F strategy targets specific problems and thereby focuses on managing specific variables and (expected) disturbances. It again works for optimization rather than for greater flexibility and increasing options. This is not to say that the addressal of specific problems is not important; the design of the F2F strategy misses yet to go beyond these and to build general resilience for the long term. In chapter 1, the review of international reports highlighted the growing agreement and concern over the impact of broader systematic interactions, in particular of the global political economy and other socio-economic trends such as shifting consumption patterns, urbanization, and globalized supply chains, on environmental sustainability. To different degrees they all question the current trajectory of technological progress, optimization, and free-market economies to present improvements; instead, these trends are increasingly considered part of the problem (Walker and Salt, 2006). Yet, the F2F strategy relies on exactly these dynamics.

With regard to resilience building, the strategy, therefore, remains rather weak. Addressing core negative drivers, as identified in the above chapters, are necessary and valuable actions to be taken. Against the background of resilience thinking, the question to be raised here is yet one of the unexpected consequences. Managing one part of the system for greater control has other parts of the system change in response – and does so usually at the cost of overall resilience (Walker and Salt, 2006). The impact of the proposed actions may well improve specific problematic situations but may equally be spatially and temporally limited and create new challenges in a different part of the larger system. For example, less GHG emissions within the EU food production could ignite a process of outsourcing these emissions to other countries; in absence of strict and exact import policies, it could lead to an increase of emission- and resource-intensive food items to be imported from outside the EU without the necessary accounting of emissions, therewith falsifying overall statistics[35].

[35] I am aware of this being hypothetical. However, the trend exists already (Bettel, 2021). Apart from that, experiences for example with emission reduction schemes have shown exactly such dynamics, where countries have been recognized for significantly reducing GHG emissions without taking into account the emissions produced abroad of imported products. For more on emission-outsourcing see for example Baumert et al. (2019) or IPCC (2014).

Admittedly, the resilience theory remains challenging (sometimes confusing) as it is abstract, multi-dimensional, and highly context-dependent (Cabell and Oelofse, 2012). I chose to engage with resilience thinking for social-ecological systems as I understand the call for food system transformation on the premises of a) food systems being fundamentally social-ecological systems and b) being in need of a new configuration rather than better management (optimization). Consequently, the resilience understanding I see as preferential is concerned with understanding food systems as complex adaptive systems, which do not act linear and predictably, are multi-leveled, too complex to be measured precisely, have self-organizing and learning capacities, as well as most importantly perceives people and nature as interdependent and as one social-ecological system. The F2F strategy does not do this.

Social-ecological resilience requires us to focus on the system as a whole, and the acknowledgment that change is continuous; stability is not a healthy systems' state. Stability, however, suggests reliability and is therefore preferred by policy-makers and people in general; change, on the other hand, implies insecurity and uncertainty. The history of food systems development yet indicates that there is no stability even if aimed for, and social-ecological resilience thinking proposes that it is also not desirable. On the contrary, the heuristic model of the adaptive cycle suggests that the passing of its four development phases is advantageous for systems, as it allows them to adjust, adapt and transform and to ultimately be more resilient to greater disturbances. The second model of the panarchy is an extension of this cycle and helps to understand the progression of change/development over spatial and temporal scales. It provides necessary memory and informs on possibilities of cross-scale interactions. As such, it focuses on the interactions of multiple adaptive cycles and provides important insights into system's dynamics, which can e.g.. inform political decision-making.

Social-ecological resilience urges to accept change, to focus on state variables, which are identified to control a system, and to study these towards their critical thresholds (e.g. planetary boundaries). This tends to be easier done for biophysical thresholds than for social and economic variables but there are increasing attempts to include slow variables like changing identities, values, worldviews, or power reactions (Folke et al., 2010). General resilience thinking is thus in the first instance a framework, with which to understand the dynamics of SES by studying linkages across temporal and spatial scales and the interplay between social, economic, and ecological components.

Box 4 F2F- Focus areas

- Ensuring sustainable food production
- Ensuring food security
- Stimulating sustainable food processing, wholesale, retail, hospitality and food services practices
- Promoting sustainable food consumption and facilitating the shift to healthy, sustainable diets
- Reducing food loss and waste
- Combating food fraud along the food supply chain

In terms of a European Green Deal, this means that the addressal of identified negative dynamics is an important task for managing the system to keep it from crossing those critical thresholds that we know of. The six desired outcomes (Box 4) are relevant aims in face of current problems. They present, however, a strive for optimization and do not address the assertion that modern food systems are in an undesirable configuration. I argue that with this the F2F strategy presents itself as short-sighted. Actual transformation can only be achieved by moving beyond the desired specific resilience and by viewing food systems holistically – as social-ecological systems and across different scales. Some forms of specific resilience can moreover prove themselves to be costly in the long run - depending on how their change affects established feedback loops and creates different responses across the broader system. An understanding of the dynamics as captured in the adaptive cycle and the panarchy are necessary to gain insights into the broader interactions and feedback loops.

For example, the F2F strategy does consider the need for addressing shifting diets and to incentivize healthier and more sustainable diets. It does, however, not consider what makes people currently shift their diets towards unhealthier, less sustainable food options: This might be due to a lack of information, an economic decision, it could be tied to (cultural) values, or it might be a lack of availability and accessibility. Similarly, the F2F strategy addresses high pesticide usage and aims to reduce it by 50 percent. It wants to incentivize integrated pest management but does not discuss why farmers use the current amount of pesticides – is it a lack of information, an economic decision, a (personal) value of this specific method, or the lack of access to alternatives. This can/should be exercised for all behavioural changes envisaged.

A transformation involves the breakdown of the old configuration's resilience and processes of resilience building in the new, favourable regime. Therein the recognition of driver multiplicity and complexity helps in assessing the assets of an alternative regime vis-à-vis the current one. In the more desirable configuration, social-ecological resilience then needs to be built by allowing the system to adjust and adapt to changes. Resilience thus is processual. This quality is yet not reflected in the F2F strategy. There is neither a vision of a favourable alternate regime nor the support for resilience building in the sense of creating space for flexibility, adjustment, and adaptation. Instead, the F2F strategy focuses on increasing control over variables, such as emissions, pollution, resource usage, food waste, production and consumption patterns, etc.

Thinking in terms of social-ecological systems, social-ecological resilience allows to identify the problems that arise from growing control and increased efficiencies: it tends to lock the system in, usually in the *k*-phase of conservation (cf. 5.a.). Control and the sense of stability and reliability, which derives from it, are, however, false friends: it deprives the SES of its natural variations and the opportunities for re-organization, adjustment, and adaptation to changing social and ecological environments; these are core to resilience. With globalization, those strategies of control have spread to large parts of the world and have not just increased connectivity between spatial scales but also contributed to a growing homogenization; diversity in how and what we produce and consume has been declining – even if the experience in the local supermarket may deceive us.

Food system resilience requires not a diversion from but a reversion of current trends; it requires alternatives that exist next to each other, more diversity, and tight feedbacks between system components, which allow for (quick) responses whenever needed; it requires trust, and time and space for learning to take place. Food systems require to be acknowledged as complex, self-organizing systems with non-linear behaviour, continuous changes, and a quality to surprise.

5.2. Recommendations

In the management of food systems towards resilience, holistic and long-term thinking is required. This would also allow us to understand current problems as symptoms of a maladaptive, possibly dysfunctional system. The problematical outcomes presented in figure 1.2. should be treated as starting points,which indicate a greater system's misconfiguration.

From the perspective of social-ecological resilience, I finally make the following recommendations:

- Employ strategic transdisciplinary analysis of the undesirable system. There is a need to understand the constraints that lead to the problematical outcomes, which can be of different natures, such as
  - ➔ **Ecological constraints** often due to the loss of or severe reduction in resources, i.e. soil quality, water, biodiversity, pollinators, nutrient availability etc.
  - ➔ **Economic constraints** may contribute to actors choosing the unsustainable over the sustainable approach if the former presents itself as economically beneficial.
  - ➔ **Knowledge constraints** as in a limited understanding of long-term, broad-scale impacts of current processes/approaches, which could incentivize change; missing information

on the cost and benefits of alternative approaches; or a lack of access to knowledges and skills necessary for more sustainable procedures; etc.

➔ **Socio-cultural constraints** as in consumers/producers holding on to practices due to culturally ingrained values, beliefs, and worldviews, or other aspects that inform their (collective) identity.

- Identify a desirable configuration for modern food systems. In the case of the EU, the focus is on sustainability, which requires a clear definition. The Science Advice for Policy by European Academics (SAPEA), who officially inform the European Commission Group of Chief Scientific Advisors, provides the following definition of a sustainable food system as one that

  "provides and promotes safe, nutritious and healthy food of low environmental impact for all current and future EU citizens in a manner that itself also protects and restores the natural environment and its ecosystem services, is robust and resilient, economically dynamic, just and fair, and socially acceptable and inclusive. It does so without compromising the availability of nutritious and healthy food for people living outside the EU, nor impairing their natural environment" (SAPEA, 2020, p. 68).

  I understand this as applicable for the EU and suggest that it can be read as the desired outcomes of food systems. With the identification of the problematical and desired outcomes, it is necessary to establish pathways of configuration towards the desirable system. At this point, soft system methodology (cf. Checkland and Poulter, 2006) can inform the process of developing purposeful activity models, which can be used to discuss and define actions to be taken in reality. These should take into account relevant socio-cultural aspects, power relations, and other factors which could constrain their success.

- As it has been suggested that a transformation rather than an adaptation is necessary, it will be necessary to initiate processes that reduce the undesirable resilience and allows for shifting state variables towards the values of the desired basin of attraction. Often an unstable or semi-stable state of the system is advantageous to processes of transformation. This is, however, challenging to anticipate. Opportunities also need to be considered at various scales, from local to international as well as from individuals and businesses to pan-European organizations and governments.

- The desired systems configurations need to be social-ecologically resilient. Once the transformation has taken place resilience needs to be built. Here the principles (cf. Biggs et al., 2015), values (cf. Walker and Salt, 2006) and attributes (Walker, 2020) of resilient systems should inform the management/policy of the newly configured system. A list comprising core aspects of what characterizes social-ecological resilience can be found in appendix 5.

With regard to the research question, my conclusion is that the proposed Farm to Fork strategy of the European Green Deal does neither address transformation nor resilience in ways that a growing literature on social-ecological resilience suggests is necessary. I understand therewith that the answer to my research question has to be that its potential to improve the social-ecological resilience of agri-food systems is very limited. The F2F strategy lacks depth in what it understands to be desirable, the proposed actions focus on the problem-level and neglect the multiplicity of underlying dynamics and feedback structures; finally, it does not include any actions that support the qualities that make up social-ecological resilience - a growing diversity, acknowledging the four phases of the adaptive cycle, establishing modularity, preserving response flexibility, creating space for adjustment/transformation, and allowing for institutional structures to guide systems'developments - rather than to steer them for optimalization.

Conclusion

This thesis analyzed the potential of the proposed Farm to Fork strategy, which is part of the recently published European Green Deal, to contribute to a transformation of food systems towards (social-ecological) resilience. I understood the proposal of the Farm to Fork strategy to be a response to the call for a transformation of food systems as documented in a variety of influential international reports. I suggested that a growing urgency can be observed to accompany these reports.

In the absence of a definition of how the European Commission understands resilience, I engaged with the theoretical conceptualization of social-ecological resilience. Resilience is currently a popular ("sexy") term that finds application also beyond the sciences and policy-making; this has contributed to variances in meaning depending on the field of application. As a side-effect, confusions of these different meanings can be expected. There is, hence, a need to distinguish theories, e.g. of *engineering resilience* from *social-ecological resilience*. Because food systems are fundamentally social-ecological systems, I chose to analyze the proposed Farm to Fork strategy towards the latter. Chapter 2 introduced, thus, resilience thinking as a framework with which to approach coupled human-nature systems. I outlined briefly the development of the concept, introduced the central ideas of the adaptive cycle, the panarchy, as well as of the landscape of multiple basins of attractions; with these heuristic tools the dynamics of social-ecological systems can be captured, theorized, and analyzed. In order to do so, I emphasized the important role of identifying state variables, systems' drivers, their thresholds, and feedback loops. Finally, the chapter introduced seven basic attributes that characterize resilient systems.

Methodologically, the choice of systems thinking presented itself as the natural choice: both the food systems approach, as well as resilience thinking rely on systems models. Food systems, I showed can yet been conceptualized in different manners, which is why a plurality of conceptual models exists. All of these have however in common that they emphasize the complexity and interrelatedness of all systems components; the inclusion of ecological, social, and economic systems components is central. The model of the simplified holistic food system map (figure. 3.3.) was introduced as a general depiction of the great number of processes food systems; this was complemented by the conceptual frameworks by Polly Eriksen (2008) and the HLPE (2017) (figures. 3.4. and 3.5), which focus on environmental change and food security, respectively and emphasize the role of systems drivers and feedback loops towards these outcomes.

In the analysis, I first applied the heuristic tools of resilience thinking to food systems. This helped visualize the development of food systems over time and to highlight the continuous presence of growth and optimization narratives in the shaping of modern food systems. I presented the F2F strategy in terms of concrete actions (table 4.2) and assessed these towards their addressal of systems drivers and problematical outcomes (appendix 3). In a second step, I used this assessment to interpret their contribution to a food systems' transformation as well as to the building of food systems' resilience. My evaluation concluded with the estimation that the F2F strategy, as it has been proposed, will likely fail to initiate a meaningful transformation towards sustainable and resilient food systems. I reasoned for this in my last chapter by outlining how the proposal focuses on increasing efficiency and optimization, and aims for adapting the system to perceived problems rather than to fundamentally changing it. Problems get addressed at the problem-level, hence the EU has missed the important opportunity to analyze the problems as symptoms of greater and deeper problems in the current configuration of modern food systems. The approach of the strategy hints further at the usage of resilience in the meaning of resisting rather than in what I established should have been the desirable understanding – that of social-ecological resilience. My final evaluation of the strategy is thus that the F2F strategy will not achieve resilient food systems but, on the contrary, may potentially worsen the systems' "robustness" by attempting to stabilize the systems in their undesirable configuration. I closed the chapter with a set of recommendations that derived from the social-ecological resilience perspective.

This thesis presented a theoretical discussion as the F2F strategy at this point in time does not hold any legislative power; it ”only” formulates the commitments the EU has set out for themselves. I see its value in presenting an alternative perspective and therewith a contribution to what should be a deliberative policy context. Resilience thinking embraces the quality of continuous change, and this characterizes also the processes of conceiving and implementing policies: after the initial implementation follows a phase of crisis, reassessment, and improvement (and so on). In this sense, I hope for a lively debate around the F2F strategy to help spur the process of reassessment and reorganization for a better understanding of what our desired food systems should be and provide, how to build them and how to support them with the amount of flexibility, crisis and (self-) reorganization that these complex adaptive systems need.

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Appendix

Appendix 1: A brief history of modern food systems

Significant changes have occurred and transformed traditional agricultural production and predominantly local and regional food systems into extensive industrialized agricultural production and globalized food systems. These developments have increased production and efficiencies of food systems and have contributed to a general reduction in global hunger since the 1950s until recently[36].

Discussing the problems of modern food systems, therefore, requires to view the historical development and transformation of food systems. An understanding of the past illuminates the core dynamics of change and helps contextualize the observed problems.

The socio-economic context that formed modern food systems

The formative development of the modern food systems came about with both colonialization, free trade, and industrialization from the late-18th century onwards. Significant advances were made in technology and science, which were both influenced and influencing the political and economic pursuits of their days. Within the field of food regime analysis, which is concerned with "rule-governed structure[s] of production and consumption of food on a world scale" (Friedmann, 1993a, 30-1 in McMichael, 2009, p.142), three regimes are generally distinguished for the last 150 years:

(1.) Between 1870- the 1930s: cheap food and raw materials from the colonies support industrialization in Europe.

(2.) After the events of World War II and through to the 1970s: agricultural surpluses in the developed countries become employed in food aid programmes in developing countries. This overlaps with the push for industrial agriculture around the world not least through the initiative of the 'Green Revolution'. It is marked by increasing mechanization, a highly input-intensive agriculture, land consolidation, and financial integration of agricultural products into global markets.

(3.) Since the 1980s: with the expansion of neoliberal capitalism, the food sector has increasingly been subordinated to global trade agreements, privatization, financialization and corporatization. Driven by profit, it is characterized by near-monopolization of market shares

[36] This statement is contested! Some understand that higher production has helped to fight hunger while critics argue that socio-economic and political factors rather than productivity are decisive for the access to sufficient nutritious food. According to more general statistics on world hunger, the trend was indeed until 2015 one of reduction. Since 2015, however, world hunger is increasing again (cf. McCarthy, 2020). It is important to notice that such a statistic is incomplete as it does not indicate under- and malnourishment, it does not reflect differences among regions and it does not give details on drivers, which can range from natural disasters, war and conflict to other political and/or economic decisions that hinder groups of people from accessing food and/ or means of production.

by few agri-food corporations, which next to the machinery and chemical inputs increasingly also engage in patenting and commodification of organic matter (genetic resources).

In comparison to the traditional ways of producing and trading food, the production and supply chains of today are vehemently different due to the technological innovations made since industrialization and the possibilities of modern globalized trade systems. Additionally, research into biological and chemical possibilities has made possible new farming methods, intensification, and higher production values. I will here focus on three core socio-economic areas, which substantially shaped modern agriculture and the broader food systems.

i. The arrival of industrial capitalism

Agriculture, for the longest, had been conducted as subsistence food production. With the rise of industrialization and capitalism, this was yet to change radically. Capitalism in particular was associated with the division of labour, while industrialization created possibilities of mass production. The technological revolution that sprang from steam- and later gasoline-powered machinery had a great impact on traditional handicrafts including agricultural production. New social relations between (land)owners and workers developed, production began to aim for surpluses, which could be traded, therewith giving rise to the commercialization of agriculture. Mutually reinforcing, technological and productive advances further mechanized agriculture and subordinated it fully to a capitalist mode of production. A differentiation in traditional on-farm-activities led to the creation of a new industry of external suppliers (machinery, seeds, pesticides, fertilizers, etc.) and service purveyors (from storage and aerial spraying to accounting tasks).

The time of industrialization was also the time of colonialization, which contributed to the establishment of the first global trade routes for food and transnational corporations (Clapp, 2016). Since then, industrial agriculture has become the predominant form of farming throughout the developed world. With the help of technology and science, new production methods developed, new (hybrid-)seed varieties were adopted, fertilizers and other chemicals became standard inputs supporting high-output monocultures with specialized irrigation systems and planting and harvesting machinery (ibid.). Apart from industrialization and technology did war efforts, too, contributed to the intensification of industrial agriculture. Important mechanical, technological, and scientific advances in warfare found appropriation for agricultural means. For example, when chemists Fritz Haber and Carl Bosch developed a way to artificially fixate nitrogen (the so-called Haber-Bosch process), this was to allow large-scale production of explosives. Later, the chemical identification of nitrogen, phosphorus, and potassium for plant growth led to the commercial production of synthetic fertilizers instead. Insecticides, at the time most famously DDT, had been militarily employed to help with tropical dense tree coverage and fighting diseases like malaria and typhus (EPA, 2017). During the late 1940s research into these herbicides ("weed killers"), had seen first successes in the chemical removal of unwanted weeds without threatening the crop and were made commercially available for farming after 1945 (until 1972). Between 1950 and 1998, the usage of synthetic fertilizers rose tenfold, while pesticide use in the US alone grew forty-fold between 1940-1970 (Clapp, 2016).

In combination, mechanization and synthetically manufactured fertilizers and pesticides made possible large-scale farming and economic specialization. Monocultures slowly replaced diverse farming systems. Businesses developed to cater to the needs of these new farming systems by providing the respective vehicles, chemicals, and improved species. The distribution of hybridized and genetically modified variants were key ingredients also in the *Green Revolution* [37]as they are high-yielding as well as more resilient towards different climate- and pest-related events. With appertaining agro-chemicals, these improved variants are said to be even more productive. Finally, livestock, too, has been increasingly managed near-mechanically in factories with the possibilities of antibiotics and vaccines reducing the risks of diseases from dense animal keeping.

Agriculture today is a capital-intensive production system continuously striving for innovation and greater efficiency. The industrialization of agricultural production has farmers surrounded by a continuous offer of new products for the optimization of activities. With modernization, agriculture has further been increasingly linked to other markets system, i.e. for inputs or energy (petroleum, gas, etc.) and underlies their supply-demand fluctuations. Finally, industrialization and modernization also meant a shift of economic power and market control away from the farmers (Barlett, 1987).

As a result of these developments, small-scale and/or family farming has become increasingly difficult as, economically, it has gotten difficult to compete with the bigger industrial farmers[38.] This has promoted, too, that agriculture today is a highly consolidated industrial farming complex (Clapp, 2016; Hauter, 2012; MacDonald et al., 2017; Wach, 2018; Deter, 2016), in which few farmers and

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[37] The green revolution describes a set of technological advances in the 1950s and -60s to increase agricultural production. It focussed particularly on the use of high-yielding cereals and new forms of cultivation. Today the green revolution is also associated with a high degree of mechanization, hybrid seed varieties, and the application of agro-chemicals (synthetics fertilizers, pesticides, herbicides etc.).

[38] As Nixon's second secretary of agriculture, Earl Butz used slogans such as "get big or get out" (Clapp, 2016, p. 51), "agriculture is big business" and that farmers must "adapt or die" (Hauter, 2012, p. 22f.).

investors control the majority of farmland as well as advantageous access to the market. Secondly, industrial farming created an entirely new business branch around agricultural inputs, from heavy machinery and synthetic fertilizers and pesticides to hybrid seeds and other improved genetic materials. The marketing of these new technologies has spawned the establishment of a new agribusiness consisting of whole companies and corporations exclusively engaged with the retail of farm products (Clapp, 2016; Hauter, 2012).

However, industrialized agriculture did also double food production between 1820- 1920 (Scully, 2002, p. 29) – a result that has widely been used as an argument in support of industrial agriculture.

ii. Commercialization, diversity, and changing consumption patterns

The improvements in agricultural production and technology were soon to be accompanied by advances in food processing and distribution technology: from the expansion of infrastructure (i.e. railways, lorries, and airplanes etc.) to preservation methods of canning, freezing, and chilling. Industrial mass production not only changed people's work lives but eventually also their eating habits and diets. Fast food indeed has its origin in these socioeconomic developments as people were to spend less time on meal preparation but rather to work in factories or offices. The 20th-century food systems then not only saw a move away from traditional to industrialized agriculture but also major changes along the entire supply chain: Refrigerators spread and changed possibilities of preserving food items both for transportation, markets, and households. Sourcing of food moved from local to regional and global defying a sense of seasonality due to the new possibilities of global food trade. The discovery of chemical additives helped create a completely new sector of food processing and preservation. Today food processing constitutes one of the biggest food industries, contributing to significant dietary changes and the growing consumption of fast and convenience foods all over the world (McMichael, 2009). Supermarkets only became popular in the first half of the 20th century. With the new possibilities of conservation and preservation, the extended shelf-lives of products allowed for ever more diverse, far-traveled products to be transported and stored. In the 1970s, the invention of the bar-code made it possible to track products at any given stage of the chain, allowing supermarkets to keep track of their stocks automatically. This had a profound impact on management efficiency. Finally, with the arrival of the internet in the 1990s, traditional ways of communicating and thus ways of purchasing, selling, and controlling stocks, etc. changed distinctively (Lang, 2004; Lang et al., 2009). Deriving from the new possibilities, just-in-time distribution became the organizing principle; it increased delivery efficiency avoiding any hold-up, which is unnecessary storage.

Simultaneously, and as a result of advances in psychology, new marketing strategies[39] brought about important power shifts, initially from farmers to manufacturers and eventually to retail. The latter's purchasing power and the new focus on product development and branding created a "dazzling display of apparent choice, with thousands of products vying for attention" (Lang, 2004, p. 5). Advertising has become much more than the information about a product; it became a tool for psychologically creating feelings of needs and wants (and thus demand) in potential customers. In the 21st century emerged also so-called lifestyle products, which are to a great extent selling an idea of belonging to a specific group/lifestyle by using a particular product and brand (e.g. identifying with youth, freedom, being adventurous, being vegan, health-concerned, environmentalist, creative, young at heart etc.) Indeed, advertisement is rarely done by farmers any longer, and also at manufacturers and retailers is marketing today usually outsourced.

In addition to technological advancements, new labour relationships, and new food processing possibilities, the new food systems also come with significantly changed diets – that is fat-, sugar- and salt-rich, high in protein, high in carbohydrates etc. These contribute increasingly to health problems, like diabetes, overweight and obesity, cardiovascular problems, and others. While companies spend great amounts of money on marketing their products, so do governments see themselves increasingly in need to spend money on consumer education. However, the financial possibilities (or willingness to spend) vary significantly: to use an example from Lang (2004), "while the UK Government spends around £5 million on healthy eating advice, Coca-Cola alone spends £27 million in the UK [on marketing] yearly" (p. 13). As a direct consequence, the economic cost of modern diets and lifestyles have public health expenses rising rapidly (ibid.).

The modern food system is more diverse in products and more complex in processes. Rather than a direct connection between a farmer and a consumer, there are today whole new sectors of processing, marketing, retailing, and catering between these two. Not only has there been a shift in where and how consumers purchase their food but also in what foodstuff is bought, with supermarkets offering products from all over the world as well as a huge selection of processed, ready-made food items. In fact, the modern food system is essentially characterized by "easy access to highly processed food" (Pradyumna et al., 2019, p.173).

iii. International cooperation, food aid, and free trade agreements

[39] Cf. Scott, 1904. https://www.theatlantic.com/magazine/archive/1904/01/the-psychology-of-advertising/303465/ (16.09.2020).

Politically and economically, a new era of internationalization began after World War II. The USA were now the leading economic and political power (Clapp, 2016) and were as that also to shape the political food economy all over the world.

After their experiences with the *New Deal* programmes of the 1930s, which had pushed on the industrialization of agriculture and provided them with substantial production excesses, the US strategically used the export of their food surpluses for their international relations (McMichael, 2009). The US initially used food surpluses for food aid programmes in post-War Europe and then successively in other developing countries, as a way of distributing the surpluses that so far had to be stored at high prices. Indeed, not only was storage expensive but also did excess produce press food prices downward to an extent that farmers' incomes were no longer worthwhile the work (Clapp, 2016). The first decade after the war was strong on food aid programmes. Next to the humanitarian motivation, there were the economic incentives as food aid meant that surpluses were traded out of the domestic market, thereby supporting the national farming sector while developing new export markets (ibid.). The 1960s and 1970s then saw a shift towards exporting industrial agricultural methods - in what was called the *Green Revolution* – with the aim of helping developing countries to help themselves. Via institutions like the World Bank (WB) and the International Monetary Fund (IMF), the US, in particular, pushed for an "agro-export model" (McMichael, 2009, p. 143) and invested significantly into developing new markets accordingly. Consequently, schemes like the structural adjustment programmes (SAPs)[40], the Green Revolution, and programmes like 'agriculture for development' all promoted industrial agriculture and surplus production for a world market. Food aid has all the while continued where hunger was acute.

These developments have to be viewed in the larger context of post-1945. After the end of World War II, an entirely new political economy arose, which was to substantially affect production, distribution, and trade. A core decision was for the western countries, i.e. USA, Canada, Western Europe, Australia, and Japan, to agree on a common monetary management system, which was to govern the financial and commercial relations between them. This new international economic system involved the establishment of core institutions and a set of rules and procedures. As a result, the International Monetary Fund (IMF) and the International Bank for Reconstruction and

[40] Structural adjustment programmes consisted of a series of government-led policies in return for financial support by the World Bank and the International Monetary Fund. These policies were based on the market ideology of the Reagan and Thatcher administration and are considered an example of neoliberal development theory. Core aspects were the reduction of governments, removal of subsidies, privatization, currency devaluations, reduction of tariffs and quotas, no state control of exports, etc. (cf. Willies, 2011, p.56-60).

Development (IBRD), today part of the World Bank, were founded. One aspect of their respective works was to provide a fixed exchange rate, which was initially tied to the gold standard and since 1971 to the US dollar. These institutions were to regulate the convertibility of currencies among each other and to encourage free trade. A failure to form an International Trade Organization (ITO) led to the General Agreement on Tariffs and Trade (GATT). Between 1947-1994 the agreement was to promote the reduction of trade barriers, i.e. tariffs and quotas, among member countries. Since 1995, the GATT has merged into the World Trade Organization (WTO), which is today the core international forum for national governments to negotiate their trade agreements.

The beforementioned schemes, most importantly the SAPs, were results of these developments and in combination with other programmes, set out to shape the production and trade of agricultural commodities by tying loans for development to conditions, such as participating in free trade, and opening up for investments “with the agricultural sector as a prime target” (Clapp, 2016, p. 62). The underlying idea was that a specialization in few agricultural commodities would benefit poor countries as they could sell the surplus and with the money earned, they can afford to import what was needed for their national food security. In the long run, this would make them equal commercial trading partners, rather than aid recipients. At the same time, rich countries did not have to worry about high storage costs and continued to have their grain surpluses exported, too. All food produced would thus be able to flow freely through a world market, be accessible, and therefore help food inequalities around the world.

In reality, the SAPs’ expectation of liberalized agricultural markets left most indebted countries with little choice but to relax their policies on tariffs and quotas, especially on imported food (Clapp, 2016; Holt-Giménez and Shattuck, 2011). In 1994, agricultural products officially became integrated into the GATT, opening up the agricultural market. The result was the agreement on agriculture (AoA), a treaty under the WTO, which officially subordinated agricultural commodities to international trade rules, further liberalizing the world food system and restricting individual states from regulating their food and agriculture production (Holt-Giménez and Shattuck, 2011). At the same time, another agreement was found on trade-related intellectual property rights (TRIPS Agreement), which defines rules for patents and the likes within trade. It essentially is a means of protecting intellectual property and allows corporations and industries to legally protect their products from replication. This has made it possible to patent genetically modified seed varieties and to develop a new, international market for agricultural biotechnology products (Clapp, 2016).

The export of the industrial production model combined with new liberal trade agreements and means of intellectual property protection made it possible for agribusinesses and corporations to grow and expand their operations around the world. It allowed them not only to sell their products on a global scale but more significantly also to globally source resources (ibid.). The expansion took place both horizontally and vertically with corporations integrating smaller firms along the supply chain. Since the 1990s, this includes also retail grocery firms, which increasingly engage in direct acquisition and processing of fresh foods (ibid.).

Increasingly a corporate food system

As a result of all these developments, the dominant agri-food systems of the developed countries have become characterized by large-scale production, mechanization, extensive irrigation, monocultures, specialization, input-intensive and -dependent, that is, a high reliance on synthetic pesticides and fertilizers. Food production is subordinated to aims of economic efficiency and is hence profit-based. This means that socio-economic drivers have become the dominant force in the current food systems at the same time as they perpetuate an alienation of food production from consumption: with large-scale packaging and (global) distribution through supermarkets the distance between people and the natural origin of their food has grown to an extent that no contact with production is at all necessary.

The modern food system is further marked by an expansion of (transnational) corporations. This process has indeed been so significant that food regime theorists call the current period the *corporate food regime* (the 1980s until present) (Holt-Giménez and Shattuck, 2011). The corporate food system distinguishes itself by a high volume of food (quantity) that is moved through the system. Production often takes place in major agricultural regions with their produce being transported over long-distances, that is, several hundred and thousand kilometers. The focus of this system lies on modern production techniques and economic efficiency. It usually implies large-scale production (*economy of scale*[41]) and a specialization in one or a few products. Food in this system has become a commodity, generic and independent of local origin, which is traded in standardized pricing frameworks. At the same time has the production of food become an object of financial investments with organizations and banks investing in the growth of the sector in expectation of financial gains in the future.

[41] Economy of scale refers to the idea that with high production-levels (quantity) of one product the overall efficiency goes up while costs go down because certain inputs remain the same or increase unproportionately in relation to the income made from the end product.

Most characteristic is yet that global food corporations have become the central actors in the management of food. This became possible with the promotion of privatization since the 1970s and -80s (Clapp, 2016). Since then, the scale and scope of transnational corporation has progressively grown and “more concentrated as well as segmented, with relatively few global firms dominating large subsectors of the system” (ibid. p. 96). This pertains to three areas in particular, which are i) agricultural commodity trading and food processing, ii) the agricultural input sector and, iii) food retail (Clapp, 2016). The trend toward greater concentration has been further pronounced with firms becoming increasingly integrated into both a specific product-market (horizontal integration) and along the supply chain (vertical integration). In particular the 1990s saw a great number of mergers and acquisitions which created a situation in which any of these global firms usually operates in several, if not all of the supply chain segments. At times the patterns of interrelations are so dense that it becomes difficult to characterize a company as belonging to one sector or another (ibid.).

Alone in the last five years, three major mergers took place in the seed and agrochemical sector– Dow and DuPont, Bayer and Monsanto, Syngenta and ChemChina – with the result that as of 2018 “just four agrochemical giants control 70% of the global pesticide market and the top four seed firms control 67% of the global seed market” (Clapp and Purugganan, 2020, p. 1266). However, concentration has occurred all along the supply chain, from supply to processing, distribution, and retail (ibid.). This process matters with regard to choice and power distribution: for the former, a high concentration leaves farmers with less choice in which inputs to use; this includes also genetic variety in seeds and livestock. For the latter, a high concentration also means a concentration of financial and political capital, allowing firms to set standards and prices, to block unpopular measures, shape the public debate, lobby for their own interests, and to set the trend for further investments and development (Clapp and Purugganan, 2020; IPES-Food, 2017; Clapp, 2014).

Finally, as consequences of massive privatization and consolidation, which has been observed since the 1990s, a power imbalance in particular in financial means has increasingly fuelled also conflicts of land and resources with land grabbing, loss of livelihood, displacements, militarization and forceful evictions of farmers, indigenous peoples and/or other minority communities (Clapp and Purugganan, 2020).

Appendix 2: A brief historical review of *Green New Deal*- ideas

Discussions of a *Green New Deal* (GND) have yet existed for over a decade.

In 2006, the Global Greens, a network of green parties around the world, started a "Green New Deal Taskforce" and ideas thereof were later to become part of the US- Green Party's political campaigns of Howie Hawkins and Jill Stein (Democracy Now, 2012; Stein, 2012; Stewart, 2018). Another early mentioning can be found in a 2007 *The New York Times* opinion piece, in which Thomas L. Friedman wrote,

> "I've learned that there is no magic bullet for reducing our dependence on oil and emissions of greenhouse gases (…). The right rallying call is for a "Green New Deal." […] If we are to turn the tide on climate change and end our oil addiction, we need more of everything: solar, wind, hydro, ethanol, biodiesel, clean coal and nuclear power — and conservation. It takes a Green New Deal because to nurture all of these technologies to a point that they really scale would be a huge industrial project." (The New York Times, 2007).

By 2008, the UK-based *Green New Deal Group*[42] released a report "A Green New Deal" proposing as a response to what they perceived as a triple-crunch crisis - credit crisis, climate change and high oil prices – "structural transformation of the regulation of national and international financial systems, and major changes to taxation systems" and "a sustained programme to invest in and deploy energy conservation and renewable energies, coupled with effective demand management." (Green New Deal Group, 2008). At the same time, the *Green Economy Initiative* of the UN Environment Programme (UNEP), too, picked up on these thoughts and proclaimed in a 2008-report[43] "a global green 'New Deal' is needed to transform the world's economies" (Eccleston, 2008). This was, of course, at the time of the financial crisis of 2007/2008, which briefly had many countries contemplating possibilities of "green investments" and a general "greening" of the economy. However, the initial enthusiasm dropped with the economic recovery around 2010 and little of the proposed ideas materialized (Barbier, 2019). While ideas of a *Green New Deal* never really vanished, so were they yet held mainly by different Green Parties in the US and Europe and remained without sizeable support beyond these circles - until recently. On February 7th, 2019, US- representatives in the lower house, Alexandria Ocasio-Cortez and senator Ed Markey, released a 14-page *Green New Deal* policy proposal (Ocasio-Cortez 2019). The non-binding resolution operates with a vision of transforming the US economic system toward being carbon-neutral by 2030. In reference to President Roosevelt's *New Deal* of the 1930s, the *Green New Deal* consists of a number of

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[42] About the group: https://greennewdealgroup.org/about-the-group/ (08.02.2020).
[43] https://www.cbd.int/development/doc/UNEP-global-green-new-deal.pdf (08.02.2020).

legislations to address ecological, economical, and social crises, such as climate change, financial instabilities, unemployment, poverty, and structural inequalities.

Prior to COVID-19 and in view to the presidential election in November 2020, the US debate around the *Green New Deal* seemed to have gained significant recognition and received popular support from climate justice, environmental, and youth organizations (by January 10th, 2019, over 600 organization had signed a letter to Congress in support of the *Green New Deal*).

In the EU, on the other hand, with little prior public debate, EU- President Ursula von der Leyen in an almost surprising move did follow suit and introduced the European Commission's *European Green Deal*[44] to Parliament on December 11th, 2019. It consists of 50 policies and the goal of "creating the world's first carbon-neutral continent by 2050" (Khan, 2019). On January 15th, 2020, this proposal found major support in the EU Parliament and paved the way for the elaboration of suggested policy packages.

Appendix 3: Systems as a way of thinking *about* the world

i. Defining systems

Conceptualizations of systems can be found in many disciplines, from engineering and computer sciences to psychology, cultural studies, and economics. System-like frameworks have been employed by physicists, biologists, and chemists since the 19th century and developed into a *general systems theory* (GST) by the late 1940s (Checkland, 1999). Etymologically, the term *system* derives from the Latin word *systēma* meaning "an arrangement" or "a whole compounded of parts" (etymonline, 2020). For its use in the sciences it may, however, be more useful to think of a system as "the abstract concept of a whole which may or may not turn out to be useful as a descriptive device for making sense of real-world wholes" (Checkland ,1999, p. 48).

A system is distinctively different from a collection of elements as it requires an interrelatedness or interdependence of its parts. Therefore, in the realms of systems thinking, a system can also be perceived as an "adaptive whole" (Checkland, 1999, p. 49), which is a separable complex entity with so-called *emergent properties*, which are properties that are only achieved in the collective interplay of all parts (ibid.). However, these emerging properties only come about as a consequence of a

[44] The EU dropped the "new" from its deal entirely, of which neither an explanation nor a discussion has been found by me (by October 2020). This gives rise to speculation as to why this choice was taken. One possibility could be that the New Deal is formally a chapter of US history and has no relation to the European political past. Another possibility is, however, that cutting out the link to the original New Deal carries the political message of not committing to the Rooseveltian ideas of welfare and broad governmental investment schemes.

specific arrangement of all parts, meaning that a different arrangement or the lack of an individual part would not lead to the same emerging property; the overall performance of a system thus relies on a specific interplay of all parts (Kim, 1999).

Such an arrangement dependency suggests that some form of communication between elements must take place for their interplay to be successful. In the simplest form, a *feedback* mechanism is required for transferring information between individual parts as well as between the system and its environment. As an example, the human body (as a system) responds to an increase in external and internal temperatures higher than 36˚C by internally sending out signals to activate its sweat glands. The initiation of perspiration helps to cool the body until, finally, new signals will be sent out to stop the process. Equally, also beyond such immediate interplay are systems dependent on *communication* (feedback loops) and *control* (response mechanisms) as they need to act on both external and internal changes through correction, adjustment, and learning (Checkland, 1999).

Any one system can be part of another, bigger system, thus exist as a subsystem in yet a greater adaptive whole with new emergent properties. Systems thinking needs therefore also be concerned with identifying different layers (hierarchies), systems' boundaries, relationships, and *purposes* (Armson, 2011). The latter may largely be attributed to systems by people; however, the interplay of parts toward an emerging property may also be understood as inherently teleological, and hence purposive. The nature of purposes differs, of course, depending on the essence of a system – natural, technical, and social systems naturally have very different purposes, which might be mechanical (a toaster is to roast bread), functional (the sweat glands are to produce perspiration for a cooling effect) or intentional (the jurisdiction of a nation is to deliver justice).

Finally, systems always operate in a specific environment, and even if the environment is not part of the system it can influence a system's operations. Likewise, even if a system operates independently of its environment it may have an impact on the latter. For a holistic understanding of systems' functionality and positionality, these interactions also need to be considered.

ii. Using systems thinking

Offering a form of meta-language, systems thinking has lent itself to various disciplines as a tool to talk about complex compounds and as an "explanatory device" (Checkland 1999, p. 48) for the observed system behaviour. Important to note is that systems thinking as an approach distinguishes itself from traditional analytical thinking in its interest to study <u>interactions</u> between different components rather than aiming for an understanding of these individual components[45] (Aronson, 1998). It, therefore, tends to expand the complexity of its study rather than breaking it down into ever smaller units. As such it offers itself well for the study of complex problems with several parts or actors involved, and for problems, which exist in the relationship between these elements, and/or the system and its environment. It is particularly adapted to the study of recurring problems over time, focussing on the communication between elements and their responses to change (including adjustment). Yet, with different ontologies, different conceptualizations of systems get employed, of which the distinction between hard and soft systems is particularly important.

Hard systems are generally perceived to be systems that exist in the world and can be engineered in response to a problem. This conceptualization is thus rather technical and aligned with the understanding that such systems can be disassembled and reassembled for the purpose of adjustment. Such a conceptualization does not capture what is largely understood as human qualities, i.e. consciousness, intentions, values, worldviews etc. Consequently, a hard systems-view offers a problem-solving approach toward clearly defined objectives.

Soft systems, on the other hand, recognize that human activities tend to be non-linear. The humanities and social sciences, therefore, employ a system's view rather as a framework or intellectual construct of the world for the purpose of exploring problematical situations. A soft systems-view also acknowledges that there may not be a final solution but rather continuous learning and adjusting within dynamic contexts (Ison, 2008).

Throughout the 1970s and -80s, a new approach developed to explicitly work with soft systems. Known as soft systems methodology (SSM), its understanding is not about engineering but rather about managing systems. Most prominently advanced by Peter Checkland and colleagues, it works with social situations, which are "always complex due to multiple interactions between different elements in a problematical situation as a whole" (Checkland 2006, p. 4). SSM uses systems ideas as a means "to structure thinking" and to think in an organized manner of actions to improve a situation (ibid.). As a tool, SSM tries to organize and structure social situations while being aware that in the human realm situations are continuously changing as well as largely framed by subjective

[45] 'Analysis' is broadly defined as "separation of a whole into its component parts"(Merriam-Webster 2020). Consequently, systems analysis would be concerned with scrutinizing components and details of a system; systems thinking on the other hand is interested in the individual components with regard to their larger roles and interactions in the overall system.

perceptions, which are influenced by cultural and social environments, personal development, and emotions. Consequently, “every situation involving human beings is unique” (ibid., p. 6) and cannot be dealt with according to one scheme or by employing a particular technique; instead, problematical situations should be approached with a set of principles, “which can be adapted for use in a way which suits the specific nature of each situation in which it is used” (ibid., p. 4).

As people generally act with purpose, SSM employs the system’s idea, as described above, to represent purposeful actions as systems. This means that a system (an operation) consists of various activities, which bring about an emergent property (purpose). Importantly, though, SSM integrates the existence of various worldviews. As a result, the same system can be reproduced for other stakeholders (and worldviews) and generate entirely different understandings on a system or problematical situation (e.g. a hotel manager presumedly holds a different view with which to assess a problematical situation at work than the receptionist or the cleaning personnel). Therefore, any activity model can never depict the real world but offer “one way of looking at and thinking about a real situation” (ibid., p. 11). If this raises the question of validity and the usefulness of such models, then it needs to be stressed that this is not about right or wrong but about finding ways of improving a situation; therefore, these models need to be thought of as intellectual devices to investigate a situation and to engage in a process of discussing and debating what is desirable and how to initiate change for the better – as perceived by the stakeholders. Hence, in the absence of a generalizable hypothesis about a system, SSM aims for finding desirable and feasible criteria to improve one activity model at the time (Checkland, 2006). SSM therewith is a tool only for the interrogation into situations and their management.

Built on systems thinking, SSM explicitly employs systems as abstract conceptualizations of reality and as descriptive tools for the study of real-life complex matters (Checkland, 1999). It incorporates the notion of worldviews to account for different perspectives present in a situation, and it is a facilitator for a structural debate with the aim to improve a situation. Thus, rather than a linear problem-solving process, SSM operates in cyclic processes for constant improvement: from identifying the problematical situation and taking actions of improvement a study of changes ensues leading to continuous adjusting and learning (Checkland, 2006).

Appendix 4: Assessment of systems drivers and problems addressed by the Farm to Fork strategy

Actions proposed	SES Driver(s) addressed	Problem(s) addressed
At least 25% of EU farmland to be under organic farming by 2030. Support sustainable practices (nature-based, technological, digital, space-based); Eco-schemes: boost precision agriculture, agro-ecology (including organic farming), carbon farming, agro-forestry, etc.	Intensive use of external inputs Chemical pollution Interference in nitrogen and phosphorus cycles Changing production patterns GHG emissions	Pollution (GHG emissions, nitrogen, phosphorus, other chemical wasters), Land degradation, Atmospheric aerosol loading, Ocean acidification.
Reduce overall use and risk of chemical pesticides and more hazardous pesticides by 50% in 2030. revision of the Sustainable Use Directive (SUD) to reduce the use and dependency on synthetic chemicals pesticides; reduction in use of pesticides by the implementation of Integrated Pest Management (IPM); make a new legislative proposal to enhance the implementation of Integrated Pest Management (IPM). revision of the pesticides statistics regulation to overcome data gaps and reinforce evidence-based policy making;	Chemical pollution Atmospheric aerosol loading GHG emissions	Pollution (GHG emissions, nitrogen, phosphorus, other chemical wasters), Land degradation, Atmospheric aerosol loading, Ocean acidification.
Reduce nutrient loss (especially of nitrogen and phosphorus) by 50% in 2030 while ensuring that there is no deterioration in soil fertility; **Reduce use of fertilisers by at least 20% in 2030.** Encourage precision fertilisation. Recycling of organic waste for organic fertilisers manage better nitrogen and phosphorus application. Develop integrated nutrient management action plan	Interference in nitrogen and phosphorus cycles Unsustainable resource usage	Pollution (GHG emissions, nitrogen, phosphorus), Land degradation Atmospheric aerosol loading, Ocean acidification.
Reduction in environmental and climate footprint Renewable energy (biogas, solar panels and other energy efficiency solutions) promote the EU carbon farming initiative under the Climate Pact, promote new green business	GHG emissions Growing energy demand (Technological progress)	Environmental change, Pollution (GHG emissions).
Reinforce vigilance on plant imports adopt new measures to protect plants better from emerging pests and diseases, reinforce vigilance on plant imports and develop new innovative techniques incl. plant protection products containing biological active substances.	Proliferation of invasive species	persistent food and nutrition insecurity due to climate change.
increase alternative feed materials *(insects, algae, and by-products from the bio-economy (e.g. fish waste).), foster EU-grown plant proteins (reduce dependency on imports of unsustainably produced feed), and feed additives;*	GHG emissions	Environmental change.

revision of the feed additives regulation to reduce environmental impact of livestock farming		
Reduce EU sales of antimicrobials for farmed animals and aquaculture	Unsustainable usage	Food safety risks/public health.
Revise animal welfare legislation *Evaluation and revision of the EU legislation on animal welfare, including on animal transport and slaughter of animal; Consideration of options for animal welfare labelling.*	?	Food safety risks/public health.
improving advisory services *to enabling farmers to become sustainable;*	Unsustainable resource usage Intensive use of external inputs GHG emissions Interference in nitrogen and phosphorus cycles Chemical pollution Atmospheric aerosol loading	Pollution (GHG emissions, nitrogen, phosphorus, other chemical wasters), Land degradation, Atmospheric aerosol loading, Ocean acidification.
Guaranteed decent income;	financial insecurity for food producers (farmers and farm workers)	Deprivation of family/small-scale farmers and farm workers.
Better efficiency and effectiveness of direct payments under CAP	financial insecurity for food producers (farmers and farm workers)	Deprivation of family/small-scale farmers and farm workers.
Protect critical staff (agri-food workers) better in reference to the European Pillar of Social Rights	Low wages financial insecurity for food producers (farmers and farm workers)	Deprivation of farm workers.
Improve agricultural rules/legislative initiatives to strengthen position of farmers, their cooperatives and producer organisations in food supply chains and to capture a fair share of the added value of sustainable production; **Revise fishery control system for fairness**	financial insecurity for food producers (farmers and farm workers) Low returns	Deprivation of farm workers, Power shift (?).
Initiatives to stimulate reformulation of processed food, *including the setting of maximum levels for certain nutrients; initiatives to facilitate the shift to healthier diets;* *Facilitate nutrient profiles to restrict promotion of food high in sugars, fat and salt.* *mandatory front-of-pack nutrition labelling to enable consumers to make health conscious food choices* *improve channels to spread relevant information (health)*	Shifting diets Consumption patterns and changing production	Malnourishment, deficiencies, and overconsumption resulting in “diseases of civilization”/public health.
Revise food contact materials legislation to improve safety and public health.	Chemical pollution	Food safety risks (contamination, diseases, fraud, etc.)/public health.
Revamp agricultural crisis reserve; **Conceive a common response mechanism** *for ensuring food supply and food security in crisis*		Food and nutrition insecurity.
Improve corporate governance framework *including a requirement for the industry to integrate sustainability into their strategies.* *Legislative initiative on re-use to substitute single-use packaging,* *Create a voluntary sustainable labelling framework with a sustainable food logo that*	Changing production and consumption patterns Chemical pollution GHG emissions	Pollution (GHG emissions, other chemical wasters), Public health.

would integrate the nutritional, environmental, climate and social dimensions of foodstuffs (on nutrition, climate, environment, social aspects)		
Tax incentives to encourage consumers to choose sustainable and healthy options	Shifting diets Consumption patterns	Malnourishment, deficiencies and overconsumption resulting in "diseases of civilization/public health.
Halven food waste by 2030; *Proposal for EU-level targets for food waste reduction; set a baseline and propose legally binding targets to reduce food waste; a revision of EU rules on date marking*	Unsustainable resource usage	High amounts of food loss and waste.
Scale up fight against food fraud along the agri-food chain. *adopt zero tolerance policy, strengthen cooperation, control and investigation*		Food safety risks (contamination, diseases, fraud, etc.)/public health.
Setting mandatory minimum criteria for sustainable food procurement in institutional catering *to promote healthy and sustainable diets, including organic products, in schools and public institutions*	Consumption patterns	Malnourishment, deficiencies and overconsumption resulting in "diseases of civilization" /public health.
Circular bio-based economy, **Promote circular business models**	Growing energy demand GHG emissions	High amounts of food loss and waste, Pollution (GHG emissions, other chemical wasters).
Geographical indication and sustainable criteria labelling as marketing standard	GHG emissions Unsustainable resource usage	Environmental change, Pollution (GHG emissions, nitrogen, phosphorus, other chemical wasters).
Short supply chains	GHG emissions Global trade patterns(?)	Environmental change, Pollution (GHG emissions, nitrogen, phosphorus, other chemical wasters).
Tax system should aim for price differences *to reflect their real costs in terms of use of resources, pollution, GHG emissions and other environmental externalities*	Climate change/GHG emissions	Environmental change, Pollution (GHG emissions, nitrogen, phosphorus, other chemical wasters)
Revision of EU marketing standards/EU code of conduct *for responsible businesses and marketing practices for healthy, sustainable food options* *provide for the uptake and supply of sustainable agricultural product;* *reinforce the role of sustainability criteria taking into account the impacts on food loss and waste*	Shifting diets Climate change/GHG emissions Unsustainable resource usage Intensive use of external inputs Chemical pollution	Environmental change, GHG emissions, Malnourishment, deficiencies and overconsumption resulting in "diseases of civilization"/public health, High amounts of food loss and waste.
Seek commitment from food companies to: *Reformulate food products for health and sustainability, reduce environmental footprint and energy consumption.* *Ensure food prices campaigns do not distort consumers' perception of the value of food.* *Reduce packaging*	Shifting diets Growing energy demand Climate change/GHG emissions Chemical pollution Unsustainable resource usage	Malnourishment, deficiencies and overconsumption resulting in "diseases of civilization" /public health, Pollution (GHG emissions, nitrogen, phosphorus, other chemical wasters).
facilitate better registration of seed varieties *and ensure easier market access to traditional and locally-adapted varieties (incl. organic and new innovative techniques)*	Resource degradation Limited species variety used in agriculture (?)	Environmental change, Security risks food systems due to environmental change.
Facilitate market access for innovative feed additives, alternative feed materials *(insects,*	Climate change/GHG emissions Chemical pollution	Pollution (GHG emissions, nitrogen, phosphorus, other chemical wasters).

algae, etc.) that help reduce the carbon footprint, pollution as well as methane emission.		
clarifying the scope of competition rules *in the TFEU[46] for collective initiatives that promote sustainability in food supply chain*	Trade patterns (EU)	?

Appendix 5: Core principles and values of resilience building according to Walker and Salt (2006) and Biggs et al. (2015) summarized

The proposed principles to enhance social-ecological resilience in combination suggest the following:

1. Diversity and redundancy are often considered central to resilience. A higher diversity in system components offers a broader variety in responses to disruption. It has shown that more heterogeneous systems are more resilient. Diversity exists in the number of different components (variety), the number of representatives of each component (balance), and the degree of difference between them (disparity) (after Stirling 2007 mentioned in Biggs et al., 2015). Diversity can further be studied toward various aspects, and it is possible to speak about e.g. cultural diversity, functional diversity, response diversity etc. Redundancy complements diversity by describing the components and pathways in a system that perform similar processes. As such redundancies are understood to be able to compensate for each other in case of loss or failure (Biggs et al., 2015). Both diversity and redundancy increase system resilience by providing alternatives in times of change and crisis.
2. Ecological variability refers to the need to let environments pass through times of disruption and crisis rather than attempting to control and minimize them. A system that is prevented from experiencing these phases misses the opportunity to adjust and learn and will eventually lose its ability to respond to crisis. It becomes vulnerable.
3. Modularity and connectivity deal with the structure and strength of interaction between system components between each other and across scales. Connectivity is important for example after a disturbance as it informs the process of recovery. At the same time, a highly connected system is also more vulnerable as crisis can easily spread. The overconnected system may also lose diversity and therewith flexibility. The degree and value of connectivity is, therefore, context-dependent (Biggs et al., 2015). Modularity (or compartmentalization)

46 Treaty on the Functioning of the European Union, part of constitutional basis of the EU.

describes strongly connected subsets that are loosely connected with other subsets. It is suggested that such modularity has a positive effect on the stability of systems and increases resilience (Salt and Walker, 2006; Biggs et al., 2015).

4. Slow variables and (tight) feedbacks directly affect the configuration of SES. It is suggested that in most SES a limited number of key slow variables and feedback processes configure the system (Biggs et al., 2015). Fast variables on the other hand usually respond to the condition created by these slow variables. Feedback is critical in the interplay between variables as they determine the response to change and disruption. Feedback is important in signaling changes and consequences and should therefore be tight (i.e. in temporal and/or spatial proximity). Negative feedback can help in maintaining a system's configuration in case of disturbance. However, if changes in slow key variables are too severe for feedback to counteract change the system is bound to cross critical thresholds into a different regime with new feedback processes. Therefore, the management of slow variables and internal feedback processes are crucial in maintaining a system's current regime (if desirable) or for purposefully moving it into a new more desirable configuration. Identifying these slow key variables and feedback processes is yet often difficult in practice.
5. Complex adaptive systems (CAS) thinking integrates how actors/people, individually and collectively, make sense of SES dynamics (Biggs et al., 2015). As worldviews or mental models, these different understandings inform people's interaction within SES. Therefore, CAS thinking emphasizes the need for a holistic and integrative approach to SES, acknowledges a multiplicity in engagements with and the existence of uncertainty surrounding SES. As an approach, CAS thinking stresses the need to learn and experiment in order to change and adapt the cognitive foundations and paradigms that inform people's decisions and actions. CAS thinking views SES as CAS, which hold a high degree of interconnectedness, potential for non-linear change, uncertainty, and a multiplicity of perspectives, and embraces uncertainty and surprise "as opportunities for positive motivational change" (ibid., p. 147). A challenge remains yet "to understand and anticipate behaviour of a CAS […] with neither a definitive formulation nor clear solutions" (ibid., p.148).
6. Learning and innovation allude to the properties of CAS and point to the importance of continuous learning. Acknowledging SES as CAS means to recognize adaptive processes as well as a complexity that is never entirely understood. As a consequence, continuous production and reproduction of knowledge (i.e. learning) is required to enable adaptive

processes and maintain those qualities that help sustain a system in case of disruption. Learning is a nuanced process and includes processes such as acquiring information, facts, skills, and methods, memorizing, deriving meaning, and interpreting and understanding reality in different ways (Biggs et al., 2015). As a scientific process, learning further means to formulate alternative hypotheses, conduct deliberate experimentation (→ innovation), monitoring, and evaluation (ibid. 2015). Resilience can be enhanced through learning by providing new information and observations, which in turn can inform and improve system operations and lead to innovation.

7. Social capital and participation are understood to be key to (collective) response in cases of change and crisis (Biggs et al., 2015). Resilient SES require trust, well-developed networks, and leadership (Salt and Walker, 2006), while participation helps initiate and built such relations. Participation means the involvement of stakeholders in management and governance processes. Participation is yet a broad concept and can range from informing all actors involved to active involvement in management and/or decision making or even an absolute decentralization of power structures (Biggs et al., 2015). The form of participation that is most suitable is context-dependent and should be open to revision. The strength of participation lies in bringing together a diversity of actor, knowledge, and worldviews; diversity in stakeholders increases legitimacy potentially builds relationships and trust, increase communication, and improve understanding. A greater diversity of stakeholders can, however, also result in conflict and obstruction of progress if not assembled, supported, and executed appropriately.
8. An overlap in governance or the promotion of polycentric governance systems describes a certain degree of connectivity, modularity, and redundancy. Polycentricity suggests the interaction of multiple governance units - both horizontally and vertically. The cooperation provides increased institutional resources and collective action toward collectively experienced problems. It further allows for engagement and participation, knowledge share, and collective decision-making of different actors and institutions. Polycentricity is thus concerned with matching the level of governance to the scale of the problem. Ideally, any governance body interacts and links efforts with the relevant other authorities "both horizontally and vertically to achieve a balance in collaboration and autonomy" (Biggs et al., 2015, p.229). Overlapping entities allow for improved connectivity over scales, broadens participation, increases legitimacy and accountability, facilitates learning and experimentation, creates response diversity, and finally allows for redundancies that can

correct or minimize weaknesses and errors in governance (Biggs et al., 2015). The modularity and redundancy of polycentric governance systems supports successful experimentation to spread while failures in governance remain isolated. Resilience is enhanced by the increased response diversity and functional redundancies.

9. Ecosystem services, as proposed by Salt and Walker (2006), suggests the inclusion of those ecosystem services that do not get recognized in market-driven economies as they hold no monetary values but are considered *free*, that is, unpriced. Often these services only get recognized when they have been or are threatened to be lost. These, they suggest, need to be considered in development proposals and assessments (Salt and Walker, 2006).

These principles of how to build social-ecological resilience do appear in a particular order of importance but can be distinguished as focussing on properties and processes of the SES (1-4, 9) and focussing on the processes of their management and governance (5-8).

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